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Abstract

Two experiments were conducted to examine the role of three facets of numeracy (objective (ONS), subjective (SNS), and symbolic number mapping (SMap)) in three anchoring tasks (experimenter-given, self-generate, and valuation). We found that the three numeric competencies were associated with different anchoring tasks. SMap was associated with none of the three anchor tasks, while ONS consistently predicted stronger susceptibility to self-generated anchoring. The role of ONS and SNS in experimenter-given and valuation tasks were inconsistent. In Experiment 1, where the direction of adjustment from an anchor is specified, ONS and SNS were positively associated with anchor susceptibility in a valuation task, while they were not in an experimenter-given anchor task. On the other hand, in Experiment 2 where the direction of adjustment from an anchor is uncertain, ONS and SNS were positively associated with anchor susceptibility in an experimenter-given anchor task, while they were not in a valuation task.

Keywords: anchoring effect; numeric competencies; individual differences; decision biases; symbolic number mapping; anchor susceptibility

Introduction

Anchoring refers to a tendency for people's numeric judgments to incorporate an initially considered standard, regardless of its relevance to the given numeric judgment tasks (Tversky & Kahneman, 1974). Anchoring has been examined in diverse domains, including factual knowledge, negotiations, time estimation, physical length estimation, math calculation, medical decisions, and legal sentencing (for a recent review, see Furnham & Boo, 2011). A recent project on replicability of diverse findings in psychological science tested anchoring effects at 36 different labs around the world, and found that anchoring is a robust phenomenon, with an effect size stronger than in the original study (Klein et al., 2014). Moreover, anchoring has been known to be hard to debias (Wilson, Houston, Etling, & Brekke, 1996).

Despite its robustness, the role of individual difference factors in anchoring effect is inconsistent and inconclusive (Bergman, Ellingsen, Johannesson, & Svensson, 2010; Bodenhausen, Gabriel, & Lineberger, 2000; Brandt, Evans, & Crawford, 2014; Furnham, Boo, & McClelland, 2012; Welsh, Delfabbro, Burns, & Begg, 2014). For example, McElroy and Dowd (2007) investigated the role of personality traits on anchoring, and found that *openness-to-experience* to be positively associated with the anchoring effect. Furnham et al. (2012), however, did not find the same result from their study. Studies on the role of cognitive abilities in anchoring have also shown inconsistent results. For example, Bergman et al. (2010) showed that participants with higher cognitive reflection task (CRT) score were less influenced by an anchor than participants with lower CRT score, while Oechssler, Roider, and Schmitz (2009) and Stanovich and West (2008) did not.

Surprisingly, even though most anchoring tasks involve numeric estimation or judgments, the literature on individual differences and anchoring has not shown any significant effects of numeracy on anchoring bias. Numeracy an important cognitive ability, and is a separable construct from other cognitive abilities (Peters & Bjalkebring, 2015). Moreover, previous studies showed that numeric competencies are associated with diverse decision tasks (Burns, Peters, & Slovic, 2012; Dieckmann, Slovic, & Peters, 2009; Liberali, Reyna, Furlan, Stein, & Pardo, 2012; Miron-Shatz, Hanoch, Doniger, Omer, & Ozanne, 2014; Peters, 2012), but only a handful of studies have investigated the role of numeracy on anchoring bias, all finding null effects. For example, Stanovich and West (2008) showed a null effect of numeracy (partially captured from SAT score) on anchoring, and Welsh et al. (2014) investigated the effect of numeracy skill on anchoring susceptibility using the Numerical Ability Test (Bennett, Seashore, & Wesman, 1947). Both studies, however, did not find any significant association between numeracy and anchoring biases.

