The Stepwise Anchoring Paradigm: Measuring Reliable Components of Anchoring and Adjustment as the Next Step in Moderator Research

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Abstract

Although anchoring research has explored personality moderators for at least 13 years, it has not produced any robust findings. The reason for this surprising fact is rooted in the problem that most anchoring tasks have unacceptable reliability levels. In a preregistered experiment, we introduce a paradigm that we call the *stepwise anchoring paradigm*. It is based on the incumbent insufficient adjustment model of anchoring and previous research by Frech et al. (2020). Using the stepwise anchoring paradigm and estimates of animals' weights, we reliably measured parameters of anchoring effects and investigated whether these parameters were correlated with theoretically relevant personality traits (i.e., cognitive reflection and impulsiveness). The reliability of the number of adjustment steps was acceptable ($\alpha = .869$, 12 items, $N = 125$) and much higher than the reliability of the total adjustment ($\alpha = .387$), which has previously been used as an indicator of susceptibility to anchoring. However, we found no robust anchoring effects and no correlations between anchoring parameters and impulsivity or cognitive reflection. Thus, although a method for reliably measuring the susceptibility to anchoring is now available, its validity is still questionable.

Keywords: anchoring and adjustment, anchoring effect, reliability, cognitive reflection, impulsiveness

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When people make numerical estimates, their estimates have been shown to be biased toward random numbers that they have previously considered. This phenomenon is called *anchoring* and has been investigated rigorously since it was made famous by Tversky and Kahneman (1974). Many models have been proposed to explain why and when anchoring occurs (e.g., Frederick & Mochon, 2012; Mussweiler & Strack, 1999a; Wegener et al., 2001), and in recent years, substantial research has been devoted to answering the question of which personality traits moderate the susceptibility to anchoring (e.g., Cheek & Norem, 2018; Furnham et al., 2012; Teovanović, 2019; Welsh et al., 2011).

However, after a decade of research on individual differences in anchoring, results have been extremely inconsistent. For example, Cheek and Norem (2019) found evidence of positive, negative, and null correlations between openness to experience and anchoring, and the same has been true for the relation between agreeableness and anchoring. The most plausible explanation for these blatant contradictions is the lack of a method to reliably assess people's susceptibility to anchoring (Röseler et al., 2019). In fact, how strongly an anchor influences people's judgments of one item is not or is only weakly correlated with how strongly an anchor influences their judgments of another item (for an overview of reliabilities of anchoring tasks, see Röseler et al., 2019, p. 21).

All Models Are Wrong, but Some Are Useful

Anchoring research that has been conducted without a solid theoretical foundation has not yielded many insights. For example, studies on incidental anchoring (i.e., presenting anchors below the attention threshold; Critcher & Gilovich, 2008) and subliminal anchoring (i.e.,

presenting anchors below the perception threshold; Mussweiler & Englich, 2005) could not be replicated (e.g., Klein et al., 2018; Röseler, Schütz, Blank et al., 2020, respectively). Thus, the most promising way to both develop an anchoring task that has high reliability and find moderators on this basis seems to refer to theories and models of anchoring.

However, this is easier said than done. There are many theories, and in line with Box (1976), each of them has been faced with findings that the theory has not been able to explain. Moreover, there have been contradictions, even among predictions that were derived from the same theory. Replication failures and a lack of empirical content in the domain of personality moderators have made strong theorizing even more difficult. Most researchers have not tried to falsify any of the models but have simply attempted to make their own model more plausible than the other models, for example, by stating that “... the explanatory sufficiency of each theory reduces the value of alternate theories...” (Mochon & Frederick, 2013, p. 77; see also Yarkoni, 2020, May 6 for a general discussion about falsification in psychological science). In the following, we summarize the most popular anchoring theories and argue for why the insufficient adjustment model (e.g., Epley & Gilovich, 2001) is the most useful theory for personality moderator research.

