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Resisting the Pull of Erring Intuition

Explanation Reduces Acquiescence in the Ratio Bias Paradigm

Guðrún Rut Guðmundsdóttir, Lilja Magnúsdóttir og Margrét Nilsdóttir

Sálfræðideild
Hug- og félagsvísindasvið
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12 eininga lokaverkefni
sem er hluti af
Baccalaureus Artium-prófi í sálfræði

Leiðbeinandi
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Útdráttur

Mannshugurinn virðist notast við tvo ólíka hugferla í ákvarðanatöku; ýmist grípur hann á lofti það fyrsta sem stekkur upp eða hugleiðir valkostina stundarkorn og nálgast þá á yfirvegaðan og rökréttan hátt. Þessir hugferlar hafa verið rannsakaðir og þeir aðgreindir eftir nokkrum ólíkum flokkunarkerfum og þá einna helst með hjálp kenninga sem gera ráð fyrir að rökhugsun yfirbugi og leiðrétti innsæið þegar það greinir villu í niðurstöðu þess síðarnefnda. Slíkar hugferla-kenningar taka ekki með í reikninginn að fólk á það til að fylgja hugboðum sínum, jafnvel í þeim tilfellum þegar það veit að það er órökrétt. Þetta hugræna fyrirbrigði hefur verið útskýrt og skilgreint af Jane Risen (2016) og hugtakið sem hún notar mætti þýða sem innsæiseftirgjöf (e. acquiescence). Þetta hefur verið rannsakað lítillega en fyrstu niðurstöður styðja tilvist þess (Walco og Risen, 2017). Í þessari rannsókn endurgerum við eina af tilraunum Walco og Risen (2017), nánar tiltekið þá sem byggir á að kalla fram hlutfallsskekkju (e. ratio bias). Við staðfestum niðurstöður þeirra og rennum þar með frekari stoðum undir tilvist fyrirbærisins, en jafnframt freistum við þess að hafa áhrif á styrk tilhneigingarinnar með því að útskýra fyrirfram á skilmerkilegan hátt þá skekkju sem um ræðir. Þátttakendur (n = 905) voru fengnir til liðs við rannsóknina í gegnum til þess gerða vefsíðu. Þau tókust á við hlutfallskekkjuverkefnið auk þess að svara nokkrum viðbótarspurningum sem gefa áttu mynd af breytileika milli einstaklinga. Niðurstöður benda til þess að útskýringin á hugskekkjunni ýti almennt undir að þátttakendur láti rökhugsun ráða við lausn verkefnisins. Gagnagreining leiddi í ljós að inngripið dró úr líkum þess að þátttakendur væru móttækilegir fyrir skekkjunni, og jók líkur þess að standast hið villandi hugboð. Við ályktum að draga megi úr innsæiseftirgjöf með því að upplýsa fólk um þá hugskekkju sem glímt er við. Við ræðum þau hugferli sem mögulega búa að baki þessum áhrifum og veltum því fyrir okkur hvernig þau tengjast einstaklingsmun á tilhneigingum til innsæis- eða rökhugsunar auk hjátrúar. Einnig veltum við því upp hvaða fræðilegu og hagnýtu þýðingu niðurstöðurnar gætu haft í sambandi við aðferðir til að takast á við hugskekkjur og þá sérstaklega með tilliti til kenninga um tvískipt hugferli (e. dual-process theories).

Lykilorð: ákvarðanataka, innsæiseftirgjöf, innsæi, hlutfallsskekkja, kenningar um tvískipt hugferli

Abstract

The human mind seems to have two distinct systems for making choices; simply doing what springs to mind intuitively or using a more deliberative, conscious and logical approach. This apparent division of mental processes has been researched and described in numerous ways, most notably through models based on the assumption that rational analysis corrects and overrides intuition when a fault in its conclusion is discovered. Such corrective dual-process models, as they are collectively referred to, do not take into account that people sometimes "go with their gut" even in instances in which they know it is illogical to do so. They are said to *acquiesce* to their intuition, a phenomenon documented and defined by Jane Risen (2016) and supported by preliminary evidence in a series of experiments (Walco and Risen, 2017). In this study we replicated and elaborated on the ratio bias experiment of Walco and Risen (2017), providing confirmatory evidence for the occurrence of acquiescence and examining whether the tendency could be reduced by providing relevant information about the bias in advance. Participants (n = 905) were recruited through an online data collection platform. They completed the ratio bias task and responded to several exploratory survey questions measuring individual differences. We found that providing a clear and concise explanation of the bias at hand generally increased rational responding to the task. Our analyses showed that the manipulation reduced the frequency with which participants were susceptible to experiencing the faulty intuition, and when intuition and reason were in conflict, resistance to the faulty intuition was increased. We conclude that the acquiescence tendency can effectively be reduced by informing people about the cognitive bias in question. We discuss the possible mechanisms that might underlie this effect, how it relates to individual differences in intuitive and rational decision-making preferences and superstitiousness, as well as implications and future directions concerning debiasing techniques and interventions, particularly in the context of dual-process theories.

Key words: decision making, acquiescence, intuition, dual-process models, ratio bias

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Humans are contradictory creatures; striving for logic and reason but at the same time clinging to magical beliefs and superstitions; possessing the ability to draw reasonable conclusions, but still driven by primitive impulses. When our hearts and heads disagree, we often seem more compelled to follow the heart. It is not surprising then that clichés such as "listen to your heart" and "go with your gut" strike a chord with many, and few if any popular songs have been written about analysing and calculating the odds of success. The familiar conflict that arises when our "gut feeling" points us in the opposite direction to what our more reflective and critical mind would deem a wiser way to go has recently gathered increasing attention from researchers studying the psychology of decision-making. It has aptly been described by some as a "brain at war with itself" (Stanovich, 2004) and "two minds in one brain" (Evans, 2003) in the context of so-called *dual-process theories*, predominant and widely applied models describing how we reason and make decisions on the basis of two theoretical processes or systems.

The Dual-Process Framework

In these dual-process theories, the "gut feeling" and the "reflective and critical mind", otherwise known as "intuition" and "reason", respectively, are seen as two underlying modes of processing or thinking styles with distinct characteristics. These two kinds of thinking are often for simplicity referred to as *System 1* and *System 2* (e.g., Kahneman & Frederick, 2002), but the two go by various names in different theories (see Evans, 2008, for an overview). In a nutshell, one could be said to be fast and intuitive, while the other is slow and deliberate. The intuitive System 1 encompasses the unconscious processes producing the automatic and effortless answer that quickly springs to mind in response to a problem, task or a choice. In contrast, the rational System 2 involves the slow and deliberate thought processes that people consciously engage in for arriving at a logical and considered answer. The case for two relatively independent styles of thinking like these models describe has a convincing empirical research base behind it (see Evans & Stanovich, 2013, for a review)

[1] The introduction section is in part based on contents from a pre-registration document co-authored with Peter Shepherdson (Guðmundsdóttir, et al. 2020), uploaded to the Open Science Framework (https://osf.io/x8sdy/).

Although this general idea of two different thinking styles is similar across different dual-process accounts, the models differ in how the communication of these two styles is depicted. In the *corrective* (Gilbert, 1999) or *default-interventionist* (Evans, 2008) category of dual-process models, the key assumption is that System 1 is the default, but when System 2 is elicited, its conclusions will override those offered by System 1 if they conflict. In other words, System 2 will, once engaged, recognise when its counterpart has produced a false intuitive response and correct it. This, however, is an effortful and taxing process, and due to the limited capacity of human cognition, people are prone to rely heavily on their System 1's responses, even when they are illogical and may bring about undesirable consequences. This account has been advanced by Stanovich (1999; 2004), Evans (2003; 2006) and Kahneman and Frederick (2002; 2005).

A different category of dual process models has been called *parallel-competitive* (Evans, 2008) and here, the assumption is not that the intuitive System 1 is necessarily the "auto-pilot", but rather that the two systems can be engaged simultaneously, the two thinking styles competing and System 2 not always having the last word in the debate (e.g., Epstein et al., 1996; Sloman, 2014).

It is important to note in this context that decisions derived by the processes of System 1 are by no means always in error, although, according to the theory, they sometimes lead to cognitive biases when left unchecked. They can be seen as heuristics, or mental shortcuts, based on accumulated knowledge and experience and are crucial in everyday decision-making when neither the time nor the mental capacity is available for constantly being engaged in rational analysis (Kahneman, 2011). In fact, unconscious and intuition-driven thinking has been argued to be superior in some ways, most notably in the case of expert decision-making (Kahneman & Klein, 2009; Reyna, 2004). Along this line of reasoning, expert judgment can be seen as System 1 in action, with previous deliberate thinking having been converted into intuitive knowledge over time, that can quickly and automatically be retrieved and used for inference.

Moreover, System 2 is in no way infallible either and does not always lead to outcomes superior to those based on reasoning by the automatic, intuition-driven System 1. It seems that deliberate and needless analytical reasoning can sometimes hinder, rather than facilitate, optimal decision-making, as shown in examples of people making decisions that better correspond with expert opinion when deliberation is prevented (Wilson & Schooler, 1991). Furthermore, recent research has provided evidence that logical responses to classic reasoning problems can be fast and intuitive rather than slow and deliberative (De Neys & Pennycook, 2019).

All this being considered, the general consensus within the dual-process framework is nevertheless such that common biases of thinking are a result of System 1's heuristic processes, and that System 2 needs to be engaged to correct them (Evans, 2008; Gilbert, 1999; Kahneman & Frederick, 2005). This does not rule out the possibility that an intuitive response can be the same as the one yielded by rational analysis. Indeed, in such cases, the assumption is that the two systems are in agreement, with no conflict being detected and System 2 not needing to intervene and correct the conclusion of System 1.

