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A meta-cognitive account for the impact of implausible suggestions on estimations

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Abstract

We propose a model of why implausible numeric suggestions function as anchors and influence people's estimates. In two experiments we tested the hypothesis that people's confidence in their knowledge modulates their susceptibility to implausible suggestions. We found that higher confidence reduces the impact of implausible anchors. A third experiment showed that knowledge, defined as participants' agreement on a value, weakly affects the impact of a suggestion. These results indicate that theoretical accounts for the impact of implausible suggestions on estimations should consider the role of meta-cognitive information.

Keywords: confidence, knowledge; anchoring; suggestions; assimilation

Introduction

People often make numeric estimations in circumstances of uncertainty. It is well known that in these situations they tend to assimilate their estimates to numeric values suggested to them. This assimilation bias, called *anchoring* (Tversky & Kahneman, 1974), has been demonstrated in several domains (for a review, see Chapman & Johnson, 2002).

These suggested values do not have to be reasonable to exert an effect on estimation. For example, people who are asked to estimate Gandhi's age at death provide higher estimates after being asked whether Gandhi died at the age of 214 than after being asked whether he died at the age of 86 (Mussweiler & Strack, 2001). The fact that even blatantly implausible suggestions can affect estimates is counterintuitive: because people should easily identify the claim *Gandhi lived to 214* as false, they should easily discard this suggestion. This suggestion should therefore have little impact on judgment. Why is it then that implausible anchors affect people's estimates?

One possibility is that the influence of these suggestions is mediated by internally generated knowledge (e.g., Mussweiler & Strack, 2001). On this explanation, anchoring occurs as a consequence of two processes: an adjustment process (Tversky & Kahneman, 1974) followed by a selective accessibility process (Mussweiler & Strack, 1999, 2001, Strack & Mussweiler, 1997). Implausible suggestions are typically given by asking people to consider a numeric value via a comparative question, e.g., *Was Mahatma Gandhi younger or older than 214 years when he died*? When answering this question, people draw on their knowledge of the domain (e.g., people's longevity). They consider the boundary value of the distribution, for example, that the maximal age a person can reach is 117 years old. Because the given anchor exceeds this value, people can reject it as a viable estimate and end up adjusting their estimate to that boundary. Importantly, in this process, people do not need to rely on their knowledge of the particular target in question (Gandhi).

It is only in the next step, when people are asked to provide an absolute number that they access specific knowledge of the target. At this stage they compare target-related knowledge to the domain-maximum value to which they had adjusted and test the hypothesis that the target item's extension is similar to the domain maximum. This confirmatory testing increases the accessibility of knowledge consistent with the hypothesis (e.g., Gandhi accomplished many things in his life; is often portrayed as an old man) and this knowledge is then used to form the absolute judgment (Mussweiler & Strack, 2000, 2001).

This model explains how implausible anchors of different magnitudes can produce equally high estimates (e.g., the anchors 214 and 271 yield comparable estimates for Gandhi's age; Mussweiler & Strack, 2001). In addition, this model makes an implicit assumption regarding the role of knowledge: Because the internally generated domain-maximum value that people use as a proxy for adjustment is the upper limit of the domain, this value must be the upper bound for estimates. People should therefore not provide estimates higher than that boundary.

In this paper, we consider the relative role of knowledge and confidence in mediating the effect of implausible suggestions. Building on the aforementioned framework, we develop an account that explains how the impact of extreme anchors is mediated not only by people's knowledge, but also by their confidence in that knowledge – i.e., by their meta-cognitive assessment of their own knowledge. A central premise of our account is that people's confidence in their knowledge of the domain in question can affect their sensitivity to extreme anchors in the context of the comparative judgment. For example, consider two people who think that the maximum age a person can live is 125 years. One person is certain of this assessment, but the other is not. It is reasonable to expect that the first person will effectively adjust to 125 (as in Mussweiler & Strack, 2001), but that the second person will still be influenced by the initial implausible anchor. Confidence in target knowledge could also affect people's evaluations of extreme anchors, in the context of the absolute judgment. For example, an implausible anchor might have a limited effect on the estimate of a person who is certain that Gandhi died in his seventies. However, the same anchor may strongly influence a person who thinks that Gandhi died in his seventies but is less certain.

This meta-cognitive account makes two novel predictions: First, people's estimates will be more influenced by implausible anchors for domains and targets whose knowledge is associated with low confidence. Second, when presented with an implausible anchor, people's estimates may exceed the domain maximum, particularly when people's confidence in their knowledge of the domain or the target is low.