Selective Accessibility Model

According to the selective accessibility model (e.g., Mussweiler & Strack, 1999a, 1999b), people test whether the anchor is a good value (hypothesis-consistent testing) and activate knowledge that is consistent with the anchor (semantic priming). Potential moderators in this line of reasoning would be those that are relevant to semantic priming, such as need for cognition (Petty et al., 2008) or associative thinking (Wood et al., 2011). Although this model has been the most prominent one for some years, recent findings have raised doubts about its usefulness. For

example, in the case of ego depletion, different researchers derived from the selective accessibility model the opposing ideas that ego depletion leads to stronger (Banker et al., 2017) and weaker (Francis et al., 2018) anchoring effects, and both were wrong (Röseler, Schütz, Baumeister, & Starker, 2020). Even stronger doubts arose when the “most compelling evidence” for the selective accessibility model could not be replicated: No evidence for a faster recognition of words that were primed by an anchor (e.g., “summer” for a hot temperature anchor) could be found in a series of five preregistered experiments (Harris et al., 2019).

Scale Distortion Theory

The scale distortion theory is one of the more recent accounts of anchoring effects. In its original version, anchoring was construed as only a language effect (in contrast to a representation effect; Frederick & Mochon, 2012). Accordingly, in this line of reasoning, a high anchor does not increase the accessibility of high numbers as proposed by the Selective Accessibility Model, but it makes numbers that would otherwise seem plausible “appear smaller.” For example, “1,000 pounds [seems more plausible as an estimate for] a larger animal in the presence of this small anchor than without it” (Frederick & Mochon, 2012, p. 2). A recent refinement of the model (Mochon & Frederick, 2013) yielded two conditions that must be met for anchoring to occur: (a) the anchor and target must be assessed on the same scale and (b) the anchor and target must be related, or respondents must be forced to compare them. Mochon and Frederick (2013) argued that random anchors actually carry conversational norms (Grice, 1982). However, this account of anchoring is not an exclusive one—that is, it does not contradict other models.

When asking how assimilation toward the anchor actually works, the model does not offer a detailed account. Thus, to derive specific predictions, one has to rely on other models.

Furthermore, hypotheses about which personality traits (besides the knowledge of conversational norms) may be relevant moderators cannot be derived from scale distortion theory.

Insufficient Adjustment Model

A more specific model is the insufficient adjustment model. This model was inspired by Tversky and Kahneman's (1974) brief description of anchoring as "people make estimates by starting from an initial value that is adjusted to yield the answer" and the observation that the "adjustments are typically insufficient" (p. 1128). Epley and Gilovich (2001) refined this statement by describing the adjustment process via TOTE units (test, operate, test, exit; pp. 392-393). In this line of reasoning, a respondent tests whether the anchor seems plausible (test), adjusts it by adding or subtracting a number (operate), tests again (test), and stops (exit) as soon as the anchor seems plausible (see Figure 1). This model is the only one that provides the basis for measuring parameters other than the total adjustment (which was unreliable in almost all reported cases) and thus derives more specific hypotheses on personality traits that may moderate the susceptibility to anchoring. Different from all the other models, this model can be formalized, and on this basis, adjustment functions with different parameters (e.g., number of adjustment steps, adjustment step size, speed) can be modeled (see Figure 2). By conceptualizing adjustment in this way, adjustment can be understood as the result of a process that involves multiple parameters. This also means that, even if differences in total adjustment are unreliable, there may be underlying parameters that may be reliable. In other words, it may be less important to know *where* one arrived than to understand *how one got there*.

Figure 1

Anchoring and Adjustment in the TOTE Model

Figure 2

Hypothetical Adjustment Functions from a High Anchor for Two Subjects A and B

Individual TOTE parameters have already been measured. Frech et al. (2020) introduced a paradigm that required participants to indicate the adjustment steps they made. We used their data (<https://osf.io/dq48j/>, Study 2) to compute the reliabilities of different parameters and found that the total adjustment ($\alpha = .513$, three items, $N = 146$) and the number of steps ($\alpha = .693$) were reliable, but the average step size ($\alpha = .097$) was not. Moreover, step size decreased in a nonlinear manner such that the initial steps were the largest (for the code and detailed results, see

https://osf.io/yd7c8?view_only=783cf849e6804d678f624e7cda32cd99). In the following, we thus focused on the number of steps as an indicator of adjustment.

What is problematic about Frech et al.'s (2020) task, however, is that only high anchors were used, and participants provided only price estimates—and this is not a typical task in anchoring research. Moreover, the differences were qualitative, that is, the scale had no units, and the distances between the ticks that had been marked were not measured. Instead, participants wrote the numbers next to the ticks. This probably explains why the total adjustment was relatively reliable, too. Still, in the experiment on buying decisions, the total adjustment (i.e., the price estimate) was potentially confounded with the willingness to pay. Other anchoring moderator research has been plagued by similar problems (e.g., Bergman et al., 2010).

