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A hard to read font reduces the causality bias

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Abstract

Previous studies have demonstrated that fluency affects judgment and decision-making. The purpose of the present research was to investigate the effect of perceptual fluency in a causal learning task that usually induces an illusion of causality in non-contingent conditions. We predicted that a reduction of fluency could improve accuracy in the detection of non-contingency and, therefore, could be used to debias illusory perceptions of causality. Participants were randomly assigned to either an easy-to-read or a hard-to-read condition. Our results showed a strong bias (i.e., overestimation) of causality in those participants who performed the non-contingent task in the easy-to-read font, which replicated the standard causality bias effect. This effect was reduced when the same task was presented in a hard-to-read font. Overall, our results provide evidence for a reduction of the causality bias when presenting the problem in a hard-to-read font. This suggests that perceptual fluency affects causal judgments.

Keywords: causality bias, illusion of causality, debiasing, perceptual fluency, contingency

1 Introduction

Causal inference is the process by which we are able to capture the potential influence of one event A on another event B. The learning of this kind of causal relationships between an event A, called cue or potential cause, and an event B, called outcome or effect, has important adaptive value. To appropriately process, learn and judge the cause-effect relationship between A and B allows us to predict the future event, based on current information, and adjust our behaviour.

In many situations, animals and people detect causality with great accuracy, relying on the contingency between the potential cause and the effect (Matute, Blanco & Díaz-Lago, 2019). The contingency between these two events can be calculated on the basis of an index, the ΔP index (Jenkins & Ward, 1965), which is the difference between two conditioned probabilities: the probability that the effect occurs in the presence of the potential cause, P(E|C), minus the probability that the effect occurs in the absence of the potential cause, P(E|noC). Many studies suggest that people evaluate causal relationships following this normative index (Baker, Murphy, Vallée-Tourangeau & Mehta, 2000; Jenkins & Ward, 1965; Matute & Miller, 1998; Wasserman, 1990), and high correlations have been observed between the ΔP index and participants' causal judgments (Allan & Jenkins, 1983; Wasserman, Elek, Chatlosh & Baker, 1993). Although other authors have reported deviations from this index, and have proposed other ways to measure contingency that make different assumptions (see Perales & Shanks, 2007 for an extensive review of this topic), the ΔP index is arguably the most used method in the literature to measure contingency (e. g., Allan & Jenkins, 1983; Cheng & Novick, 1992; Shaklee & Mims, 1981; Shanks & Dickinson, 1987).

Importantly, the deviations from the normative response seems to be systematic (Blanco, 2017; Matute et al., 2019). Under certain circumstances, particularly when there is no contingency between the two events and one or both of them occurs frequently, people's judgments tend to systematically depart from the normative index and tend to overestimate the causal relationship between the two events (Allan & Jenkins, 1980; Alloy & Abramson, 1979; Jenkins & Ward, 1965; Shanks, 2007). This gives rise to a cognitive bias which has often been called the illusion of control (because it often refers to cases in which the potential cause is the participant's behavior, therefore cases in which the bias produces an illusory sense of control; e.g., Alloy & Abramson, 1979). This bias has also been known as the illusion or the bias of causality, which is a more general term that can also refer to

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any other causes; see Matute et al., 2019, for a review). We will use this more general term.

The bias of causality can have some potential positive consequences, particularly when the potential cause is our own behaviour. Some studies have found that inferring a causal link between certain behaviour and a desirable, although uncontrollable, outcome, can prevent negative emotions and behaviours related to the lack of control, such as depression and learned helplessness (Matute, 1994; Taylor & Brown, 1988). However, in another wide range of situations the illusion of causality has negative implications. There is evidence suggesting that the causality bias underlies important problems such as social stereotypes (Crocker, 1981), superstitious thinking (Matute, 1994), pseudoscientific practices and the proliferation of bogus treatments (Matute, Yarritu & Vadillo, 2011). Thus, it is important to find strategies to debias people in situations where an overestimation of causality can have serious negative consequences. Although some well-known manipulations can reduce the bias of causality, most of them are based on the manipulation of the frequency of the potential cause, the frequency of the outcome, or both (Matute et al., 2019). However, in real life non-contingent situations the frequency of the outcome is always uncontrollable, and in situations where the potential cause is an external event, the potential cause is also uncontrollable. Therefore, it is important to find strategies to reduce the illusion of causality without needing to manipulate the frequency of the events.