The experiments presented here tested these predictions. In Experiment 1, we examined how implausible anchors affect estimates in domains for which upper boundary values were associated with either higher or lower confidence ratings (all confidence ratings were obtained in independent norming). In Experiment 2 we tested whether the level of confidence in both domain and target knowledge interacts in determining the anchoring effect. We could therefore identify the effects of both domain and target confidence on the impact of implausible anchors. In Experiment 3, we operationalized people's knowledge in terms of the degree of participants' consensus in estimating the target and domain-maximum values. We examined whether it mediates the effects of implausible anchors.

Construction of Materials

We constructed 40 candidate domains. For each domain we generated two target items: one for which we expected that people would be more confident in their knowledge with respect to the domain, and one for which we expected that they would be less confident. For example, we expected that people would be more confident in their knowledge of the number of stories in the Empire State Building than in their knowledge of the number of stories in The Petronas Towers in Kuala Lumpur, Malaysia. This resulted in three norming questions for each domain: one referring to the *domain's maximum* value (e.g., what is the number of stories in the tallest skyscraper ever built) and two referring to the two *targets* within the domain (e.g., how many stories are there in The Empire State Building / The Petronas Towers).

These questions were distributed across three lists so that each participant answered a question referring either to the domain maximum or one of the two domain targets. For each question, participants (N=40 Stony Brook undergraduates) provided a numerical estimate and then indicated their confidence in their response on a scale from *1* (not confident at all) to *7* (extremely confident). The mean confidence ratings for the domain maximum question ranged from 1.14 to 3.92 (M = 2.14, SD = 0.66). The mean confidence ratings for target items ranged from 1 to 4.71 (*M* = 1.95, SD = 0.7).

On the basis of these confidence ratings, we chose six domains for Experiments 1 and 2 (see Table 1). Three were domains for which people were more confident of the domain's maximum (mean confidence = 2.58; items 1, 2, 3 in Table 1), and three were from those for which people were less confident (mean confidence = 1.9, items 4, 5, 6, in Table 1). Within these six domains, the mean confidence ratings for the two targets were 2.43 (higher confidence) and 1.74 (lower confidence). Numeric estimates for the targets did not reliably differ in any domain. To conclude, domain-confidence (confidence in domain-maximum ratings) and target-confidence (confidence in extension of specific targets) was manipulated orthogonally.

After choosing the six domains, we constructed anchor values for each domain based on the numeric estimates for the domain maximum. The lower anchor was set at 1 standard deviation above the mean estimate for the domain maximum. The higher anchor value was constructed to be 4 standard deviations above the mean estimate for the domain maximum.

For Experiment 3, we chose materials based on the dispersion of the response distributions in the norming study. In that experiment, 'knowledge' of the target and domain was defined in terms of the tightness of the distribution of estimated values. Items with tight distributions were those in which participants tended to provide similar estimates, and those with wide distributions were those in which estimates varied greatly.

Table 1: Experimental items in Experiments 1 and 2 (Higher-confidence targets not used in Exp. 1)

Domain	Higher-Confidence Target	Lower-Confidence Target
Higher Confidence Domains		
1) Speed of cars	BMW-Z4	Pontiac Solstice
2) Number of movies	Julia Roberts	Sophia Loren
3) Number of stories	Empire State building	Petronas Towers
Lower Confidence Domains		
4) Number of women's rights law voted for by a woman senator	Hillary Clinton	Dianne Feinstein
5) Number of sections in newspapers' Sunday edition	N.Y. Times	L.A. Times
6) Number of deaths from natural disaster	2004 tsunami in Indonesia	1999 earthquake in Turkey

Experiment 1

This experiment tested whether domain confidence mediates the impact of extreme anchors. In this study we included only lower-confidence targets within each domain because these offered the largest potential for anchoring effects. The paradigm consisted of a comparative question followed by an absolute question. The comparative question asked participants if they agreed or disagreed with a given anchor, e.g.: *The Pontiac Solstice can reach a top speed of 226 MPH: Agree / Disagree*. Following, if they disagreed, they were asked to provide their absolute estimate. This phrasing of the first question was used because in contrast to the phrasing used in prior works (which asks whether the actual number is higher or lower than the given anchor), there is no pragmatic implication that the suggested value is necessarily wrong. In addition, we constructed two variations of this question where we prefaced it with the clause *It is true that…* and *It is false that…* (e.g., *It is true that the Pontiac Solstice can reach a top speed of 226 MPH*). This framing was meant to increase or decrease the relevance of the anchor for the judgment following pilot work showing that phrasing a proposition as true increases its perceived veracity. The three framings (Neutral, True, False) were manipulated between participants.