Acquiescing to Intuition

Risen (2016; 2017) has argued that, despite its merits, especially in terms of its usefulness in explaining the prevalence of cognitive biases, superstitions and magical thinking, the default-interventionist account fails to explain why people sometimes detect an error in their intuitive judgment but decide to ignore it, a process she calls *acquiescing to intuition,* or simply *acquiescence.* She has pointed out that although the models in their current form explain why people have faulty intuitions, they cannot explain why people often continue acting on these faulty intuitions when they are well aware that they are false, or at least sense that they are not quite right. An example of this is a simple experimental task where people are given a choice between three envelopes, one of which contains a dollar bill (Walco & Risen, 2017). When they have made their choice, they are offered the opportunity to exchange their chosen envelope for the other two, thus doubling the chance of winning. Many people refuse the offer and stick with their initial pick. Another example from everyday life is the often-bizarre behaviour of the stereotypical sports fan, who must sit in their lucky spot on the couch during a match, or the student who has to wear her lucky hoodie to every exam.[2] It is surely a well-recognised fact that people do not always follow their own advice or behave in line with their own good judgment.

In view of this, Risen has proposed a new revised dual-process model that accounts for this phenomenon, allowing for the possibility of better judgment being overshadowed by a strong sense of erring intuition. She suggests that System 1 provides intuitive judgments by default and that if System 2 is elicited, it may or may not intervene and correct them if at

[2] This may or may not apply to one of the authors of this thesis.

fault. Put differently, the refinement of the model involves the decoupling of detecting an error and correcting it. This may sound similar to the parallel-competitive models mentioned above, which also allow for the possibility of System 2 not necessarily gaining the upper hand while the two being simultaneously engaged. Note, however, that these models differ to the one proposed by Risen in the way that they do not assume System 1 to act as the default.

The argument for acquiescence is in part inspired by research showing that often when people respond to a reasoning task in a biased way, they nonetheless exhibit conflict sensitivity, measured in various ways including self-reported confidence, response latency, skin conductance, eye-movements and active brain regions (e.g., Bonner & Newell, 2010; De Neys & Pennycook, 2019; Mevel et al., 2014). Conflict sensitivity refers here to implicitly sensing an error of judgment, without necessarily detecting the source of the error, let alone correcting it.

The Empirical Case for Acquiescence

In a series of experiments, Walco and Risen (2017) provided empirical support for the occurrence of the acquiescence tendency by creating a conflict between an intuitive (System 1) and rational (System 2) response to a task. One of their experiments was based on the *ratio bias paradigm*. The ratio bias has been demonstrated repeatedly (e.g., Bonner & Newell, 2010; Denes-Raj et al., 1994; Koehler & James, 2009) and involves an error of judgment when estimating probabilities involving similar ratios of large versus small numbers. In an example ratio bias experiment, participants choose between two lotteries with a different number of winners but similar probabilities of winning in each. The consistent result is that people have a proclivity to judge ratios of large numbers as higher than objectively higher ratios of small numbers.

Walco and Risen (2017) built upon these results in their research to show that the suboptimal lottery is chosen because it is intuitively appealing, and that awareness of the rational choice, and a potential cost of going against that choice, does not necessarily correct the initial faulty intuition. The result of their experiment was that a considerable proportion of participants who reported that they experienced the conflict between intuition and reason in the first place, decided to follow their intuition, nevertheless. Although the difference between experimental and control conditions did not reach statistical significance, possibly due to insufficiently large sample size, acquiescence was demonstrated in all three of the other experiments they conducted. The rates of acquiescence among participants experiencing a conflict varied between a third to a half, depending on the different biases used, providing compelling support for its existence. Keeping in mind that firstly, there was a possible – albeit modest – monetary gain involved, which previous research has shown to increase the odds of rational analysis being triggered (Epley & Gilovich, 2005; Rozin et al., 2007), and secondly, that the odds of winning were clearly displayed, the tendency seems remarkably resilient. What remains unclear is which factors might influence this process and to what extent.

The Debiasing Issue – Reducing Acquiescence

In this regard, Risen (2016) suggests that by activating thought processes associated with System 2 before participants are subjected to the potential conflict, the tendency to acquiesce could be reduced. In other words, the extent to which System 1 functions as default could be influenced if System 2 is triggered in advance, reducing any pull of an intuitive error of judgment. One might assume that this could be done by offering knowledge of what is correct before the participant has a chance to form an intuitive response. However, as acquiescence essentially requires that the individual acknowledges the rational alternative, but yet decides to opt for the intuitive one, it is reasonable to assume that providing further information on what is rational would not be beneficial, and further, that this tendency cannot be accounted for merely by lack of cognitive ability or education (Risen, 2016).

We believe that this idea could instead be implemented by providing a comprehensive explanation of the systematic bias underlying the intuitive but suboptimal response people are prone to give. Such an intervention is conceptually similar to Ecker et al.'s (2010) approach to reducing the effect of misinformation by providing explicit warnings about its source and continued effects, and it might be useful in counteracting the tendency to acquiesce. Essentially, participants are being made more aware of possible biases in their thinking. Note that when a potential answer to a choice or a dilemma springs to mind quickly, as is the case of intuitive, System 1 thinking, it is less likely to be doubted at all, let alone reevaluated, than if it comes with a delay (Thompson et al., 2011). It is, therefore, reasonable to assume that explicitly warning people of biases and explaining them would have an effect of increased awareness and more second-guessing of one's own thinking and as a result, the strength of System 1's response would be reduced. It follows that the potential benefit of providing information in advance would not be due to more people understanding what is rational, but rather in them being "geared" towards rational thinking and thus less susceptible to the pull of a faulty intuition. If such a priming effect exists, we assume it is not strong enough to eliminate the tendency but might reduce its effect slightly.

Additionally, a different cognitive process might be at work, in which the previously counter-intuitive option becomes intuitive to participants as a result of the explanation, in turn minimising the conflict and increasing the odds of choosing the optimal alternative. Claidière et al. (2017) propose this explanation for their experimental results involving the spread of counter-intuitive beliefs. Their experiments demonstrate how a shift in the understanding of a reasoning problem with a shared intuitive but incorrect answer can happen as a result of argumentation.

Even though the concept of biases in reasoning is well known and rests upon a large assortment of empirical results (Gilovich et al., 2002), less is established about methods to generally reduce their influence. A number of studies on various methods of debiasing yield somewhat promising results that suggest the malleability of people's proneness to the relevant biases (e.g., Aczel et al., 2015; Evans et al., 2004; Morewedge et al., 2015) although results are mixed and the view debated (e.g., Beaulac & Kenyon, 2014; Wilson et al., 2002). The problem seems to lie in the temporary and often poorly transferrable improvements made by such interventions, which hitherto have typically focused on informing people of and teaching them facts about, biases (Fischhoff, 1982; Weinstein & Klein, 2002; Wilson et al., 2002). In the context of dual-process theories, these interventions can be said to be centred around an attempt to trigger more deliberate thinking, or System 2, thus relying on the presupposition that this will correct and override a biased, intuitive response. In other words, they are based on the assumption that being informed of biases serves to reduce their effects and make people engage in more rational thinking when confronted with them. As we outlined above, such interventions might be a futile effort, if System 2 often fails to correct people's false intuitions, even when these deliberate reasoning processes have been successfully elicited. Therefore, approaches that take an effect of acquiescence into consideration might bear more fruit.

The Present Study

In this study, we aimed to replicate and extend the findings of Walco and Risen (2017). Specifically, we planned to conduct a ratio bias experiment based on their Experiment 1. In addition to determining the presence of acquiescence, we aimed to assess whether providing participants with information about the relevant bias, prior to the conflict, reduces the rate of acquiescence. We hypothesised that *participants who are provided with an explanation of the ratio bias in advance will be less likely to acquiesce*, but we expected this effect to be moderate to small.

We were also interested in the relationship between acquiescence and individual differences in intuitive and rational thinking preferences as well as superstitiousness. Here again, we were building on the work of Walco and Risen (2017), who performed an analysis of the relationship between participants' reported intuitiveness and their tendency to acquiesce in the ratio bias experiment. They concluded that self-reported preference for rationality is a significant predictor of choosing the rational option irrespective of condition. We included similar exploratory items to measure these differences, inspired by items of Epstein's (1996) Rational-Experiential Inventory, which was developed to measure individual differences in analytical and intuitive thinking styles. There is some evidence for an increase in the perceived value attached to a decision when it is derived from one's thinking strategy of preference (Higgins et al., 2003). People seem to be more pleased with the choices they make if they "feel right" about how they arrived at their conclusion, and for some, this feeling of rightness is attached to following their affective reactions, while for others it means being more analytical. We suspect that such thinking preferences might be predictive of how prone people are to acquiescing.

On the topic of superstition, which has been associated with the intuitive system, people endorsing intuitive decision-making have been shown to be more likely to hold superstitions than their more rationally inclined counterparts (Epstein et al., 1996; Lindeman & Aarnio, 2007; Svedholm & Lindeman, 2013). As alluded to earlier, superstition has indeed been proposed as a prototypical case of acquiescence in real-world behaviour (Risen, 2016). In addition to this, we asked participants how strongly they perceived the conflict, or a "pull" of their intuition to complement analyses on its relative strength and prevalence. By way of these exploratory analyses, we hoped to gain insight into whether acquiescence and the potential effectiveness of the explanation are dependent on individual differences in intuitive and rational decision-making tendencies.

1. Method[3]

1.1. Participants

Participants were recruited through the online research platform *Prolific Academic* (https://www.prolific.co/) and received £1 for their participation. We restricted the sample to participants with a minimum of 18 years of age, who had English as their native language and were located in one of the majority English-speaking countries. A total of 914 completed the experiment, but due to occasional problems with saving of the data files, 905 were included in the final sample. The mean age was 36 years, and the range was 18-77 years. The sample consisted of 56.6% females (n = 512), 41.2% males (n = 373), 0.7% non-binary (n = 6) and 1,5% who did not provide an answer (n = 14).