Recent research suggests that thinking in a foreign language is one such strategy that can be used to reduce the causality bias (Díaz-Lago & Matute, 2019), and there are reasons to believe that processing fluency could be a factor underlying this effect (see Costa & Sebastián-Gallés, 2014). Processing fluency refers to the subjective easiness or difficulty experienced during the processing of external information. Research in this field has shown that this metacognitive experience plays a key role in how people process, interpret and judge the information presented. Fluency modulates likeability and familiarity (Song & Schwarz, 2010), veracity (Reber & Schwarz, 1999), predicted effort (Song & Schwarz, 2008b), judgments of learning (Yang, Huang & Shanks, 2018), and even moral decisions (Spears, Fernández-Linsenbarth, Okan, Ruz & González, 2018).

The use of disfluent fonts seems to improve performance in memory tasks (Diemand-Yauman, Oppenheimer & Vaughan, 2011; French et al., 2013; Weissgerber & Reinhard, 2017), and in reasoning tasks (Alter, Oppenheimer, Epley & Eyre, 2007; Rotello & Heit, 2009). Although it is important to note that these results should be interpreted with caution, given the difficulties to replicate the study conducted by Alter et al. (2007; Meyer et al., 2015), it is reasonable to expect disfluency effects to be fragile (Weissgerber & Reinhard, 2017), particularly when using overloading tasks.

Interestingly for our present purposes, the fluency that participants experience during the task has an impact on cognitive biases, such as the *Moses Illusion* (i.e., the inability to detect misleading questions due to semantic overlap, as, for example, when people do not realize that the name of Noah has been substituted by Moses in a question about Noah's Ark; Song & Schwarz, 2008a), the *framing effect* on the *risk aversion bias* (i. e., the preference for safer choices despite identical outcome distributions when the options are framed as gains; Korn, Ries, Schalk, Oganian & Saalbach, 2017), and the *hindsight bias* (i.e., the illusion that one could have predicted an outcome before it happened; Sanna & Schwarz, 2006). Thus, there are reasons to believe that fluency may also have an impact on the causality bias.

Considering the reported debiasing effect of disfluency in other cognitive biases and the potential role of fluency on the foreign language effect on causal illusions, we decided to perform an additional test on whether fluency is a factor that can modulate the bias of causality. Therefore, the goal of the present research was to test whether the overestimation of causality observed in non-contingent situations can be reduced by increasing the difficulty experienced during the processing of the information.

In order to achieve this goal, we presented a standard causal learning task in two different font types: an easy-to-read font, and a hard-to-read font. Also, and in order to make sure that any reduction that we might observe in the overestimation of causality were not due to a generalized decrement of the judgments in the hard-to-read font, we also manipulated the actual contingency between the potential cause and the effect. Thus, in an orthogonal two-factor design, two groups observed two unrelated, non-contingent events (one in an easy-to-read font, the other in a hard-to-read font), and two other groups observed a potential cause and effect that were actually related to each other (i.e., contingent condition).

Although the illusion of causality could in principle occur with positive contingencies as well as null contingencies, taking into account that the causality bias has generally been reported in cases of null contingency (Allan & Jenkins, 1980; Alloy & Abramson, 1979; Jenkins & Ward, 1965), and taking into account our previous results using a paradigm very similar to this one but using a foreign language manipulation (Díaz-Lago & Matute, 2019), we expected a correct detection of causality in the contingent condition; therefore no reduction of a bias could be expected in this case as a function of font. However, in the non-contingent condition we expected to replicate the standard illusion of causality when the easy-to-read font was used, and so we expected to be able to reduce this bias in the non-contingent condition when using the hard-to-read font.

2 Study 1

2.1 Method

2.1.1 Participants

One-hundred and sixteen undergraduate students from the University of Deusto (mean age 18.66 years; 95 women) participated in the study. They were all native Spanish speakers. Participants gave their informed consent and were rewarded with course credits.