Method

One-hundred and eighty-six Stony Brook University undergraduate students completed the forms as partial fulfillment of course requirements. We matched the 6 target items with 2 anchor values and thus obtained 12 questions. We then created three counterbalanced lists so that each participant would be presented with only one target and one anchor from each domain in either true, false, or no framing. The overall design was 3 (Framing: None, True, False) X 2 (Domain confidence: Lower vs. Higher) X 2 (Anchor magnitude: Lower vs. Higher). In this and the following experiments, each item was presented on a separate sheet and was mixed with other questions in a larger survey.

Results and Discussion

We standardized participants' responses to each question by transposing their response to z scores with respect to the mean of the domain-maximum question and its standard deviation. To provide a conservative estimate of the effect of anchors we then removed those responses in which participants agreed with the anchor value (26%). This is a conservative estimate as it includes only responses given after participants rejected the anchor, which are likely to be lower than the anchor itself. We also removed highly atypical responses 10 standard deviations above the domain mean (1%). We therefore used data from 53 participants who provided a data point for each experimental condition. As Figure 1 shows, higher anchors (Anchor+) yielded higher estimates, ($F(1,52) = 16$, $p < .001$), consistent with prior literature. Crucially, for higher-confidence domains the effect of higher anchors was reduced, but confidence did not have an impact on responses to lower anchors ($F(1,52) = 6.3$, $p < .05$ for the interaction). The data also show a main effect of domain confidence ($F(1,52) = 4.22$, $p < .05$). There was no effect of framing (true vs. false vs. baseline), nor any other effect.

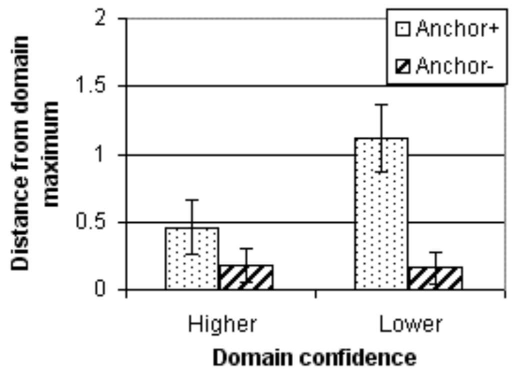

Figure 1: Domain confidence mediates anchoring

The departure from domain maximum (y = 0) was reliable for the higher anchors in both domains (lower-confidence domain: $t(54) = 4.6$, $p < .001$; higher-confidence domain: $t(54) = 2.4$, $p < .05$), but responses for lower anchors did not differ from 0 ($ps = 0.12$). Thus, we can conclude that participants' estimates were anchored to the domain maximum only in the case of lower implausible anchors, which were 1 standard deviation above the domain maximum. When these anchor values were even more extreme, their influence on estimates was stronger, though it was modulated by participants' confidence of the domain in question. Note, in addition, that because we removed responses that agreed with the anchor value, our analysis is a very conservative estimate of the influence of the anchor.

Experiment 2

Experiment 2 extended our test of the impact of confidence on anchoring by manipulating both domain and target confidence. In addition, the experiment used the standard phrasing of the comparative question (e.g., *the Pontiac Solstice can reach a top speed of* <u>*more than*</u> / <u>*less than*</u> *226 mph*), which does not pragmatically imply that the anchor value is potentially valid. It is possible that this phrasing would lower estimates in the high anchor condition because, as opposed to the phrasing used in Experiment 1, it implies that the given number is incorrect. Participants circled the more sensible option in the comparative judgment and then indicated their estimate in the absolute judgment (*What is your estimate of the top speed of a Pontiac Solstice?*).

Method

One-hundred and fifty-four Stony Brook undergraduates took part in the study as part of course requirement. We used the same six domains as in Experiment 1 but included both targets for each domain, for a total of 12 questions that were then presented with either a lower or a higher anchor. The domains and targets we used are shown in Table 1. We assigned the questions to 6 experimental lists so that each participant saw only one question from each of the six domains. The design was: 2 (Domain confidence: Lower vs. Higher) x 2 (Target confidence: Lower vs. Higher) x 2

(Anchor magnitude: Lower vs. Higher).

Because we constructed anchor values to be higher than the domain maximum, we expected that participants would typically judge that the real value was less than the anchor (e.g., judge that the top speed of a Pontiac is less than 226 mph). To balance the distribution of their responses, we included two filler items with low anchor values so that for these items participants could easily indicate that the target value was greater than the anchor.