To better understand whether the paradigm introduced by Frech et al. (2020) is indeed fit to reliably measure the number of adjustment steps and potentially other adjustment parameters such as adjustment step size, the paradigm has to be adapted and used with classical anchoring effects. That is, adjustment after high *and* low anchors needs to be used for estimates that cannot be confounded with willingness to pay. This is what we tested in the present study. We refer to our version of the approach as the stepwise anchoring paradigm (STAP).

Potential Moderators of the Adjustment Process

We used the TOTE model to derive specific hypotheses on the question of which personality traits predict susceptibility to anchoring. We selected potential moderators by testing for a “common language” between anchoring and the moderators, that is, by considering which personality traits affected the TOTE process: Low cognitive reflection (Frederick, 2005) and high impulsiveness should both be associated with limited considerations and thus with the tendency to quickly affirm the “test” question in the TOTE process, conclude that a number is a

good estimate, and thus stop adjusting. Thus, we argue that both impulsivity and cognitive reflection should predict the number of adjustment steps.

Anchoring and Adjustment as Intuitive and Impulsive Responding

There is little previous research on impulsiveness and anchoring. The closest are reports by Röseler, Schütz, Baumeister, and Starker (2020) and Röseler et al. (2019), who correlated susceptibility to anchoring scores with self-control (Tangney et al., 2004) and found no effect but observed that the total adjustment was not reliable. Considering that intuitive and impulsive answers should lead to an earlier exit from the TOTE process (i.e., "yes, the proposed value is a good answer"), we argue that impulsivity should lead to a smaller number of adjustment steps. The corresponding argument can be made with respect to cognitive reflection: The easiest response to anchoring questions is usually the anchor or a value that is very close to it. This also holds for intuitive responses to the questions from the cognitive reflection task (CRT; Frederick, 2005), and this is why we would predict a positive relationship between the number of adjustment steps and cognitive reflection. In line with this reasoning, associations with other heuristics and biases and the CRT score have been found (e.g., base rate fallacy, conservatism bias, and endowment effect; Hoppe & Kusterer, 2009). But still, findings on anchoring have been heterogeneous: Whereas Meub et al. (2013) and Welsh et al. (2011) reported effects, there have also been reports of null findings (e.g., Bergman et al., 2010; Oechssler et al., 2009; Welsh et al., 2011). In our opinion, the inconclusiveness of previous findings can primarily be attributed to the problem of the low reliability of anchoring effects. This is why we used a new paradigm and tested the reliability of the number of adjustment steps in the anchoring process as a potential alternative indicator of susceptibility to anchoring.

Method

To test the STAP and to determine whether it could provide reliable anchoring parameters (i.e., number of adjustment steps and adjustment step size), we asked participants to estimate the weights of different animals, and we provided high and low anchors. We asked participants to indicate each adjustment step on a scale ranging from 0 to 100 kg. We informed participants of the necessary direction of adjustment (by presenting them with estimates that were too high or too low and had allegedly been made by previous participants) so that the participants' adjustments would be made in only one direction.

Our hypothesis, method, and plan for data analysis were rigorously preregistered (https://osf.io/5ua98?view_only=783cf849e6804d678f624e7cda32cd99). We report how we determined our sample size, all data exclusions, all manipulations, and all measures (Simmons et al., 2012). Slight deviations from the preregistration had to be made (i.e., the analysis script included errors that were fixed before we finished collecting all the data). All changes in the analysis script have been highlighted and commented on.

Planned Sample and Sensitivity

Data were collected online via social networks. Participants were offered the opportunity to participate in a lottery for a 10€ voucher in an online shop and could opt in for feedback on their performance. To provide feedback, we programmed an R (R Core Team, 2018) Shiny-app (Chang et al., 2020) that displayed the number of correct responses in the CRT task, the susceptibility to anchoring, the number of steps, and the z-scored absolute proportional inaccuracy of the estimated animal weights relative to all participants. On the basis of our capacity, we had planned to recruit at least 100 participants with a goal of recruiting approximately 208 participants from June 5 to June 30, 2020.