2.1.2 Procedure and Design

Participants performed the experiment in a large computer room. They were randomly assigned to one of four consecutive and identical replicas. Once they arrived, participants sat in front of an individual computer that was already prepared with the program launched. After some brief instructions about how to navigate through the task, participants started the experiment. First, we presented the informed consent. If participants agreed to volunteer in the experiment, the program randomly assigned them to one of the four experimental groups. In the causal learning task we asked participants to imagine being a medical doctor who had to judge the relationship between a fictitious drug called 'Batatrim' (potential cause) and the healing of the symptoms produced by a fictitious disease (outcome), based on the information contained on 40 medical records (i.e., trial-by-trial procedure). In each medical record, divided in three horizontal panels, participants read information about one fictitious patient affected by the fictitious disease. In the upper panel, participants saw whether or not the patient had taken the drug. Below, in order to engage participants and maintain their attention to the task, we presented a predictive question about whether participants thought that the patient would feel better after taking the drug or no. Once they answered by clicking in one of the two buttons ('yes' or 'no'), information about the recovery (or not) of the fictitious patient appeared in the lower panel (see Figure 1). Typically, the information is presented along with pictures of the drug and the patient, but we eliminated the pictures in order to force participants to read, thereby avoiding potential shortcuts.

Once participants saw the medical records of the 40 patients, we asked them to judge the causal relationship between the two events by answering the causal question *'To what extent do you think that Batatrim has been effective in healing the crises of the patients you have seen'*. Participants could answer this question by clicking on a 0 to 100 scale (0=*'Definitely NOT'*; 100=*'Definitely YES')*. Immediately afterwards, we presented a manipulation check. In four 1 to 7 Likert scales (one at a time), we asked participants *'Was the experiment easy to read or hard to read for you?'* (1 = extremely difficult; 7 = extremely easy); *'Was the experiment short or long for you?'*, (1 = extremely long; 7 = extremely short); *'Was the reading of the experiment fluent or disfluent for you?'*, (1 = extremely disfluent; 7 = extremely fluent); and *'Will you be willing to repeat the experiment?'*, (1 = extremely unwilling; 7 = extremely willing).

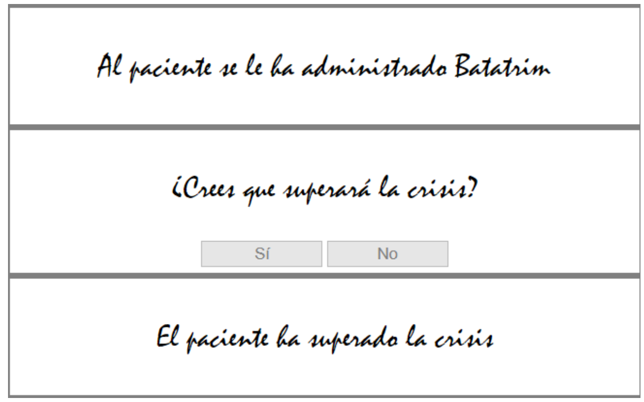

Figure 1: Screenshot of one trial of the hard-to-read group (in Spanish).

To test the impact of processing fluency on the illusion of causality, and in order to avoid carry-over or anchoring effects in the critical non-contingent conditions, we manipulated orthogonally the font type of the text and the contingency between the potential cause and the effect using a two-factor between-subjects design.

Thus, two experimental groups observed a drug that was non-contingent with the healing of the symptoms, one in an easy-to-read font (Arial 12, N = 32), the other one in a hard-to-read font (Mistral 12, N = 31). As controls, two other groups viewed a drug with a true contingency, one in the easy-to-read font (N = 21), the other in a hard-to-read font (N = 32). Table 1 summarizes the design and the details about the ΔP index. In order to replicate previous findings and to induce a strong illusion in our participants, we used a high probability of the outcome (i.e., p(O) = .75). More specifically, all participants in the non-contingent groups saw 15 trials where the drug was present and the patient recovered (type *a* trials), 5 trials where the drug was present and the patient did not recover (type *b*), 15 trials where the drug was absent and the patient recovered (type *c*), and 5 trials where the drug was absent and the patient did not recover (type *d*). For the control, contingent groups, the number of trials were 15*a*, 5*b*, 3*c*, and 17*d*. Although the number of trial types was fixed for all participants depending on the experimental condition, the order of presentation was randomized separately for each participant.