Results and Discussion

We removed responses that were greater than 10 standard deviations from the domain maximum (1%). Data were normalized with respect to the domain-maximum distribution as in Experiment 1. Figure 2 shows the results for the higher confidence domains (items 1, 2, 3 in Fig. 2 top) and for the lower confidence domains (items 4, 5, 6 in Fig. 2 bottom). For each item the figure shows the mean estimations relative to the domain maximum, for lower and higher confidence targets (T+/T-) when presented with higher or lower anchors (A+/A-).

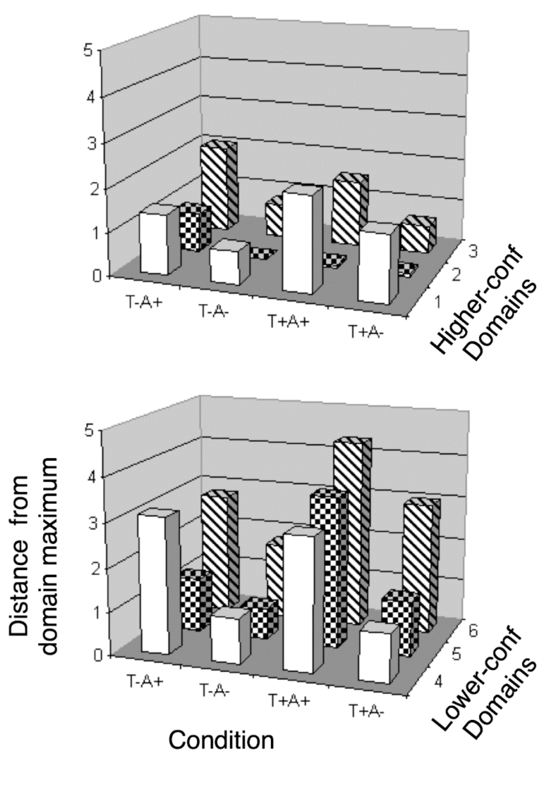

Figure 2: Individual domain results in Experiment 2

First, we examined response patterns separately for each domain, because each consisted of a manipulation of target confidence and anchor magnitude. All domains showed reliable main effects of anchor magnitude; higher anchors yielded higher estimates (*p*s < .05). Table 2 shows the other reliable effects. Four domains showed main effects of target confidence: Higher target confidence yielded higher estimates in three domains. Two domains showed an interaction between target confidence and anchor magnitude. Thus, on the single-item level the anchoring effect was as expected, but target-confidence did not reveal the predicted effect.

Table 2: Individual domain effects in Experiment 2

Domain	Target	Interaction	Notes
1	F = 5.2, p < .01	-	T+>T-
2	F = 3.3, p = .07	F=5.3, p < .05[a]	T+<T-
3	-	-	
4	-	-	
5	F = 31, p < .001	F=11.2, p<.01[b]	T+>T-
6	F = 7.4 p < .01	-	T+>T-

Note. [a]stronger anchoring effect for lower-confidence targets. [b]stronger anchoring effect for higher-confidence targets

As a second analysis we performed an omnibus anova. Because the design consisted of 8 conditions applied to six thematic domains, we did not conduct a repeated measure analysis since no participant responded to all eight conditions. Instead, all factors were modeled as between-participant responses. As expected from the analyses of the individual domains, this analysis revealed that high anchors were associated with higher estimates (M = 2.45 vs. .93; $F(1, 792) = 109$, $MSE = 454$, $p < .001$). As shown in Figure 3, the impact of anchors was stronger when confidence in domain knowledge was lower, resulting in a reliable interaction between domain confidence and anchor value ($F(1, 792) = 6.82$, $MSE = 29.4$, $p < .01$). This finding replicates that of Experiment 1.

Figure 4 shows the impact of domain and target confidence. Lower-confidence domains were associated with higher estimates (M = 2.27 vs. 1.11; $F(1, 792) = 63$, $MSE = 252$, $p < .001$). Higher-confidence targets were associated with higher estimates, but only for lower confidence domains. This resulted in an interaction between the two factors ($F(1, 792) = 7.25$, $MSE = 30.0$, $p < .01$) as well as a main effect of target confidence ($F(1,792) = 6.67$, $p < .01$).