Hypothesis on the Reliability of Anchoring

As equivalence testing (Lakens et al., 2018) for coefficient alpha is not implemented in common statistical software, we tested for whether the reliability in our paradigm was *lower* (one-tailed test) than the reliability reported by Frech et al. (2020), that is, $\alpha = .69$, three items, $N = 146$. Given a sample size of $N = [100, 208]$, reliability needed to be $\alpha = [.415, .485]$ for us to detect a significant difference with $\alpha = \beta = 5\%$. This was still much higher than commonly estimated reliabilities of anchoring tasks (for an overview, see Röseler et al., 2019, p. 21). Our expectation was that, despite the high power, we would not find a significant difference between the reliability reported by Frech et al. (2020) and the reliability in the present study, and thus, we would be able to conclude that the number of adjustment steps is indeed a reliable anchoring parameter.

Hypotheses on Personality Moderators

Estimates of the correlations between traits and the number of adjustment steps could not be made because there is no previous research on this issue. We thus conducted sensitivity analyses for the personality trait hypotheses, that is, the correlations between the number of adjustment steps and (a) the cognitive reflection task score and (b) the impulsiveness score, too. The minimum Bravais-Pearson correlations for $N = [100, 208]$, $\alpha = \beta = 5\%$, and one-tailed tests needed to be $r = [.321, .225]$. A necessary condition for this hypothesis to be testable is a nonsignificant finding for the reliability hypothesis, that is, the reliability of the number of adjustment steps must be high.

Measures and Materials

The task we used to measure the anchoring parameters was a computerized, modified version of the paradigm used by Frech et al. (2020). Participants estimated the weights of

animals on a scale ranging from 0 to 100 kg (of which only options 1 to 99 kg were selectable due to technical restrictions¹). For each animal, the anchor that was presented was an estimate that had allegedly been provided by a previous participant and was too high (or too low). Thus, the direction of necessary adjustment was known, which addressed the concern that failing to consider the direction of adjustment may obfuscate potential moderation effects (Cheek & Norem, 2018).

We asked the participants to adjust their estimates by starting from the provided anchor and indicating all steps by clicking on the respective points of the scale. The instructions were adapted from the procedure used by Frech et al. (2020). The respective numeric values were automatically displayed when someone moved the mouse over the scale. A translated example of one item from the anchoring task and the scale are presented in Figure 3. We told participants that adjustment was possible in one direction only: When the anchor was high, we told participants that we would use their lowest estimate as their final estimate, and when the anchor was low, we told them that their highest estimate would be used as their final estimate. To test whether participants had understood the task, we presented them with a sample estimate similar to the one in Figure 3 and asked them to identify the final estimate. Participants were allowed to proceed only if they provided the correct answer.

The 12 items consisted of six pairs of animals that have similar weights. Anchors were chosen proportionally and symmetrically around the true values and in the range of 1 to 99 kg. For each of the pairs of animals, participants were given one high and one low anchor (see Figure 3 for an example with a high anchor). Thus, we were able to compute both within-

¹ Due to a technical error, the value of 57 kg was coded as 5 so that we thereby did not know whether a value of 5 represented an actual value of 5 kg or 57 kg. For the items whose low and high anchors were lower and higher than 57, respectively, we checked whether a value of 5 was coded, and we found one case. As a value of 8 was checked, too, we made no changes.

subjects anchoring strength and between-subjects anchoring strength. Participants were randomly assigned to one of two groups and presented with six high and six low anchors. Table 1 provides an overview of all items (animals), actual weights, anchors, and the anchors presented in the two groups.

Table 1

Overview of Item Pairs, True Weights, and Anchors in the Anchoring Task

Pair	Animal	True weight	High anchor	Low anchor
1	Rabbit	4.5	8	1
1	Cat	4.25	8	1
2	Fox	8	14	2
2	Racoon	8	14	2
3	Badger	15	26	4
3	Pelican	15	26	4
4	Beaver	25	40	10
4	Deer	25	40	10
5	Wolf	50	75	25
5	Goat	50	75	25
6	Hyena	60	84	36
6	Warthog	60	84	36

Note. Participants in Group 1 were given the anchors that are highlighted in grey.

Figure 3

Sample Item with Three Highlighted Estimates

The estimate of the person before you was **too high**. What would you estimate?