The sample size was pre-registered on the basis of simulated datasets. To estimate the odds of obtaining evidence in favour of or against our hypothesis, we conducted the planned analysis on data simulated to include a 10% change in the probability of acquiescence using a binomial model. We then altered the number of participants in each simulation in order to ascertain how many were needed to obtain a reasonable chance of discriminating between simulations with and without the effect. Based on those measures, we predetermined that we would continue collecting data until either reaching a sample size of 100 per group (approximately 400 overall), or obtaining a Bayes Factor (BF) > 3 or < 1/3, implying evidence in favour of a model containing or without the effect of interest, respectively. Upon reaching the 100-per-group criterion, the data revealed a visible trend but ambiguous evidence. Accordingly, we continued data collection until the BF > 3 threshold was met.

1.2. Materials

The online experiment used for data collection was hosted on Pavlovia (https://pavlovia.org/) and accessed on a web browser through the survey platform Prolific Academic (https://www.prolific.co/). The experiment was created using PsychoPy and PsychoJS (Peirce et al., 2019) and was based on the ratio bias task used by Walco and Risen (2017). Items measuring individual differences were based on those used in the study mentioned above, but with changes to the wording and response scale. Participants were also

[3] The method section is in part based on contents from a pre-registration document co-authored with Peter Shepherdson (Guðmundsdóttir, et al. 2020), uploaded to the Open Science Framework (https://osf.io/x8sdy/).

asked to complete two additional items, one asking about how strongly they perceived the intuition/reason conflict, and another for measuring the trait superstitiousness. These questions and statements were all answered on a sliding scale from 0-100 with polarised descriptions, allowing for continuous responses. The wording of these questions, along with the complete instructions and explanations associated with the task, can be found in Appendix A.

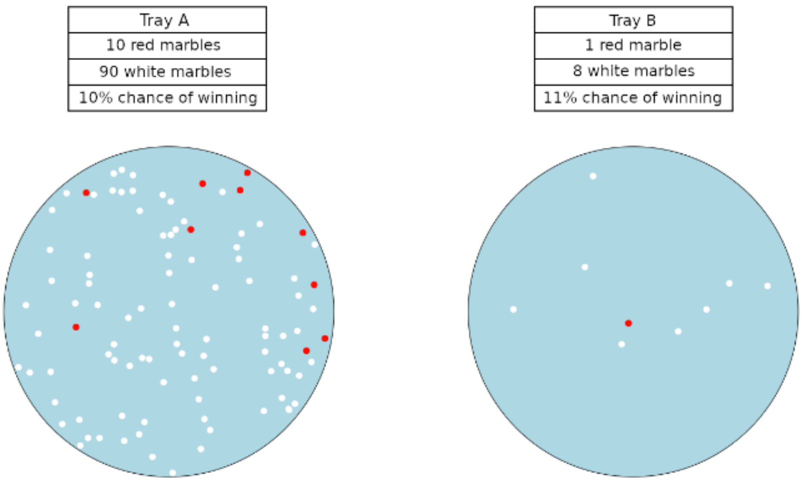
1.3. Procedure

The procedure largely resembled that of Walco and Risen (2017), where the experimental condition was designed to create a conflict between an intuitive and a rational response and the control condition was without such a conflict. In our study, we expanded the experimental design to include four conditions, using a 2 (conflict vs no conflict) x 2 (short vs extended explanation) between-subject design. In all conditions, participants were first presented with an explanation of the common conflict between intuition and reason when making decisions. As explained by Walco and Risen (2017), the purpose of this was to prevent participants feeling uncomfortable and reluctant to answer the questions in a manner that suggests conflict. They were also provided with explanations of the experimental task, an adjusted version of the one used by Walco and Risen (2017). Half of the participants also received a more extended introduction, including an explanation of the ratio bias. Following the instruction screens, all participants were then presented with an image portraying two trays containing red and white marbles in differing ratios depending on condition. The task involved choosing either tray with the aim of maximising the chance of a red marble being randomly drawn from it. The objective probabilities were displayed to participants, together with the number of red and white marbles in each tray. Before making a choice, participants were asked which tray they would pick based only on intuition or based only on rational analysis, and these responses were taken to discriminate those who experienced the intuition-reason conflict from those who did not. The two questions were asked in randomised order. In conflict trials, a different number of marbles was presented in each tray to create the bias: both contained almost equal ratios of winning to non-winning marbles, but the higher ratio was associated with fewer winning marbles in absolute terms (see Figure 1). In the control conditions, the ratios of red to white marbles were the same as in the experimental conditions, but the absolute number of marbles was similar in both trays; thus, there should have been no intuitive pull towards the tray containing a larger number of marbles.

The experimental task was set up as a lottery in which participants had the chance of a monetary reward if a red marble was drawn from their tray of choice. At the start of the experiment, participants were made aware that they had a chance of winning a £1 bonus, to be paid after the experiment had been completed and verified. The awarding of bonuses was incorporated into the Prolific Academic payment system. After participants had completed the lottery task, they were presented with the questions and statements mentioned above. In order to prevent biased responses to these items, the lottery result was given at the very end.

Figure 1

A Screenshot of the display for the experimental task



Note. The figure shows the trays used in the experimental condition. The trays are meant to induce the ratio bias, in which case Tray A would be intuitively judged as having a higher chance of winning. A red marble being drawn from the tray of choice results in a win.

1.4. Data Analysis

All data analysis was conducted in R 3.6.2 (R Core Team, 2019) using the *brms* package for Bayesian regression models (Bürkner, 2017). The Bayesian framework has several advantages over classical hypothesis testing; the most relevant for our purpose is that it provides quantification of the evidence in support or against a hypothesis of interest and can incorporate existing knowledge (Wagenmakers et al., 2018). It thus makes a more precise evaluation possible. In a nutshell, the Bayesian method involves calculations of probabilities, where an earlier belief, referred to as the *prior*, is updated with evidence provided by new data, yielding the *posterior* – an updated, better-informed estimation, on the basis of which statistical inference can be made.

Our analyses involved model comparison as a means of assessing hypotheses, and all models were fitted using the No-U-Turn sampler, which employs the Hamiltonian Monte Carlo algorithm (NUTS; Hoffman & Gelman, 2014). Each model fit was calculated by running four chains with 500,000 samples per chain, out of which the first 250,000 were discarded as the burn-in period. There was evidence of good convergence of the chains for all estimates ($\hat{R} \leq 1.01$; Gelman & Rubin, 1992). To evaluate and compare model likelihoods, we calculated Bayes Factors. This was done using the *bayes_factor* function, which makes use of bridge sampling (Gronau & Singmann, 2020). We report all Bayes Factors such that values >1 indicate evidence in favour of an effect, whereas values <1 indicate evidence against an effect, with greater departures from 1 in either direction implying stronger evidence.

1.4.1. Interaction Effect

To test our hypothesis that explaining the ratio bias reduces acquiescence, we conducted Bayesian logistic regression analysis. As per the analysis methods used by Walco and Risen (2017), we excluded the data from those participants who failed to identify the rational response and assessed whether the different conditions affected the probability of selecting the sub-optimal tray in the lottery. More specifically, our binary outcome variable (choice of rational or intuitive option, coded as 1 and 0 respectively) was predicted by the two categorical dependent variables of explanation (short vs extended) and condition (experimental vs control; i.e., conflict vs no conflict). The priors of the models were moderately informative and based on the results of a pilot study conducted with first-year undergraduates at the University of Akureyri:

Intercept $\underline{\mu}$: $\mathcal{N}(0, 1)$

Main effect of explanation $\underline{\mu}$: $\mathcal{N}(0, 0.2)$

Main effect of condition $\underline{\mu}$: $\mathcal{N}(0, 0.2)$

Interaction $\underline{\mu}$: $\mathcal{N}(0, 0.2)$

Here, $\mathcal{N}(x, y)$ indicates a normal distribution with mean = x and standard deviation = y. We used a logit link function to transform priors into the [0, 1] probability space. We compared model likelihoods for a model including the main effects of condition and explanation, together with an interaction effect, against a model with only the two main effects. Where relevant, the priors were identical for both models.

1.4.2. Effect of Condition

To assess the evidence of acquiescence by participants receiving the short explanation (i.e., equivalent to the conditions participants experienced in the study undertaken by Walco and Risen, 2017), we undertook a logistic regression on the data from participants in this group who also correctly identified the rational option. Again, this analysis involved the prediction of a binary outcome variable (choice of rational or intuitive option), this time on the basis of a single binary predictor variable (condition: experimental vs control). The priors for the intercept and effect in this regression were identical to those outlined above, and we compared this model to an intercept-only variant.

In both analyses, a slightly wider set of priors with a standard deviation of 0.3 were also used to fit the models. This was done in light of a higher than expected baseline of rational responding, which had the effect of narrowing our transformed effect priors relative to those we had used in our initial simulations. We also conducted a classical chi-square test, in order to replicate the main analysis conducted by Walco and Risen (2017) to assess the presence of acquiescence.

1.4.3. Supplementary Analyses

Simply looking at different rates of acquiescence as measured by the probability of choosing the suboptimal tray, given that one has identified it as suboptimal, could be misleading. Our manipulation may have affected either the proportion of participants who recognised which choice was more optimal or the proportion of those who experienced an intuitive pull towards the suboptimal choice. Either possible source of a change in the probability of experiencing the conflict – and thus the possibility for acquiescence – across conditions, could threaten the validity of the measure (e.g., by making the participants included in the key analysis a more selective group in one condition than another). In an effort to clarify this, we conducted supplementary analyses on the data.