The materials consisted of a standard causal learning task followed by a manipulation check. Specifically, the standard causal learning task was a computerized adaptation of the allergy task (Matute et al., 2011). The manipulation check included four 7-point rating Likert scales (Song & Schwarz, 2008a, 2008b). We asked participants about the ease of

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TABLE 1: Design summary.

	Non-contingent				Contingent			
Font type	p(C)	p(O|C)	p(O|noC)	Δp	p(C)	p(O|C)	p(O|noC)	Δp
Easy-to-read	.5	.75	.75	0	.5	.75	.15	.60
Hard-to-read	.5	.75	.75	0	.5	.75	.15	.60

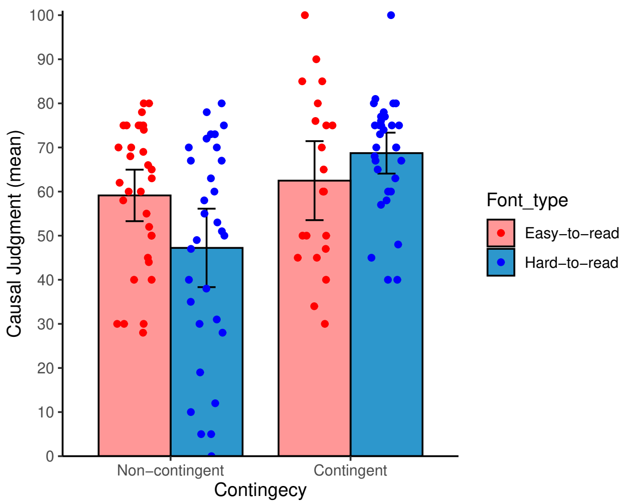

FIGURE 2: Mean judgments for each group. Error bars depict the 95% confidence intervals of the means.

reading of the task, the estimated duration of the task, the fluency of the task, and their willingness to perform the task again.[1] Due to a typo in the last question in two of the experimental groups, we excluded the responses to this scale from the analysis. Both materials were implemented in a HTML document dynamically modified with JavaScript.

2.2 Results

Figure 2 shows the mean responses to the causality question about the relationship between the drug and the healing of the symptoms.

In line with previous findings, in the non-contingent condition (that is, the one expected to develop the bias of causality) the easy-to-read group showed a strong illusion. However, the illusion of causality was markedly reduced in the hard-to-read non-contingent group. That is, both the easy to-read and hard-to-read groups developed some degree of illusion of causality. However, the results in Figure 2 suggest that the responses of the participants that performed the task in a hard-to-read font are lower, and more accurate, than the responses of the participants that performed the task in the standard, easy-to-read, font. This difference in the judgments as a function of the font type is not observed in the groups that viewed a drug with a true contingency. As predicted for this situation, both the easy-to-read and the hard-to-read groups evaluated the drug as effective, giving judgments that were close to the actual contingency ($\Delta P = .6$). This suggests that participants had a correct understanding of the task in both fonts, and is not a barrier to performing the task.

We performed an analysis of variance for the two factors (Contingency: Non-contingent, contingent; Font type: Easy-to-read, hard-to-read). This analysis confirmed the differences shown in Figure 2, revealing a main effect of contingency $F(1{,}112) = 12.56$, $p = .001$, $\eta_p^2 = .101$, mean difference = 12.422, 95% CI for the difference = [5.477, 19.367], and the critical Font type x Contingency interaction, $F(1{,}112) = 6.697$, $p = .011$, $\eta_p^2 = .056$. To explore the source of the interaction, we conducted a simple-effect analysis. The results showed a significant difference in the responses of the non-contingent groups as a function of the font type, $F(1{,}112) = 6.460$, $p = .012$, $\eta_p^2 = .055$. Participants that performed the non-contingent task in a hard-to-read font gave lower and accurate judgments than the participants that performed the non-contingent task in an easy-to-read font, mean difference = −11.899, 95% CI for the difference = [−21.176, −2.623]. As expected, this difference between the font type groups was not observed when the two events were contingent $F(1{,}112) = 1.432$, $p = .234$, $\eta_p^2 = .013$.