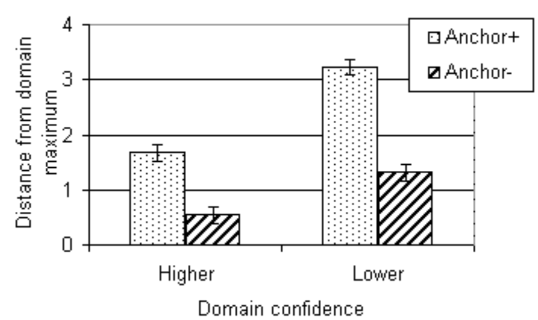

Figure 3: Domain and Anchor effects in Experiment 2

In this analysis, the general linear model accounted for 21% of the variance (adjusted R^2). A model including only anchor magnitude accounted for 12% of the variance (adjusted R^2). This demonstrates that including confidence-related factors in the model lead to a substantial increase in the variance accounted for.

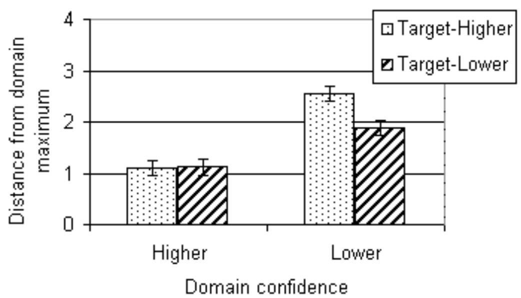

Figure 4: Domain and Target effects in Experiment 2

We also examined the departure of estimates from domain maximum (y = 0) for each item. We performed 24 t-tests as there were 4 estimates for each domain. With the exception of domain #2, estimates for all targets differed reliably from 0 (FDR corrected for multiple comparisons). For domain #2, only the higher-anchor/lower-confidence item showed a value greater than 0. Thus, for the most part, participants anchored to the given values rather than to the domain maximum. To conclude, this study replicated the findings of Experiment 1 and showed that estimations given in the presence of anchoring suggestions tended to reliably exceed the domain maximum.

Experiment 3

In this study, the impact of anchoring was evaluated as a function of participants' group knowledge. Knowledge was defined in terms of the ratio of standard deviation of a distribution to its mean -- a unit-less measure affording standardization across items. These values were separately calculated for two distributions in the norming study: that of participants' estimations of the target value and that of their estimations of the domain-maximum value. Lower values of this ratio indicate higher knowledge.

Method

One hundred and sixty-seven Stony Brook undergraduates took part in the study as part of course requirement. We chose domains and targets that were associated with higher and lower knowledge, as defined above. The values for the target ratings were 0.85 for high-knowledge targets (Min = 0.68, Max = 1.12) and 1.79 for low-knowledge targets (Min = 1.18, Max = 3.03). The mean of the three high-knowledge domains was 1.16 and that of the low knowledge domains was 2.05. This resulted in an orthogonal matching of domain and target knowledge. To dissociate the potential impact of confidence and knowledge combined, we chose these items so that knowledge thus defined would be independent of item confidence. The overall confidence in the domain-maximum for these items was quite low: 1.40 for the higher-knowledge domains and 1.60 for the lower-knowledge domains (both were lower than the lower confidence domains used in Experiment 2). The design was: 2 (Domain knowledge: Lower vs. Higher) x 2 (Target knowledge: Lower vs. Higher) x 2 (Anchor magnitude: Lower vs. Higher). The procedure was the same as in Experiment 2.

Results and Discussion

We removed 2 responses that were above 10 standard deviations from the domain maximum. Data were normalized with respect to the domain-maximum distribution as in Experiment 1 and 2.

We first examined response patterns within each domain separately, since each formed a manipulation of target knowledge and anchor magnitude. In all six domains higher anchors were associated with higher ratings (*p*s < .05). One item showed an effect of target knowledge (p = .051). No other effects or interactions were reliable in this analysis.

As a second analysis we performed an omnibus anova. This analysis revealed a main effect of anchor ($F(1,839)$ = 337, p < .001) and a main effect of domain knowledge ($F(1,839)$ = 12, p < .01). Higher knowledge domains were associated with higher estimates (M = 2.2 vs. 1.78). In this analysis, the model accounted for 29% of the variance (adjusted R^2), but a model including only the anchor magnitude factor accounted for 28% of the variance (adjusted R^2). That is, knowledge-related factors did not introduce a qualitative change in the variance accounted for.