Estimate of the person before you: **Warthog, 84 kg**

Please indicate **all your mental steps** on the scale. The value that is the farthest from the proposal will be your final estimate.

Note. Light Blue bars indicate estimates. Light Red Bars Indicate 10s. The final estimate is 72.

Cognitive reflection is usually measured with the CRT (Frederick, 2005). However, the reliability of this task is low, too. Multiple versions of the CRT have been proposed (Primi et al., 2016; Thomson & Oppenheimer, 2016; Toplak et al., 2013). In order to achieve high reliability, we used a combination of all of them. An overview of all items, their sources, and the intuitive and correct answers is provided online (https://osf.io/ujyab/?view_only=783cf849e6804d678f624e7cda32cd99). To ascertain whether the participants were familiar with the items and whether this affected the item difficulties, we asked the participants to check all the items (not the solutions) that they had already known before the experiment.

Impulsiveness was measured with the Barrat Impulsiveness Scale (BIS-11), which consists of 30 items, such as “I do things without thinking” (Stanford et al., 2009). We included an attention check as the 16th item of the BIS-11, which asked participants to check “sometimes.”

Procedure

First, participants were greeted, informed about the purpose of the experiment (i.e., to estimate the body weights of animals), and asked to answer demographic questions (age, gender, highest educational level achieved). Then they completed the BIS-11, the attention-check item, and the CRT items. After they were informed about how the anchoring task worked, the participants estimated the animal weights. Finally, we presented the CRT items again (without the solutions) and asked the participants to indicate any questions they had already known the answers to before the study and whether they had looked up the answers. Participants had the

option to enter their e-mail address to take part in a lottery and the option to receive a link to the feedback. An overview of the procedure is presented in Figure 4.

Figure 4

Study Procedure

Greeting and Purpose of Experiment
Demographic Data age, gender, educational level
BIS-11 30 Impulsiveness self-report items and attention check
CRT 13 Cognitive reflection task items
Anchoring task 12 items
CRT check Check the questions that you already knew
Lottery participation and feedback

Data Analysis Plan

Power and sensitivity analyses, data processing, data analysis, and the feedback app were conducted with R (R Core Team, 2018) version 3.6.3 and the packages pwr (Champely, 2020), psych (Revelle, 2018), cocron (Diedenhofen, 2016), dmetar (Harrer et al., 2019), meta (Balduzzi et al., 2019), stringr (Wickham, 2018), cocor (Diedenhofen & Musch, 2015), Hmisc (Harrel, Frank, E., 2020), and shiny (Chang et al., 2020). Note that the entire analysis script was preregistered. All changes (e.g., due to coding errors) are highlighted and commented on.

The BIS-11 was computed as the mean of all items after reverse scoring the negatively keyed items. The CRT score was the sum of all correct answers. We allowed slight deviations from the true values in Table 1, such as “five” instead of “5” or “Sahra” instead of “Sarah” (see

the analysis script for the exact code,

https://osf.io/pvqdk/?view_only=783cf849e6804d678f624e7cda32cd99).

The number of adjustment steps was the number of checks on the scale. We subtracted 1 from the score if the anchor had been checked, too. The final estimate was the lowest value for high anchors and the highest value for low anchors. The total adjustment was the absolute difference between the anchor and the final estimate. The mean adjustment step size was the total adjustment divided by the number of adjustment steps. The within-subjects susceptibility to the anchoring score was computed as the high anchor minus the low anchor. The mean susceptibility to the anchoring score was the mean of the six z-transformed scores from the six pairs. See Figure 5 for a graphical representation of the anchoring parameters on the scale used in the 12 anchoring tasks.

Participants were excluded from the analysis if any of the following preregistered criteria were not met: (a) age was more than 17 years and less than 123 years, (b) completed all BIS-11 items, (c) passed the attention check, (d) showed variability in responses to the BIS-11, (e) estimate was not the anchor, (f) did not skip any anchoring item, (g) reported that they did not look up the CRT answers.

Figure 5

Anchoring (TOTE) Parameters as Operationalized from the Scale used in the Anchoring Task

Note. In the example, the anchor was 84 kg (too high). There were three adjustment steps with 72 kg as the final estimate, and the total adjustment was thus 12 kg. The mean adjustment step size was thus 3 kg per step.