Taking into account the fact that Levene's test for the assumption of equal variances was significant for the test of the interaction, we conducted two complementary tests to ensure that the effect was robust. Given that our hypothesis is clear about the direction of the effect (hard-to-read causal judgments should be lower than easy-to-read ones in the non-contingent conditions) we performed a one-tailed Welch's t-test and a one-sided Bayesian t-test for independent samples, comparing the causality judgments of the two non-contingent groups. The Welch's t-test confirmed that, as expected, the causal judgments from the hard-to-read group of participants were significantly lower, $t(52.127) = 2.28$, $p = .013$, $d = 0.58$. The results from the Bayesian t-test shows that our data is over 4 times more likely under the hypothesis that hard-to-read judgments are lower than easy-to-read judgments than

[1]The original wording of the questions, in Spanish, were (1) *El experimento, ¿te ha resultado fácil o difícil de leer?*, (2) *El experimento, ¿te ha resultado corto o largo?*, (3) *La lectura del experimento, ¿te ha resultado poco fluida o muy fluida?*, and (4) *¿Estarías poco dispuesto o muy dispuesto a repetir el experimento?*

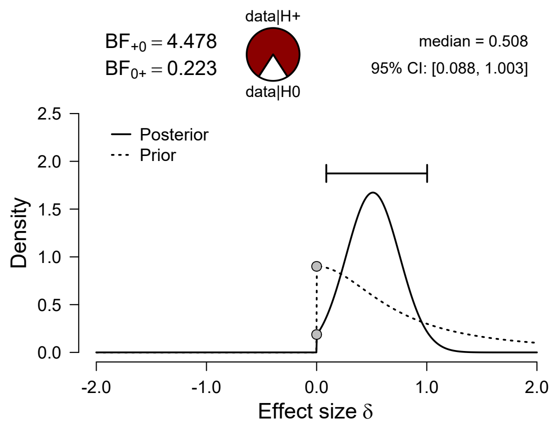

Figure 3: Prior and posterior distributions for the Bayesian t-test.

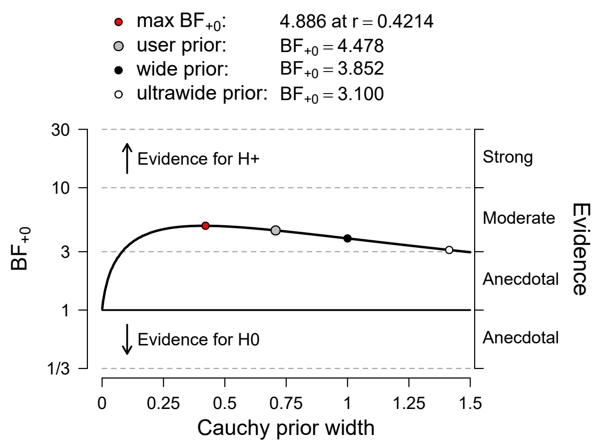

Figure 4: Bayes Factor under different priors.

under the null hypothesis, BF_{+0} = 4.48 (see Figures 3 and 4 to check the distributions and the robustness of the test under different priors).

Interestingly, the causal judgments given by the two easy-to-read groups were very similar, $F(1{,}112) = 0.413$, $p = .522$, = .004 (mean difference = −3.351, 95% CI for the difference = [−13.689, 6.986]); while participants that performed the task in a hard-to-read font did actually discriminate between the two different contingencies, $F(1{,}112) = 21.074$, $p < .001$, $\eta_p^2 = .158$ (mean difference = −21.493, 95% CI for the difference = [−30.769, −12.216).

Figure 2 suggests that the difference between the groups in the critical non-contingent condition could be rooted in a subset of participants in the hard-to-read group that gave very low responses, rather than in a general lowering of the responses in this experimental condition. A histogram of the causal judgments of both non-contingent groups (Figure 5) confirms that there are more participants in the non-contingent/hard-to-read group that gave low judgments than in the easy-to-read group, suggesting that the main effect of the font is on low score judgments.