We also examined the departure of estimates from domain maximum (y = 0) for each item. We performed 24 t-tests as there were 4 estimates for each domain. Estimates for all targets differed reliably from 0 (*p*s < .05; FDR corrected for multiple comparisons). The mean estimate for lower anchors was 1.03 and the mean estimate for higher anchors was 2.14. In other words, participants anchored to the given values rather than to the domain maximum (0). This effect was more pronounced for higher anchors.

Discussion

This research was motivated by the observation that extreme numerical suggestions strongly affect people's estimations. A factor that could explain this effect is one's confidence in his or her knowledge – a factor whose role has not be explored to date. We identified two relevant types of knowledge– that of a domain maximum and that of the specific target assessed. Our central hypothesis was that greater confidence in one's knowledge of either of these would yield decreased assimilation to implausible anchors, which in our study were defined as being either 1 or 4 standard deviations above an estimated domain maximum.

Experiment 1 examined the impact of confidence in the knowledge of the domain maximum, and Experiment 2 extended it to also manipulate confidence in the knowledge of the target item itself. Both experiments yielded the expected anchoring effect replicating prior work in the field. Both experiments indicated that higher confidence in the knowledge of the domain maximum mediates the impact of extreme anchors. In Experiment 1, confidence in domain maximum reduced the impact of the higher anchor, but not that of the lower anchor (Fig. 1). In Experiment 2, confidence reduced the impact of both higher and lower anchors, and in addition attenuated the overall anchoring effect (i.e., the difference between lower and higher anchor).

Experiment 2 also revealed how estimations were related to both domain and target confidence. When domain confidence was higher, estimations were quite low and unrelated to target confidence. This suggests that confidence in the domain maximum is sufficient for modulating the impact of an extreme anchor. Interestingly, when confidence in the domain was lower, participants gave higher estimations for *higher confidence* targets (we address this issue below). Experiment 3 tested whether knowledge, defined as the populations' consensus regarding the domain or target extensions, mediates the impact of extreme anchors. The experiment revealed a strong effect of anchor magnitude for all items, as in Experiments 1 and 2. However, this effect was not mediated by any knowledge-related factor. While higher knowledge domains appeared more sensitive to the anchors, this factor accounted for only 1% of the total variance explained in the experiment. It is possible that these domains were associated with more fluid knowledge retrieval, which lead to a tendency to accept higher values for them.

Our experiments also tested whether participants anchored to the domain maximum, as hypothesized in prior work (e.g., Mussweiler & Strack, 2001). In Experiments 2 and 3, estimates exceeded the domain maximum in all conditions. In Experiment 1 only the estimates for high confidence domains exceeded the domain maximum. However, note that since the responses that agreed with the anchor were removed, the reported effects were attenuated.

These departures from the domain maximum were also found for higher confidence domains: both anchors prompted estimates above domain maximum, with higher anchors prompting higher estimations. It is difficult to explain this by assuming that people's estimates reflect solely adjustment to the domain maximum. At the same time, the fact that the anchoring effect was stronger for lower confidence than higher confidence domains suggests that participants were influenced by the domain maximum.

The finding that higher-confidence targets were more affected by anchors when domain confidence was lower (Exp 2) was unexpected; we predicted that in general higher confidence would yield lower estimates. A possible explanation is that participants' confidence in their domain-maximum estimations and their confidence in target estimations indexed different processes. Confidence ratings for the domain knowledge seem to index strength of belief, or commitment. In contrast, confidence ratings for the target knowledge could be driven by ease-of-retrieval misattribution effects. High processing fluency can increase reported confidence of responses (Werth & Strack, 2003). People might feel more confident when estimating the maximum speed of a BMW-Z4 than that of a Pontiac Solstice, since they can easily retrieve information regarding the former. They could therefore conclude that their ability to access information easily indicates that such information is correct. This could explain why confidence in target estimations did not modulate the impact of anchors in the expected direction. Furthermore, it is possible that the experience of fluency for a target, when presented with an anchor, leads participants to more willingly entertain a large value with respect to the target: if the anchor is true of the target that would explain why it is easily recognizable.

It should be noted that in this research even the higher-confidence domains and targets did not receive very high confidence ratings. We did not use domains with very high confidence for two reasons. First, we wanted to manipulate orthogonally domain-maximum and target confidence, but we were unable to find low-confidence targets for high-confidence domains. Second, when people are highly certain of the domain-maximum or target value it is likely that anchors should not have any impact. This would have resulted in a floor effect in the study.

Although more research is necessary to understand the impact of confidence and anchor magnitude on estimations, our findings demonstrate that meta-cognitive factors are highly relevant for explaining the effects of implausible anchors.

Acknowledgments

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