Results

If not indicated otherwise (e.g., by the heading “Exploratory Analyses”), all reported results were preregistered. We highlighted changes from the preregistered analysis script in the script and discussed them if they involved aspects that went beyond coding errors.

Achieved Sample and Sensitivity

The achieved sample size was $N = 125$ (79 women; mean age = 28.84 years). A total of 66 participants were assigned to the “grey group” (see Table 1; i.e., rabbit was paired with a high anchor and cat with a low anchor). A sensitivity analysis revealed that the largest reliability for which we could have found a difference from the one reported by Frech et al. (2020) with $\alpha = \beta = .05$ was $\alpha = .506$. Given these parameters, the smallest detectable correlation between the number of adjustment steps and the personality traits was $r = .288$ (one-tailed test).

Reliability of Measures

The reliability of the CRT items was $\alpha = .802$ (13 items, $N = 125$). The BIS-11 impulsiveness scale reliability was $\alpha = .781$ (30 items, $N = 125$).

Manipulation Checks

We determined the strength of the anchoring effects between subjects (based on the two groups in Table 1) and within subjects (based on the estimates for the pairs of animals with equal weights but high and low anchors). We computed Cohen's d for all 12 items and conducted a random-effects meta-analysis to determine whether the overall effect was significantly larger than zero. However, the overall anchoring effect was not significantly larger than zero, $t(11) = 0.29$, $p = .778$, $d = 0.042$, 95% CI = [-0.279, 0.364]. A forest plot of all anchoring effects is displayed in Figure 6. Within-subjects anchoring effects were calculated for all six pairs of items with an overall nonsignificant anchoring effect, $t(5) = 0.26$, $p = .805$, $d_z = 0.029$, 95% CI = [-0.253, 0.310].

Figure 6

Forest Plot of Between-Subjects Anchoring Effects for All Items

Figure 7*Forest Plot of Within-Subjects Anchoring Effects for All Items*

Hypothesis Tests

The reliability of the number of adjustment steps was acceptable, $\alpha = .869$, 12 items, $N = 125$, and was not significantly smaller than Frech et al.'s (2020) reliability ($\alpha = .69$, three items, $N = 146$), $F(124, 145) = 2.37$, $p > .999$ (one-tailed test). An exploratory analysis revealed that the reliability in our task was not significantly higher, $p < .001$ (two-tailed test, exploratory analysis).

For the correlations with personality traits, contrary to our prediction, the number of adjustment steps was not positively correlated with cognitive reflection, $r(123) = -.103$, $p = .873$ (one-tailed) or negatively correlated with impulsiveness, $r(123) = .025$, $p = .609$ (one-tailed). Note that the directions of both correlations were opposite the hypothesized directions.

Exploratory Analyses

The reliabilities of the other anchoring parameters were lower than the reliability of the number of adjustment steps. An overview of the Cronbach's alphas for the other parameters as well as the measures reported above is provided in

Table 2. Despite their low reliability, the correlations between the other anchoring parameters and the personality traits were possible but were not observed. Correlations involving all the variables from the experiment are presented in Table 3.

Table 2

Reliabilities of the Constructs Measured in the Study

Parameter	Number of items	Average r	Coefficient α	Construct
Absolute adjustment ^a	12	.05	.39	Anchoring
Number of adjustment steps ^a	12	.38	.87	Anchoring
Adjustment step size ^a	12	.12	.58	Anchoring
WS difference score ^a	6	.13	.42	Anchoring
Weight estimates	12	.12	.61	Weight estimates
CRT 13 ^a	13	.24	.80	Cognitive reflection
CRT 3	3	.37	.64	Cognitive reflection
BIS-11 ^a	30	.11	.78	Impulsiveness

Note. $N = 125$. WS = within subjects.

^aPreregistered analysis.

Table 3

Correlation Matrix of Anchoring Parameters and Personality Traits

No.	Variable	1	2	3	4	5
1	Adjustment steps	.869	.190	-.676*	.025	-.103
2	Absolute adjustment	.190	.387	.526*	.236	-.187
3	Step size	-.751*	.931*	.622	.107	-.013
4	BIS-11	.107	.232	.134	.781	-.164
5	CRT 13	-.225	.029	.114	-.166	.802

Note. Values in italics represent Cronbach's alphas.

* $p < .001$.