We used logistic regression with the rates of identifying the rational choice and the rate of identifying the intuitive choice as outcome variables in independent analyses. We compared different models including all possible combinations of the main-, and interaction effects of explanation and condition for each of the outcome variables. Bayes Factors were calculated for each model fitted against the respective intercept only variant. To obtain the strength of the evidence for (or against) simple effects, we compared models including and excluding the effect of interest each time. We were mainly interested in the effect of explanation, but in order to assess the extent to which the condition manipulation was also contributing to the variation, and how that compared to any effect of explanation, we adapted our preregistration plan to allow for this comparison.

As in the previous analyses, the priors for the models were informed by pilot data. They were assigned a normal distribution and parameter values averaged between the pilot data posteriors and less informative priors with a mean of 0 and a standard deviation of 0.5 (see Appendix B for a complete list of the priors used).

To shed light on possible differences in experiencing the conflict for participants included in the acquiescence analyses (i.e., those who identified the rational option), we reran the best performing model from the previous analysis with only the data from these participants. The same method of specifying priors was used, using the posterior from the respective pilot analysis.

To complement the analysis of differences in experiencing the conflict, we made use of the responses to the first slider item aimed at measuring the perceived strength of the faulty intuition. We conducted a zero-one-inflated-beta (ZOIB) regression using the slider response as an outcome variable, predicted by explanation, condition and its interaction effects. To accomplish this, we used the *zero_one_inflated_beta* family in *brms*. The ZOIB method combines beta and binomial distributions and is thus useful when working with slider response data as dependent variables (Liu & Eugenio, 2016). In such data, a significant proportion of responses tend to cluster at the extremes, thus violating the assumption of normality. For this analysis, we used the uninformative default priors provided by the package (see Appendix B for further details).

1.4.4. Exploratory Analyses

Finally, we undertook exploratory analyses using the answers to the slider items included in the study. We performed a logistic regression analysis with those items as predictors of acquiescence rates, and as in our main analyses, we identified acquiescence by excluding those who failed to identify the rational response. As we had no existing data relevant to the relationships between these variables and our outcome of interest, we also made use of the package default priors [*Student's t* (0, 10)] for this analysis. Additionally, we combined the responses from the three intuition/reason items and used this new measure as a predictor variable. The scores for this variable were calculated by reverse scoring one of the items, adding all three together, and dividing the sum by three to obtain a range from 0-100 [x = (y+z+(100-v))/3]. A higher score on this item indicates a stronger perceived tendency to make decisions based on reason, and a lower score indicates a stronger perceived tendency to make decisions based on intuition. The main effects of condition and explanation, along with the interaction terms, were also included as predictors in a separate analysis. This is in part analogous to an analysis employed by Walco and Risen (2017; see their supplementary material for details). Lastly, we did the same using the binary item for feeling the intuition as an outcome variable to estimate variation in experiencing the conflict. Here, we also specified uninformative, default priors.

2. Results

2.1. Replication Results

We analysed the simple main effect of condition, focusing only on the two groups receiving the original instructions used by Walco and Risen (2017), in order to quantify the baseline strength of the acquiescence tendency. As outlined previously, acquiescence was defined as choosing the intuitive – albeit sub-optimal – alternative for the lottery, despite having earlier identified which of the two trays would give a better chance of winning. To measure this, the data from participants who failed to meet the criterion of identifying the rational option were excluded from the analysis (n = 109; 12.04%). Baseline rational responding for the lottery across groups amongst the remainder of the sample was 91.33% (n = 727/796).

The data provided clear support for an effect of acquiescence in response to the bias. Acquiescence was observed for 16.96% (n = 29/171) of participants in the experimental group, whereas the rate of choosing the suboptimal alternative in the bias-free trials of the control group was 8.20% (n = 16/178). The mean difference was statistically significant as measured by a chi-square test ($\chi^2(1) = 4.93$; $p = 0.03$). The results of the Bayesian model comparison also confirmed the effect, although providing weak evidence (BF = 2.08), with the model including the effect being twice as probable given our data than the model without.

The apparent weakness of the evidence could, to some extent, be a result of the high baseline rate of rational responding. Because the logit link function is a non-linear transformation, the effect priors we specified ended up being narrower in probability space than we had anticipated, thus skewing the results and likely resulting in an underestimation of the true effects. Assigning the priors a slightly larger standard deviation to account for this yielded a larger Bayes Factor in support of the model (BF = 3.2). These results confirm the effect observed in the original study, providing further evidence for the presence of acquiescence in the ratio bias paradigm.

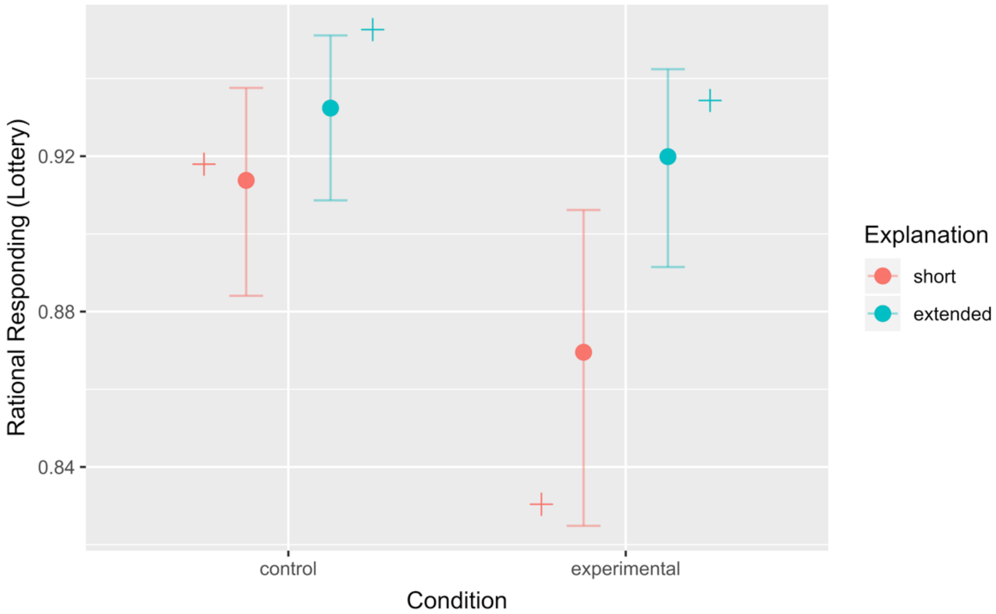
2.2. Effect of Explanation

Providing a clear explanation of the bias had an effect on how likely participants were to give in to the faulty intuition. Acquiescence was reduced from 16.96% (n = 29/171) in the experimental condition with a short explanation (experimental/short) to 6.56% (n = 13/198) in the group that got the extended explanation (experimental/extended). Focusing only on those who experienced the conflict in the first place as measured by our two binary items (i.e. wanted to choose the suboptimal tray based on gut feeling but also identified that it was suboptimal), 36.49% (n = 27/74) acquiesced having received the short explanation but 14.47% (n = 11/76) with the extended one. Thus, in our sample, there was a 22.27% shift in acquiescence upon receiving the extended explanation. The decrease upon receiving the extended explanation from the benchmark set by the respective control groups was considerably larger in the experimental group (8.76% vs 1.82% in the experimental and control groups, respectively). The effect of providing the explanation is thus dependent on condition. The Bayesian model comparison confirmed this interaction effect, yielding moderate evidence in favour of a model that included the interaction term compared to a model with only the two main effects of condition and explanation. The resulting Bayes Factor was 3.31. In other words, given our data, the interaction model is roughly three times more probable than the alternative model.

Figure 2 shows the posterior mean probability estimates of rational responding in each group compared to the mean estimates in the data. As seen in this figure, the posterior estimates of the Bayesian regression are moderately influenced by the priors, restricting the size of the effects. When specifying wider priors, the parameter estimates increased in size while the superiority of the interaction model was reduced slightly (BF = 3.01 vs the model with main effects only). Thus, the true effects are likely larger than the results of the Bayesian estimation indicates. The tabulated regression coefficients and associated statistics of the posterior distributions are presented in Appendix C. In sum, these results support our hypothesis: An extended explanation produces a lower rate of acquiescence.

Figure 2

Rational responding in each experimental condition



Note. The graph illustrates the resulting parameter estimates of the Bayesian analysis using priors informed by pilot data. The mean values in our data are represented as [+]. Error bars reflect 95% credible intervals.

2.3. Supplementary Analyses

2.3.1. Did the groups differ in terms of identifying the rational option?

When estimating variation in identifying the rational option across groups, we found a considerable difference. Somewhat surprisingly, the rates varied considerably across all groups, despite the needed information being in all cases presented in the same way (odds and percentages displayed). This demonstrates an effect of both condition and explanation, suggesting that some aspect of our manipulations increased participants' attention to the information presented. As shown in panel A of Figure 3, both control groups were more likely to identify the rational alternative than the experimental groups. The magnitude of this effect is larger than predicted based on the outcome of the original experiment conducted by Walco and Risen (2017). There was also a considerable difference between the groups receiving short and extended explanations within the experimental condition (mean difference = 11.42%), with the experimental/short group having the lowest mean estimate of all groups.

The model comparison gave strong support for interaction effects. The model that included only intercept and interaction effects provided the best account of the data (BF = 9.98e+12, relative to the intercept-only model). Thus, there is clear evidence of an effect of explanation, dependent on condition, on the probability of recognising which tray has the optimal odds: An extended explanation helps in this regard, but only when the probability is not too high in the first place.