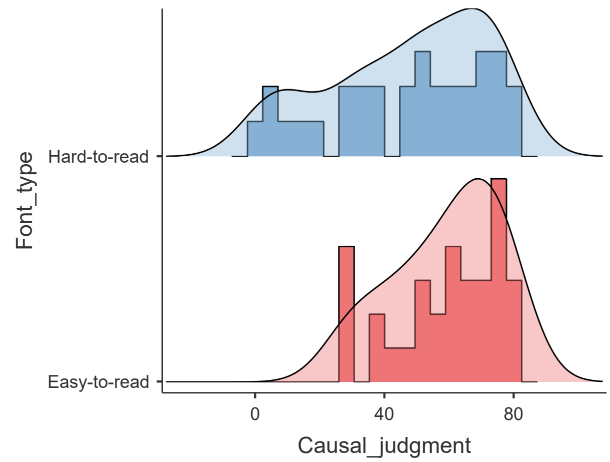

Figure 5: Histogram and density plot for the non-contingent groups.

In addition, to check that the font type manipulation was effective, we also tested if there were differences in perceived easiness, fluency, and duration as a function of font type. Table 2 shows the mean values for each of these variables. A Mann-Whitney test comparing the easy-to-read groups with the hard-to-read ones revealed significant differences in the easiness (U = 648.50, Z = −5.808, p < .001, r = −.53) and fluency scores (U = 1108.50, Z = −3.174, p = .002, r = −.29). The analyses did not show significant differences between font type groups in the estimated duration of the task (U = 1632.00, Z = −0.224, p = .823, r = −.02). Specifically, those participants that performed the task in a hard-to-read font perceived the reading of the task as more difficult, mean difference = −1.351, 95% CI for the difference = [−1.773, −0.928], and less fluent, mean difference = −0.834, 95% CI for the mean = [−1.347, −0.321], suggesting that the font type manipulation was effective in the modulation of fluency.

3 General Discussion

Overall, the results of this experiment show an overestimation of the causal relationship between the two events in non-contingent situations, whether the information was presented in a hard-to-read or in an easy-to-read font, giving raise, as expected, to some degree of the causality bias in both groups. However, the statistical analysis confirmed that participants who performed the non-contingent task in a hard-to-read font gave lower, more accurate judgments than the participants that viewed exactly the same information in an easy-to-read font. This supports our hypothesis that the

Table 2: Median, mean, and standard deviation for the final questions of the manipulation check concerning font type (i.e., 3 Likert scales, each of them from 1 to 7).

	Easiness			Duration			Fluency		
Group	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*
Non-contingent/Easy-to-read	6.0	5.72	1.11	4.0	4.38	1.07	5.0	4.84	1.42
Non-contingent/Hard-to-read	4.0	4.35	1.20	4.0	4.42	0.81	4.0	4.19	1.42
Contingent/Easy-to-read	6.0	5.62	1.12	4.0	3.71	0.85	5.0	5.14	1.42
Contingent/Hard-to-read	4.0	4.28	1.08	4.0	3.75	1.02	4.0	4.13	1.24

reduction of processing fluency should help people to judge causal relationships more accurately. The modulation in the judgments as a function of the font type is not observed in the control, contingent groups, where both groups adjusted their responses to the actual contingency between the two events. This indicates that the reduction of the causal judgments in the non-contingent hard-to-read condition cannot be attributed to a general decrease of the responses in the hard-to-read condition. Instead it shows that, as expected, presenting the information of a causal learning task in a hard-to-read font reduces the illusion of causality when causality is absent. We do not want to claim that the bias cannot occur in positive contingency conditions, but in principle it seems harder to observe it in those cases (and would require, at the minimum, several changes in the procedure and parameter testing). In any case, the main finding of these experiments is that the causality bias can be reduced by using a hard-to-read-font.