Although we used almost the same instructions as Frech et al. (2020) did, the distribution of the number of steps was different in our experiment than in the study by Frech et al. (2020). For example, the mean number of steps in our study was $M = 1.73$ ($SD = 0.61$, $N = 125$) and thus smaller than in the study by Frech et al. (2020, $M = 3.80$, $SD = 1.30$, $N = 146$), $t(269) = 16.33$, $p < .001$, $d = 2.039$. A possible reason is that people are more familiar with stepwise estimates for price negotiations than when estimating weights.

As we had asked participants whether they had already known the CRT items (not the answers to them), the exclusion of items that are well-known had the potential to change the scale and thus the correlation with the number of adjustment steps. The proportion of people who knew the items was extremely high ($p_{\min} = .18$), and the bat-and-ball item was familiar to 43% of the participants. Surprisingly, however, the number of known items was not correlated with the number of correct answers, $r(123) = .005$, $p = .954$ (two-tailed). Direct feedback from some participants suggested that some of them misunderstood the question and reported whether they *remembered the listed items from earlier in the experiment* instead of whether they had known the items.

Discussion

Although personality moderator research represents a major part of the anchoring literature from the past 13 years (e.g., McElroy & Dowd, 2007), little has changed since Furnham and Boo (2011) stated that “researchers have failed to identify any ... trait variables that have a systematic and explicable effect on anchored decisions” (p. 40). This is most likely the case because anchoring scores have demonstrated low reliability (Röseler et al., 2019). We tried to solve this problem by adapting a paradigm by Frech et al. (2020), which was based on the insufficient adjustment model of anchoring (e.g., Epley & Gilovich, 2001) and required

participants to indicate all of their adjustment steps: First, we reanalyzed the data provided by Frech et al. (2020) and found that the *number of adjustment steps* was a much more reliable indicator of susceptibility to anchoring than the traditionally used absolute total adjustment from the anchor. Still, the validity of the susceptibility score is questionable, as we did not find significant anchoring effects.

Second, we adapted the paradigm that Frech et al. (2020) had used with buying decisions and high anchors and used it with traditional anchoring items (weight estimation), a larger number of items (12 instead of three), and both high and low anchors. Furthermore, we used a repeated-measures manipulation of the anchor and were thus able to estimate within-subjects anchoring effects. An analysis of four different anchoring parameters (i.e., total absolute adjustment, number of adjustment steps, average adjustment step size, and within-subjects difference scores) corroborated the hypothesis that the number of adjustment steps is the most reliable parameter in the paradigm. The results are in line with those from Frech et al. (2020).

On the basis of the TOTE model of anchoring, we hypothesized that an early exit from TOTE loops (i.e., a small number of adjustment steps) would be related to low cognitive reflection or high impulsiveness. However, we found no evidence for either of these hypotheses. This leaves open the question of what psychological constructs may be associated with the number of adjustment steps or other adjustment parameters in anchoring.

Limitations and Future Directions

For future research with the STAP, we advise researchers to a) include more items to achieve higher reliability, b) use more difficult items in order to provoke larger anchoring effects, and c) refrain from using a visual scale, which may eliminate anchoring effects due to additional anchors (e.g., minimum and maximum estimates presented on the scale).

Furthermore, animal weight estimation and price estimation are limited by the number of animals or products. Considering the development of a diagnostic tool for assessing susceptibility to anchoring, future paradigms should use stimuli that are unlimited and thus more practical for use in repeated-measures designs, for example, estimates of the number of dots in a scatterplot (e.g., Röseler et al., 2019). Although a hyena and a warthog weigh about the same, their estimated weights may differ. This would not be the case for the number of points in a scatterplot: Most people would not realize if they were shown 50 randomly distributed points twice.

In our study, we did not discuss whether the anchor should be random or informative. Framing our anchors as estimates from a previous participant rendered the anchors informative rather than random. Although research has shown that random anchors work, too (e.g., English et al., 2006), some have found that random anchors have smaller effects than informative anchors framed as suggestions (e.g., Röseler et al., 2019, pp. 13-14), and some studies have even observed no effect at all in the case of random anchors (e.g., Schweickart et al., 2020). Future research needs to determine the degree to which random anchors lead to anchoring effects and why effects for informative anchors may be different. The STAP may provide a useful tool for addressing this question. For example, adjustment from random anchors could involve more or larger adjustment steps.