2.3.2. Did the groups differ in experiencing the faulty intuition?

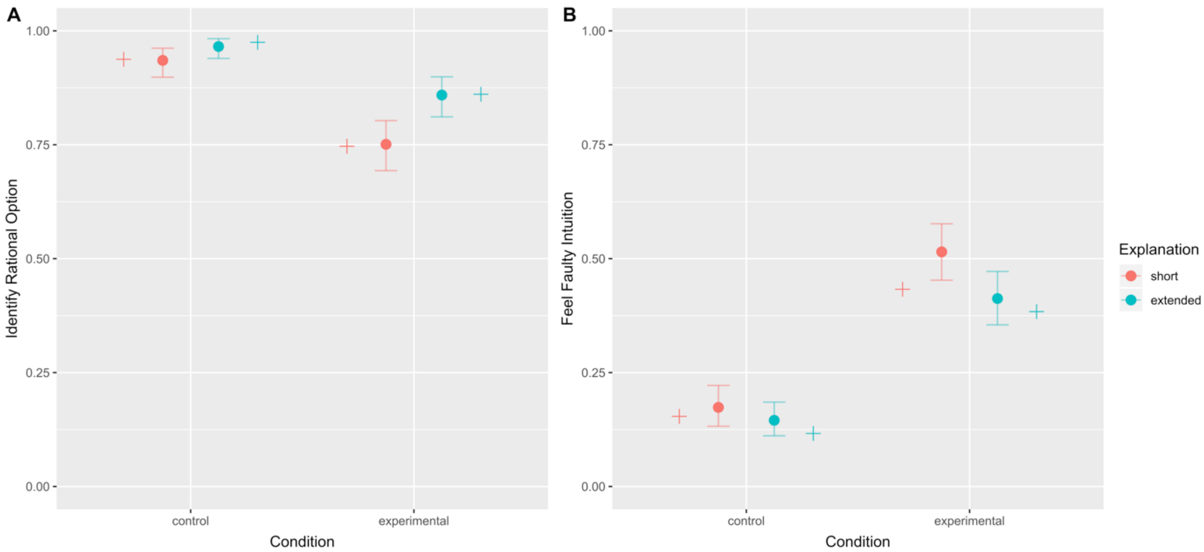
Our manipulation also seems to have affected the intuitive pull to the suboptimal tray, as the groups experienced it to a markedly different degree. This is illustrated in panel B of Figure 3. As expected, those in the experimental groups were substantially more likely to report that the suboptimal choice appealed to their "gut". Roughly half of those in the experimental/short condition felt the faulty intuition and noticeably fewer in the experimental/extended group (mean difference = 9.36%). This indicates that the explanation affects the probability of experiencing the faulty intuition.

The results of the Bayesian analysis provided evidence for main effects of condition and explanation as well as for an interaction effect. The model that best accounted for the data was the one containing these three effects (BF = 7.08e+24, relative to the intercept-only model). Deriving evidence in favour of the main effects individually, by dividing the Bayes Factors by those of the respective models excluding these effects, we got strong evidence for an effect of condition (BF = 16.38), and weak evidence for an effect of explanation (BF = 1.15).

When looking at the data from only those participants who identified the rational option (i.e., those included in the acquiescence analysis), the difference between the two groups in the probability of experiencing the incorrect intuition was smaller, or 4.89%. The results of the model comparison were in line with this. Deriving evidence for the effect of explanation specifically, dividing the odds by a model with the effect removed, yielded ambiguous evidence against an effect (BF = 0.86). Despite the small size of the effect and ambiguous evidence, this could be a notable result. If present, the effect could partly explain the variation in rational responding to the lottery, indicating a small difference between the two groups receiving short and long explanations in the conflict experienced between intuition and reason.

Figure 3

Probability of identifying the rational option and feeling the intuition across groups



Note. Graph A illustrates how extended explanations are associated with a higher probability of identifying the rational option. Graph B illustrates how extended explanation is associated with a lower probability of feeling the faulty intuition. Error bars reflect 95% credible intervals. Mean values observed in our sample are displayed as [+].

However, it should be noted that such a reduction in the proportion of participants feeling the faulty intuition can only account for a minimal component of the overall change in rational responding. To illustrate this point, a change of 4.89% in feeling the intuitive pull across the groups, multiplied by a 23.51% difference in suboptimal responding between those who felt the pull compared to those who did not (25.33% vs 1.82%, respectively), yields only 1.15%, all else being equal. In other words, roughly 1% of the 10.40% change in suboptimal responding is likely explained by a reduction in feeling the faulty intuition. Consequently, the small difference in how many experienced the conflict seems to contribute minimally to the observed change in suboptimal responding. Stated differently, the observed change represents mainly a shift in the probability of acquiescence; an increased resistance to, rather than elimination of, the faulty intuition.

In an effort to further clarify this, we made use of the responses to the slider item for measuring the perceived conflict. Together, the estimates for the beta and binomial distributions hint at a negligible difference between the two experimental groups receiving different explanations. The mean values in the beta distribution excluding the extreme responses are roughly identical (mean difference = 0.02), and a similarly high proportion of responses are clustered at the extremes, as seen in the binomial distribution. Out of those responses, between 0.5%-0.9% were at the higher end of the scale (i.e. 100), for the short and extended conditions respectively. This further undermines the assumption that the explanation significantly affects how many participants experience the conflict. The pattern of responses was roughly the same whether all participants were included or only those who identified the rational option. There seems to be a difference, therefore, in how participants generally respond to the binary questions and how they reported the perceived strength of the conflict as measured by the slider item. If answers above 10 on the scale (ranging from 0 to 100) are taken to indicate that the participant felt the conflict to a certain degree, then the vast majority (or 82%) feels the conflict according to the slider measure, while only a third does when considering the responses to the binary questions.

2.4. Exploratory Analyses

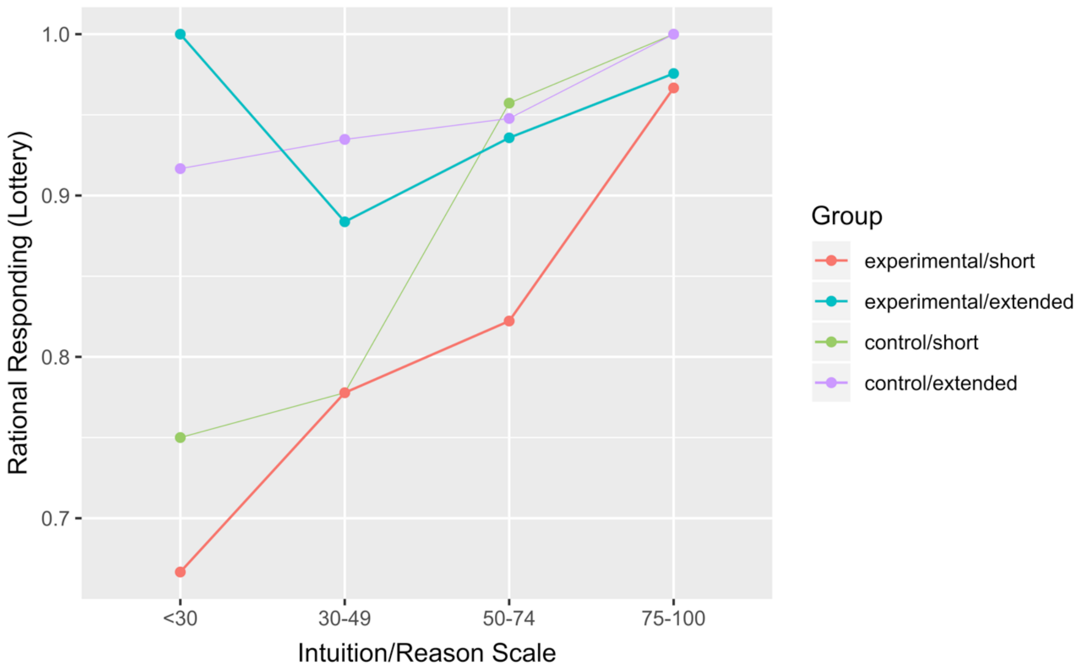
The results of the exploratory analyses suggest a moderately strong relationship between self-reported individual differences in intuitive versus rational decision-making tendencies and acquiescence. When involving all slider items as predictors, the strongest effects were observed for the perceived strength of the conflict [*How strongly did you experience an inner conflict when making the choice (a "pull" towards following your intuition)?*] and the judged importance of using reason when making decisions (*It is important to me to use reason when making choices*). Regarding the *conflict* item, the odds of opting for the rational choice decreased with stronger reported conflict (b=-0.03, 95% CrI [-0.04, -0.02]). For the *reason* item, the odds increased (b=0.03, 95% CrI [0.01, 0.04]), showing that when reason is regarded as more important, participants also respond more rationally. Interestingly, the results indicated a small effect of reported superstitiousness, in which higher scores were associated with more rational responding (b=0.01, 95% CrI [0.00, 0.02]), contrary to expectations. In other words, those who reported being highly superstitious were marginally less likely to acquiesce.

There was a larger effect when combining the three *intuition/reason* items to predict rational responding (b=0.04, 95% CrI [0.02, 0.07]). When including the main effects of condition and explanation, together with the respective interaction terms, we found small size interaction effects of both condition (b=-0.02, 95% CrI [-0.5, 0.2]; experimental relative to control) and explanation (b=0.02, 95% CrI [-0.2, 0.5]; short relative to extended).

Group differences between short and extended explanations were negligible for those participants whose scores fell on the upper half of the scale (indicating more rationality). However, when participants scored on the lower half of the scale (indicating less rationality), a small difference was found, marked by reduced rational responding in the experimental/short group. The data trends are demonstrated in Figure 4.