It should be noted that, although it is a non-significant result, the participants who performed the task in the easy-to-read font did not evaluate the non-contingent and the contingent drug differently, unlike the hard-to-read groups, who judged the non-contingent drug as significantly less effective. Taking into account that the participants who saw the contingent drug in an easy-to-read font were quite accurate in the detection of the actual contingency, it seems that this non-significant result between the easy-to-read groups could be probably due to the strong illusion of causality that the non-contingent group shows. Although the finding that participants judge a drug that does not work as being as effective as a drug that actually works may result surprising, this pattern of responses replicates previous findings on the illusion of causality. Strong illusions are quite common when using a high probabilty of the outcome, as in Matute et al. (2011), and we have found this lack of sensitivity to contingency even in within-participants studies (Experiments 1 and 2, Díaz-Lago, 2017).

The results obtained in the Likert scales confirmed that participants that performed the task in a hard-to-read font evaluated the reading of the task as more difficult and less fluent. These results indicate that we were able to modulate the metacognitive experience of easiness through the experimental manipulation. Therefore, the results of the study confirm our initial hypothesis: decreasing fluency during the causal learning task could be a factor that helps to reduce the bias of causality. However, taken into account the histogram, it seems that the differences between groups emerge in the number of participants that gave lower, accurate causal judgments in the non-contingent situation. There are almost no appreciable differences between groups when the causal judgments are high, suggesting that this debiasing effect appears due to an increasing in sensitivity in the hard-to-read group, rather than a general debiasing effect.

While we can only speculate about how fluency modulates causal judgments, it is worth to discuss our results in the context of the theoretical accounts of the fluency effect. On the one hand, some researchers have proposed that the subjective experience of fluency affects judgments directly, no matter what the content of the declarative information is. Thus, when information is presented in a disfluent setting, people will directly infer that the information is unfamiliar and the task will be difficult to perform, effortful and long (Song & Schwarz, 2008b, 2010). On the other hand, other researchers have proposed an indirect path, where fluency acts as a cue that informs people about the cognitive resources needed for the processing of the information. Therefore, if the information is presented in a fluent setting, people would engage intuitive, associative and quick processes, whereas if the information is presented in a disfluent setting, it would indicate the need to involve effortful, analytical and systematic processes (Alter et al., 2007). However, we should be cautious about this hypothesis because some studies that tried to replicate Alter et al.'s study were not able to replicate it (Meyer et al., 2015) or found that the effect was modulated by cognitive ability (Thompson et al., 2013).

In the context of the fluency literature, if fluency were modulating causal judgments directly, the disfluency experienced by the participants that performed the task in a hard-to-read font would lead to lower causal judgments, both in the responses of non-contingent and contingent groups. However, participants of the contingent groups did not reduce their judgments when exposed to the hard-to-read font.

Therefore, our results seem to be more compatible with the indirect path of influence, which can explain the disfluency effect that occurs only in the non-contingent groups. If this explanation is correct, then the font type would be affecting the selection of processes involved in the resolution of the causal learning task, activating more deliberative and analytical processes when the information is presented in a hard-to-read font (Alter et al., 2007). Although we need to remark the low generalizability of Alter and colleagues' results, the task used in their experiments and in the failed replication conducted by Meyer and colleagues, the *Cognitive Reflection Test* (Frederick, 2005), is very demanding compared to our paradigm, that is so easy that (with some changes in the cover story) it has even been used to evaluate causal inferences in children (Moreno-Fernández, Blanco & Matute, 2017). We suspect that the easiness of the task could be an important factor, since it probably prompts participants to be less frustrated and more willing to mobilize their cognitive resources (e.g., "think harder") to perform the task while decoding the font. This would eventually lead to an improvement in detecting the actual contingency in the non-contingent, bias-prone situation. That is, fluency would be working as a debias factor in the illusion of causality, as has been reported in relation to other cognitive biases (Sanna & Schwarz, 2006; Song & Schwarz, 2008a).

Regardless of the relative merits of the potential theoretical explanations, our results indicate that processing disfluency is a factor that reduces the bias of causality. These findings imply that processing fluency could be used as a strategy to reduce the causality bias without needing to manipulate the information about the cause and the outcome. The practical implications of processing fluency on the causality bias is that it could be used to enhance decision making in situations where the information about the cue and the outcome are given and, therefore, are uncontrollable to the decision maker.

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