Sources of variation of reliability between studies are still unknown and need to be investigated. For example, why was the total adjustment more reliable in our study than in other studies? The most problematic case would be if the STAP altered the anchoring process by “dictating” to participants that they needed to make adjustment steps in the form of a conversational norm or demand characteristics (Grice, 1982). This concern can partly be ruled

out because, for example, the effect of precise (vs. round) anchors on anchoring effect strength is similar in this paradigm (Frech et al., 2020) as it is in the traditional one (Janiszewski & Uy, 2008; Loschelder et al., 2014; Loschelder et al., 2017; Mason et al., 2013). To be even better able to rule out the concern that the number of adjustment steps represents only a methodological artifact, we suggest that different paradigms need to be developed to assess TOTE parameters such as the number of adjustment steps.

The most pressing problem in anchoring and personality trait research is the lack of any substantial and replicable correlation between anchoring parameters and personality traits. Although the present study provides a reliable measure of susceptibility to anchoring, we do not yet know about the validity or more specifically the construct validity of this measure. We also do not know why the *number* of adjustment steps but not the *size* of the adjustment steps is reliable. In the worst case, the number of adjustment steps might not even represent the loops involved in the TOTE process but something else. One way to establish the construct validity of the adjustment steps is to manipulate the number of steps—analogous to Frech et al. (2020) who successfully manipulated the average step size by providing exact anchors (i.e., numbers with fewer zeros in them). Some participants gave us the personal feedback that they were worried because they made only a single adjustment step by just guessing a final value immediately. It is evident (Epley & Gilovich, 2001) and in line with Frech et al.'s (2020) and our data that there are people who make multiple adjustment steps. However, it is possible that there are also some people who make only a single adjustment step.

There remain a wealth of parameters that can be integrated in the TOTE model, such as the time needed to make adjustment steps, the (non)linearity of adjustment, or whether all steps are made in the same direction. In fact, some participants asked us why the adjustments could

only be made in one direction, which suggests that the applied model may be too simple in that it does not permit the second step to be closer to the anchor than the first step. Further analyses of Frech et al.'s (2020) data showed that there were a few individuals who not only adjusted *away* from the anchor but in a later step also adjusted backwards *toward* the anchor. The paradigm used in this study is only one way to measure these parameters. Other models that incorporate parameters differently or models that use more parameters might be even more suitable for the measurement of anchoring and adjustment parameters. Future research needs to find the optimal number of parameters while still maintaining a certain degree of parsimony. Some possible TOTE models of anchoring are summarized in Figure 8 and Table 4. The model we used can be characterized by a fixed direction of adjustment, variable step size, unknown time between steps, and discrete steps.

Figure 8

Different TOTE Models Allow for Different Possible Adjustment Functions

Table 4

Overview of Model Parameters from Figure 8

Model	Direction of adjustment	Step size	Time between steps	Nature of steps
1	Fixed	Fixed	Fixed	Discrete
2	Fixed	Decreasing	Fixed	Discrete
3	Variable	Variable	Fixed	Discrete
4	Variable	Variable	Variable	Discrete
5	Variable	Variable	Variable	Continuous

Conclusion

Individual differences in anchoring have been investigated for more than a decade. Still, researchers have overlooked a crucial but necessary condition for valid results, namely, reliability. In this paper, we tested the STAP and can state that this approach is currently the first and only way to assess anchoring and adjustment reliably by breaking down the adjustment process into the number and sizes of adjustment steps. A surprising finding was that the present study, to our knowledge, is the first report of an actual contrast effect in an anchoring paradigm: instead of *insufficient adjustment*, participants showed adjustment that was too far away from the anchors.

Open Practices Statement

All study materials, data, the analysis script (https://osf.io/fjxmww/?view_only=783cf849e6804d678f624e7cda32cd99), and the preregistration (https://osf.io/5ua98/?view_only=783cf849e6804d678f624e7cda32cd99) are available online. Note that minor changes due to coding errors were made to the analysis script after the preregistration. We highlighted and explained all of these changes in the analysis script.

Author Contributions

LR planned and programmed the study and the analysis script and created the preregistration and the first draft of the manuscript. IKD, KF, YH, JCH, ELEI, AHK, SK, DS,

and AZ created the study materials and recruited participants. JJR checked and revised parts of the analysis script. All authors revised and approved the manuscript for publication.

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