Figure 4

Relation between rational responding and scores on the intuition/reason scale



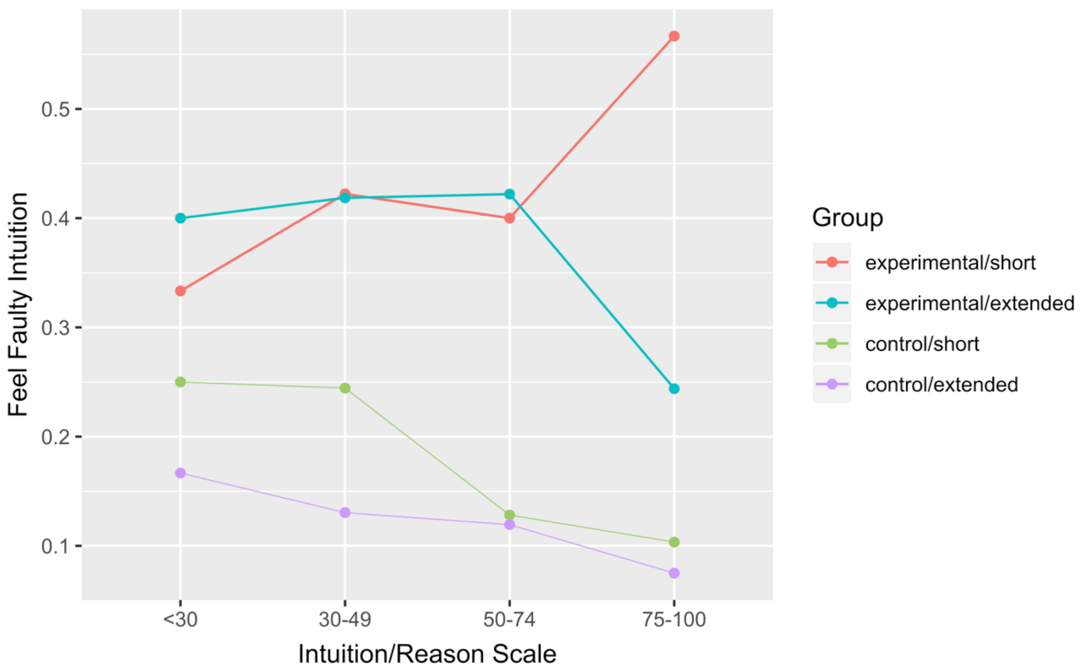
Note. The graph illustrates how those scoring low on the *intuition/reason* measure (indicating less reported weight on reason in decision-making) are more prone to acquiescence. Points represent mean values for binned responses (bin intervals are roughly determined by the number of responses).

If the faulty intuition is reduced in response to the explanation, as our earlier analyses suggest, one might infer that more rationally inclined people would be less likely to feel it in the first place, explaining why they generally respond more rationally. On the contrary, however, those scoring high on the *intuition/reason* scale seem about equally likely to experience it (b=0.01, 95% CrI [-0.01,0.03]). This indicates that those who score high are not doing so simply because they feel it to a lesser degree, but rather that they are more likely to resist it.

This explanation is further supported by a somewhat higher probability of experiencing the conflict in the experimental/short group among those scoring at the top of the *intuition/reason* scale, as illustrated in Figure 5. It is worth noting that the opposite is the case in the experimental/extended group. These participants seem to be less likely to feel the faulty intuition, demonstrating that the effect of our manipulation differs in this respect, depending on how high participants score on the *intuition/reason* measure. The difference observed is, in other words, only present at the top of this scale.

Figure 5

Relation between feeling the faulty intuition and scores on the intuition/reason scale



Note. The graph shows how the two experimental groups follow a similar trend, except for those scoring highest on the *intuition/reason* scale. Points represent mean values for binned responses (bin intervals are roughly determined by the number of responses).

Thus, it seems that our explanation affected (1) the rational responding of those scoring lower on the measure, and (2) the likelihood of the faulty intuition being perceived by those scoring higher on the measure. Considering this together, it seems that the observed difference in feeling the faulty intuition did not play a part in the reduced acquiescence rate across the experimental groups. Responses to the slider item measuring perceived strength of the conflict, rather than the binary questions, further support this interpretation. As previously explained, the responses on this item did not differ between the two experimental groups, suggesting that they felt the conflict to the same extent, irrespective of the type of explanation they received.

In sum, we found that providing the extended explanation only seemed to affect the responses to the lottery of those who scored low on the *intuition/reason* measure. Participants who reported reason being more important when making decisions almost exclusively opted for the rational alternative, regardless of which version of the explanations was provided. Furthermore, the high rate of rational responding by these participants is seemingly not due to feeling the faulty intuition to a lesser extent.

3. Discussion

Our study had two key aims. First, we planned to replicate the ratio bias experiment reported by Walco and Risen (2017). Our results indicate a very similar pattern of responding and confirm that the acquiescence tendency can be observed in this paradigm. Secondly, we wanted to study how malleable this tendency is and whether providing people with an explanation of why they might give in to it would reduce its influence. The results of our experiment show that this seems to be beneficial, at least in relation to the ratio bias. We hypothesised that upon receiving a clear and concise explanation, acquiescence would be reduced. We obtained moderate evidence in support of this hypothesis: Participants who received the explanation showed a modest difference in responding to the lottery task in comparison to those who did not receive the explanation, with a lower probability of opting for the tempting – but suboptimal – tray. Considering only those who experienced the conflict, the shift in acquiescence was considerable, or roughly 22%. Thus, although the explanation influenced acquiescence in a relatively weak bias, it did so quite comprehensively.

Group difference analyses regarding experiencing the bias and identifying the rational option showed that these effects markedly varied. In short, they revealed three different sources of influence explaining the effect of an extended explanation. Taken together, providing the explanation seems to affect the extent to which participants (1) identify the rational option; (2) experience the intuitive pull to the suboptimal tray; and (3) resist that pull, given that they experience the conflict between reason and intuition in the first place.

It was surprising that the explanation influenced how likely participants were to recognise which tray contained the better odds and, likewise, that this effect differed substantially between the control and experimental conditions. We speculate that this might have occurred because in the control condition – in which the trays look more similar – participants may have relied more on the evidence as displayed by the numbers, whereas in the experimental condition, the influence of the bias may have come in the way of such information seeking. This hypothesis could be evaluated in future research by incorporating eye-tracking measures into the experimental design.

As anticipated, the extended explanation seems to have a priming effect that reduces the instinctive appeal of the suboptimal alternative and temporarily makes the rational option intuitive. This, however, gives rise to inequivalence across conditions in the possibility of acquiescence, in that the prerequisite of experiencing the conflict is not fulfilled for as many participants. This, in turn, makes an inference about change in acquiescence more difficult. It is clear, however, that this apparent difference in experiencing the faulty intuition can only account for a small percentage of the variation in responding to the lottery. For the subset of the sample identifying the rational option, the difference in feeling the faulty intuition was minimal across groups, and not supported by our analysis. This implies that there is an effect on acquiescence and not merely a change in perceiving the conflict.

Consistent with this suggestion, when given the opportunity to report the perceived strength of the conflict, participants' responses do not seem to differ based on which type of explanation was received. Conversely, when considering the sample as a whole, the general patterns of responses to this measure and the binary questions are incompatible. When provided with the chance to give a precise estimate of how strongly they felt the false intuition, participants were more likely to report having experienced it than their answers to the binary questions suggested, irrespective of which explanation they received.

One possible explanation for this is that people might be reluctant to acknowledge the faulty intuition immediately after having read an extensive explanation of the imminent cognitive bias when only given a binary choice, but in retrospect, they admit to having experienced the conflict to some extent. The wording of the item is also important, as it implies that the conflict was indeed experienced. Another explanation for the discrepancy is that participants might be "geared" towards making a choice for the lottery and therefore more influenced by the possibility of a monetary gain, which, in turn, serves to trigger more numerical reasoning, as previous evidence has shown. This might, in turn, involve temporarily combining their intuitive feeling and rational analysis into one, the two then being separated again when later primed to reflect on the experienced conflict. As such, the binary items and the slider item might be measuring something distinct, essentially priming participants in different ways. Further speculations on this point are beyond the scope of this text, but it would be interesting to analyse the underlying thought processes in more detail. We expect this could be accomplished by analysing response latencies to the binary questions using a sequential sampling model (see, e.g., Diederich & Trueblood, 2018, for an application of such models in investigating dual-process theories).

Taken together, our analyses suggest that when provided with the extended explanation, people are more likely to resist their faulty intuition, or put differently, are less likely to acquiesce. Our results thus suggest that acquiescence can be influenced to some extent by explaining the underlying bias. Moreover, upon being made aware of the bias, participants are more likely to report the rational option as being the one their intuition favours. Turning back to our initial speculations about the underlying processes differentiating the responses of those who receive the explanation and those who do not, there seems to be some support for both a priming effect of some sort, as well as an effect in which the rational alternative becomes temporarily intuitive. Presumably, neither of these reasons can alone explain the effect fully.

3.1. Theoretical Implications

Considering our results in the context of dual-process theories, together with those of Walco and Risen's (2017), and earlier research on conflict sensitivity, we suggest that these models be revised to allow for a conflict between System 1 and System 2 to result in System 2 giving in, rather than correcting, the sometimes faulty intuitions of the former. As Risen matter-of-factly puts it: "in addition to being lazy and inattentive, System 2 is sometimes a bit of a pushover" (Risen, 2016, p. 32). This observation does not fit well into the framework of dual-process models in the current form.

We suspect that the acquiescence tendency might be one culprit explaining the apparently limited success of previous debiasing efforts, especially in terms of durability and transfer across situations and different biases. The results of our debiasing manipulation indicate that the acquiescence tendency can effectively be influenced, seemingly both by increasing the resistance to the power of intuition, or System 1, and by making the rational response more intuitive, at least temporarily. We, therefore, conclude that attempts at controlling acquiescence are an important addition to the debiasing research and its practical implementations, potentially an imperative part of future interventions of reducing the effects of cognitive biases. So far, the possibility of going against one's better judgment has not been the focal point of debiasing efforts, although their success might be partly attributed to incidentally reducing that tendency, often through similar means as employed in our study. Through increased understanding of this tendency and how it can effectively be manipulated and influenced with lasting results, future interventions could be refined to better improve intuition resistance. Evidently, it is not enough to understand the problem and know the optimal solution to it; one must also understand the factors preventing the optimal solution from being applied. Debiasing interventions should revolve around increasing general alertness regarding the fallibility of intuition, and supporting the intent to correct it, in addition to aiding an understanding of the biases themselves.

Another possible avenue for future interventions could be to focus on making the "correct" or logical response to biases intuitive, which indubitably must involve many trials across different situations. After all, expert knowledge only becomes intuitive with many years, and in the same vein, cognitive biases will be resistant to interventions as long as one's intuition is still strongly attracted to erroneous beliefs and suboptimal choices. We also conclude that by measuring acquiescence, using the criteria provided by Risen (2016; 2017), offers great opportunities for gaining fresh insights into what goes on "behind the scenes" when debiasing strategies such as explanations are implemented.

It should be pointed out that although the extended explanation decreased acquiescence rates to some considerable extent, it did not eliminate it completely. Evidently, there are still a number of people who for some reason, be it an unusually strong sense of intuition or just pure stubbornness, rebel against reason. In spite of having read a clear explanation of why they might be tempted to opt for the "incorrect" choice; been presented with a clear display of the odds and percentage chances of winning in each tray; having acknowledged which of them should be picked based on these odds; and knowing that their decision would in all probability reduce their chances of a monetary gain, they yet decide to go against the odds and pick the statistically inferior but intuitively attractive tray. In short, the results can, no less importantly, be taken to provide further evidence for the relative strength and resistance of the acquiescence tendency.

3.2. Individual Differences

Having confirmed the effect of acquiescence and that it can be reduced by providing an explanation of the underlying cognitive bias, as well as showing that this is a process behind which numerous mechanisms might be at play, we wanted to explore whether individual differences were important predictors of the tendency and if the explanation were more effective for some than others. To this aim, we measured general differences in people's intuition and rational decision-making tendencies as well as perceived superstitiousness, using general and neutrally worded statements. These were meant to give a rough idea of possible patterns and explore the possibility of a relationship between these variables. Our results provide support for small individual differences in rational responding, indicating that people who regard themselves as generally rational in their decision-making, indeed respond rationally more often than not, whilst those who report putting more weight on their intuition are more likely to acquiesce. This is in line with the results of a similar analysis conducted by Walco and Risen (2017; see their supplementary materials).

Interestingly, we found that participants who received the extended explanation were almost equally likely to respond rationally to the lottery, independent of how intuitive or rationally minded they reported being. This suggests that our experimental manipulation alters the decision-making of those who situate themselves on the intuitive side of the spectrum, whereas those presumably more rational are not affected by the explanation, as they already respond rationally regardless. One could predict that this is so because those reportedly rational individuals simply do not experience the conflict, or in other words, do not feel the intuitive pull to the suboptimal tray. Our data suggest that this is not the case. On the contrary, there seems to be little difference in this regard between those who fall high and low on the spectrum. Consequently, the more rationally inclined, as measured by our self-report items, seem to be more effective at resisting acquiescence.

In accordance with the existing literature, we assumed that superstition would be linked to intuitive decision-making tendencies and a higher likelihood to acquiesce based on previous research linking superstition and intuition. Acquiescence has indeed been proposed as one explanation for people – intuitively and rationally inclined alike – holding magical beliefs and engaging in various sorts of superstitious behaviours (Risen, 2016). Our results were inconclusive, which we suspect is due to the general wording of the item we used, as well as social desirability bias. Each individual has presumably their own definition of what superstition is, but it might often be something along the lines of "all odd rules and rituals that other people follow, and I do not", or in other words, people might often not recognise their own superstitious behaviour as such. For this reason, as well as due to cultural differences, measuring superstitiousness is especially tricky, and although such inventories have been constructed (e.g., Huque & Chowdhury, 2007; Tobacyk, 2004), their conceptual and psychometric properties have been questioned (Irwin, 2007). The possible link between acquiescence and superstition deserves attention, and it would be a worthy endeavour to develop ways to adequately study the link between the two.

3.1. Practical Implications

Even people who are considered to be quite rational in their thinking are sometimes misled by their intuition and engage in superstitious behaviours. This is most often harmless, but naturally, there are numerous instances in which going against rational analysis in decision making has negative consequences of importance. Therefore, reducing this tendency is of considerable practical value. The current study provides some preliminary evidence that this tendency can be influenced by making people aware of their susceptibility to faulty intuition and by explaining the bias that triggers this faulty intuition. The reduction, in this case, is presumably limited to the bias in question and perhaps only temporary. It has indeed been shown that interventions to combat common cognitive biases are only helpful to a limited degree. However, there is certainly good reason to hope that the effectiveness of such interventions would be greater if they were designed to specifically counteract acquiescence. The end goal would, of course, not be to make people immune to biases of thinking. Rather, it would be to elicit general awareness of one's own susceptibility to faulty intuition, contribute to more consciously driven decision-making and build resistance to the prevailing influence of erroneous beliefs.

3.2. Limitations and Future Research Directions

There are a number of limitations to our study worth noting. First, it relies on one particular type of bias, and its results might therefore not be applicable for other types of biases. The ratio bias is a common one that has been well researched and is easy to implement. However, it might not be the most aptly suited for capturing acquiescence. In the series of experiments conducted by Walco and Risen (2017) it was, in fact, the other types of biases that yielded stronger effects. It follows that replicating our manipulation using different ways of inducing acquiescence, for example those employed in said study, would be worth pursuing.

Our experimental design was restricted in the way that we were unable to control for the potential effect of our manipulation on either the proportion of participants who recognised which choice was more optimal or the proportion of those who experienced an intuitive pull towards the suboptimal choice. Our supplementary analyses, involving delving into these possibilities, was an attempt to remedy this and offer a more holistic interpretation of the results.

In terms of providing an understanding of the underlying cognitive processes, our study also comes up short. We can infer that some participants might be primed to engage their System 2, or rational analysis, others might fail to feel the conflict when they otherwise would have, and for some, both of these processes might play a part. We are, however, unable to conclude anything concrete in this respect. Exploring these underlying processes and differentiating them would be an interesting avenue for further study.

Lastly, when it comes to asserting individual differences, the validity of our measures is questionable. As our analyses were exploratory in nature, we used few and simple items in an attempt to identify possible patterns. In order to determine whether these patterns are generalisable and gauge how large or small the effects are, the use of more precise and reliable scales would be advisable (e.g., Epstein, 1996; Betsch, 2004). Further research could also put more weight on how the preferences for either thinking style and the different value put on decisions based on these preferences relates to the probability of acquiescence. It should be noted that our approach of combining the intuition/reason items into a single measure essentially assumes that intuition and reason are opposing poles on a single dimension, which is arguably an oversimplification. When employing similar methods, it would be advisable to explore whether the two can be understood as one factor or if they are relatively independent constructs.

3.3. Conclusion

In spite of its limitations, our study supports the previous finding that a certain proportion of people have a tendency to follow their intuition, despite being aware of their decision being logically inferior; and provides preliminary evidence that this tendency can to some extent be reduced by explaining the reason behind their biased thinking. Moreover, our results indicate that there are individual differences in this tendency, related to general inclinations towards intuitive or rational decision making. Providing relevant explanations seems to not only affect the rate of acquiescence but also influence how much attention people pay to the information provided, as well as their proneness to the bias itself. In our study, participants were more likely to identify which choice was optimal, and less likely to be intuitively drawn to the choice that was suboptimal, when having read the explanation of the bias. To better gauge what cognitive processes lie behind suboptimal decision-making, incorporating measures of acquiescence might be a key element. It stands to reason that efforts intended to counteract the effects of cognitive biases should, therefore, focus on not only activating analytical thought processes but also on possible ways to make people more resistant to their erring intuition when in conflict with their rationally derived conclusion, or to circumvent the conflict with intuition altogether. We conclude that increasing general awareness of how one's intuition can be fallacious and worth second-guessing, perhaps combined with making the rational choice in question more intuitively appealing, would be advantageous to this aim.

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Appendix A

List of task associated text and question items

Table 1

Introductory text and task instructions across groups

Short explanation groups	Extended explanation groups
Some decisions are made mainly on the basis of "intuition," or by consulting the "gut." Other decisions are made mainly on the basis of "reason," or through rational analysis. Sometimes your intuition and rational analysis might tell you the same thing, but sometimes they might disagree.[a] In this experiment, we are investigating how people use reason and intuition in making decisions. You will be shown two trays, each of which contains a mixture of red and white "marbles". You will get to make a choice between these two trays. Once you have made your choice, the computer will randomly select one marble from the tray. If the marble selected is red, you will receive a £1 bonus on top of your regular payment. If it is white, you will receive no bonus. You will also see information specific to each tray. You will be informed of the number of red and white marbles in each tray, as well as the percent chance that a red marble will be selected. Before making your choice, you will be asked questions about which trays your "gut" and "reason" suggest you should pick. Please look carefully at both trays and consider what it will be like to draw a marble from each of the trays.	Some decisions are made mainly on the basis of "intuition," or by consulting the "gut." Other decisions are made mainly on the basis of "reason," or through rational analysis. Sometimes your intuition and rational analysis might tell you the same thing, but sometimes they might disagree.[a] When this happens, we sometimes make unwise choices. This is especially evident when we try to judge probabilities and odds. Take for example the following two sets of odds. a) 9 out of 100 b) 1 out of 10 Research suggest we often judge the odds in a) as being better because it contains higher numbers. In doing so, we ignore the ratio and only focus on the numbers. Clearly, 9 is a larger number than 1, but people often fail to notice that 9 out of 100 (9%) is actually worse odds than 1 out of 10 (10%). When we are intuitively drawn to odds with higher numbers, while ignoring the odds themselves, we can misjudge probabilities and make worse choices as a result. In this experiment, we are investigating how susceptible people are to this bias. You will be shown two trays, each of which contains a mixture of red and white "marbles". You will get to make a choice between these two trays. Once you have made your choice, the computer will randomly select one marble from the tray. If the marble selected is red, you will receive a £1 bonus on top of your regular payment. If it is white, you will receive no bonus. You will also see information specific to each tray. You will be informed of the number of red and white marbles in each tray, as well as the percent chance that a red marble will be selected. Before making your choice, you will be asked questions about which trays your "gut" and "reason" suggest you should pick. Please look carefully at both trays and consider what it will be like to draw a marble from each of the trays.

[a] First paragraph identical to the one used by Walco and Risen (2017)

Table 2

Task associated questions and exploratory survey items

Task associated questions (binary responses)
Based only on reason (or rational analysis), which tray should you choose if you want to draw a red winner?
Based on your gut feeling, which tray feels like the one from which you are more likely to draw a red winner?
Which tray would you like to play the lottery for?

Exploratory survey items (slider responses)	Polarised descriptions
How strongly did you experience an inner conflict when making the choice (a "pull" towards following your intuition)?	No conflict at all – very strong conflict
I often follow intuition when making choices	Not at all true – very true
It is important to me to use reason when making choices	Not at all true – very true
If your intuition and reason don't tell you the same thing, which one do you usually follow?	Always intuition – 50/50 – always reason
Many people have some superstitions, believing in various supernatural influences, often related to good or bad luck. How superstitious are you?	Not at all superstitious – very superstitious

Appendix B

List of priors used for Bayesian data analysis

Table 3

Priors used for Bayesian analyses

Effect of condition	
Narrower (sd = 0.2)	Intercept µ: $\mathcal{N}(0, 1)$ Experimental condition µ: $\mathcal{N}(0, 0.2)$
Wider (sd = 0.3)	Intercept µ: $\mathcal{N}(0, 1)$ Experimental condition µ: $\mathcal{N}(0, 0.3)$
Effect of instruction	
Narrower (sd = 0.2)	Intercept µ: $\mathcal{N}(0, 1)$ Short explanation µ: $\mathcal{N}(0, 0.2)$ Experimental condition µ: $\mathcal{N}(0, 0.2)$ Experimental condition : Short explanation µ: $\mathcal{N}(0, 0.2)$
Wider (sd = 0.3)	Intercept µ: $\mathcal{N}(0, 1)$ Short explanation µ: $\mathcal{N}(0, 0.3)$ Experimental condition µ: $\mathcal{N}(0, 0.3)$ Experimental condition : Short explanation µ: $\mathcal{N}(0, 0.3)$
Supplementary analyses - Identifying the rational alternative	
Intercept only	Intercept µ: $\mathcal{N}(0.7, 0.4)$
Intercept & Explanation	Intercept µ: $\mathcal{N}(0.65, 0.4)$ Short explanation µ: $\mathcal{N}(0.15, 0.45)$
Intercept & Condition	Intercept µ: $\mathcal{N}(1, 0.4)$ Experimental condition µ: $\mathcal{N}(-0.5, 0.35)$

Intercept & Interaction	Intercept μ: $\mathcal{N}$(0.5, 0.75) Control condition : Extended explanation μ: $\mathcal{N}$(0.3, 0.8) Experimental condition : Extended explanation μ: $\mathcal{N}$(-0.1, 0.8) Control condition : Short explanation μ: $\mathcal{N}$(0.65, 0.75) Experimental condition : Short explanation μ: $\mathcal{N}$(0, 0.75)
Intercept, Condition & Explanation	Intercept μ: $\mathcal{N}$(0.9, 0.45) Condition μ: $\mathcal{N}$(-0.5, 0.4) Explanation μ: $\mathcal{N}$(0.15, 0.45)
Intercept, Condition & Interaction	Intercept μ: $\mathcal{N}$(0.8, 0.45) Condition μ: $\mathcal{N}$(-0.35, 0.4) Control condition : Short explanation μ: $\mathcal{N}$(0.3, 0.5) Experimental condition : Short explanation μ: $\mathcal{N}$(0.05, 0.45)
Intercept, Explanation & Interaction	Intercept μ: $\mathcal{N}$(0.9, 0.45) Short explanation μ: $\mathcal{N}$(0.25, 0.5) Extended explanation : Exp. condition μ: $\mathcal{N}$(-0.4, 0.4) Short explanation : Exp. Condition t μ: $\mathcal{N}$(-0.6, 0.4)
Intercept, Condition, Explanation & Interaction	Intercept μ: $\mathcal{N}$(0.85, 0.45) Experimental condition μ: $\mathcal{N}$(-0.4, 0.4) Short explanation μ: $\mathcal{N}$(0.25, 0.5) Exp. Condition : Short explanation μ: $\mathcal{N}$(-0.2, 0.45)
Supplementary analyses – Feeling the faulty intuition	
Intercept only	Intercept μ: $\mathcal{N}$(-0.25, 0.3)
Intercept & Explanation	Intercept μ: $\mathcal{N}$(-0.3, 0.35) Short explanation μ: $\mathcal{N}$(0.05, 0.4)
Intercept & Condition	Intercept μ: $\mathcal{N}$(-0.55, 0.35) Experimental condition μ: $\mathcal{N}$(0.55, 0.35)

Intercept & Interaction	Intercept μ: $\mathcal{N}(0, 0.75)$ Control condition : Extended explanation μ: $\mathcal{N}(-0.65, 0.75)$ Exp. condition : Extended explanation μ: $\mathcal{N}(0, 0.75)$ Control condition : Short explanation μ: $\mathcal{N}(-0.5, 0.75)$ Exp. condition : Short explanation μ: $\mathcal{N}(0, 0.75)$
Intercept, Condition & Explanation	Intercept μ: $\mathcal{N}(-0.55, 0.4)$ Experimental condition μ: $\mathcal{N}(0.55, 0.35)$ Short explanation μ: $\mathcal{N}(0.05, 0.4)$
Intercept, Condition & Interaction	Intercept μ: $\mathcal{N}(-0.6, 0.4)$ Experimental condition μ: $\mathcal{N}(0.6, 0.4)$ Control condition : Short explanation μ: $\mathcal{N}(0.1, 0.45)$ Exp. condition : Short explanation μ: $\mathcal{N}(0.05, 0.4)$
Intercept, Explanation & Interaction	Intercept μ: $\mathcal{N}(-0.6, 0.4)$ Short explanation μ: $\mathcal{N}(0.15, 0.4)$ Extended explanation : Exp. condition μ: $\mathcal{N}(0.65, 0.4)$ Short explanation : Exp. condition μ: $\mathcal{N}(0.5, 0.4)$
Intercept, Condition, Explanation & Interaction	Intercept μ: $\mathcal{N}(-0.6, 04)$ Experimental condition μ: $\mathcal{N}(0.6, 0.4)$ Short explanation μ: $\mathcal{N}(0.1, 0.4)$ Exp. condition : Short explanation μ: $\mathcal{N}(-0.05, 0.4)$

ZOIB analysis	
Full model	Intercept µ: *Student's t* (0, 10) Experimental condition µ: *Student's t* (0, 10) Short explanation µ: *Student's t* (0, 10) Exp. condition : Short explanation µ: *Student's t* (0, 10) Coi Intercept µ: *logistic* (0, 1) Coi Experimental condition µ: *logistic* (0, 1) Coi Short explanation µ: *logistic* (0, 1) Coi Exp. condition : Short explanation µ: *logistic* (0, 1) Phi Intercept µ: *Student's t* (0, 10) Phi Experimental condition µ: *Student's t* (0, 10) Phi Short explanation µ: *Student's t* (0, 10) Phi Exp. condition : Short explanation µ: *Student's t* (0, 10) Zoi Intercept µ: *logistic* (0, 1) Zoi Experimental condition µ: *logistic* (0, 1) Zoi Short explanation µ: *logistic* (0, 1) Zoi Exp. condition : Short explanation µ: *logistic* (0, 1)
Exploratory Analyses	
All models	*Student's t* (0, 10)

Note. $\mathcal{N}$(x, y) indicates a normal distribution with mean = x and standard deviation = y.

Appendix C

Tabulated results of Bayesian logistic regression analyses

Table 4

Results of logistic regression for main effects and interaction using narrower priors (sd = 0.2)

		95% CI for Odds Ratio		
	b	Lower	Odds Ratio	Upper
Intercept	2.63	9.97	13.87	19.49
Experimental condition	-0.18	0.61	0.84	1.14
Short explanation	-0.26	0.56	0.77	1.05
Experimental condition : Short explanation	-0.28	0.54	0.76	1.05

Table 5

Results of logistic regression for main effects and interaction using wider priors (sd = 0.3)

		95% CI for Odds Ratio		
	b	Lower	Odds Ratio	Upper
Intercept	2.75	10.70	15.64	23.10
Experimental condition	-0.24	0.53	0.79	1.19
Short explanation	-0.37	0.46	0.69	1.04
Experimental condition : Short explanation	-0.38	0.44	0.68	1.07

Table 6

Results of logistic regression for single effect of condition using narrower priors (sd = 0.2)

		95% CI for Odds Ratio		
	b	Lower	Odds Ratio	Upper
Intercept	2.04	5.47	7.70	10.91
Experimental condition	-0.23	0.57	0.79	1.11

Table 7

Results of logistic regression for single effect of condition using wider priors (sd = 0.3)

		95% CI for Odds Ratio		
	b	Lower	Odds Ratio	Upper
Intercept	2.12	5.75	8.33	12.30
Experimental condition	-0.38	0.45	0.68	1.05