In this study, we aimed to investigate the role of numeric competencies on anchoring bias by improving two limitations from the previous studies on the role of numeracy in anchoring. First, the previous studies focused on only one facet of numeracy, objective numeracy - the ability to understand and utilize mathematical concepts. However, Peters and Bjalkebring (2015) recently showed that numeracy is not a single construct. They introduced three aspects of numeracy (objective, subjective, and approximate numeracy), and that they are distinct from other. Subjective numeracy is a person's self-perception of their own ability to use and understand numbers, which might be formed by their actual ability to utilize numbers and emotional responses about numbers. Approximate numeracy is the ability to accurately classify numeric magnitude, which is known to be associated with informal math skills in early developmental stages. Peters and Bjalkebring (2015) also showed that each numeric competency is associated with different cognitive tasks. For example, objective numeracy is associated with decision bias in an attractiveness rating task (Bets task; showing lower preference for a non-loss gamble ($9 in 7/36; nothing in 29/36) over a loss gamble ($9 in 7/36; lose 5 cents in 29/36), even though the non-loss gamble has higher expected value), while subjective and approximation numeracy were not. In another task, where participants were asked to state monetary amounts that made them indifferent to risky gambles with high gains, they showed that objective and approximation numeracy were associated with closer valuation of the indifferent point for the sure thing to the expected value of the risky gamble, while subjective numeracy was not. Based on the finding that different numeric competencies are associated with different decision tasks, in this study, we used three different facets of numeracy to investigate the role of numeracy in anchoring biases.

Second, we investigated the role of numeracy on three different types of anchoring tasks: experimenter-given anchors, self-generated anchors, and valuation tasks. The previous literature on the relationship between numeracy and anchoring has focused on only experimenter-given anchors for factual questions. In the experimenter-given anchor task, participants are asked to answer a series of factual questions (e.g., the length of Mississippi river), preceded by a comparison (anchoring) question whether the answer for the given question is lower/higher than an anchor (Jacowitz & Kahneman, 1995). Self-generated anchor tasks (e.g., the freezing point of vodka) also uses factual questions, but a comparison question is not provided (Epley & Gilovich, 2001). They can use self-generated anchors by retrieving relevant quantities (e.g., the freezing point of water), and previous studies show that the mechanisms are different between experimenter-given and self-generated anchor tasks (Epley & Gilovich, 2001, 2005). Valuation tasks can also be regarded as a type of experimenter-given anchor task, but an individual's preferences plays into an important role. Indeed, valuation studies showed weaker and inconsistent results compared to other anchoring tasks. For example, Ariely, Loewenstein, and Prelec (2003) and Bergman et al. (2010) showed that a positive linear relationship between numeric anchor and willingness-to-pay, while Fudenberg, Levine, and Maniadis (2012) and Maniadis, Tufano, and List (2014) failed to replicate the effects. Based on the fact that different mechanisms are associated with different anchoring tasks, we tested the role of the three facets of numeracy in these three different types of anchoring tasks in two experiments.

General Method

Numeracy Measures

For measuring numeric competencies, we used the same measures and protocol used in Peters and Bjalkebring (2015). For the objective numeracy scale (ONS), we used an eight-item scale developed by Weller et al. (2013). An example of an ONS item is: "If the chance of getting a disease is 10%, how many people would be expected to get the disease out of 1,000?" We used the number of correct answers as a single score for ONS. The Cronbach's alpha of Experiment 1 was .74, and that of Experiment 2 was .66.

For the subjective numeracy scale (SNS), we used an eight-item scale developed by Fagerlin et al. (2007). An example of a SNS item is: "how good are you working with fractions?" We obtained a single score by adding up the ratings. The Cronbach's alpha of Experiment 1 was .85, and that of Experiment 2 was .86.

For measuring approximate mapping competence, we used a symbolic number mapping task, and followed the same procedure introduced in Peters and Bjalkebring (2015). Participants were asked to make marks corresponding to six numbers (4, 6, 18, 71, 230, and 780) on a 165-mm horizontal line with endpoints labeled 0 and 1,000, where each question was presented on a separate sheet. For the scoring, we followed the same two-step procedure used in prior studies (Peters & Bjalkebring, 2015; Schley & Peters, 2014). First, we obtained absolute deviation from the target length for each question, and summed across all the absolute deviations. Next, we log-transformed the summed absolute deviation to reduce positive skew issues, and multiplied by -1 so that a higher score indicates higher symbolic mapping ability.

The three numeric competency scales were positively correlated with each other, consistent with the literature (Table 1), but the correlation was not extremely high. This indicates that they are related but separable constructs (Peters & Bjalkebring, 2015).

Table 1: The Correlations Between Numeracy Scales (***p < .001)

	Experiment 1		Experiment 2	
Variable	1	2	1	2
1. ONS	-		-	
2. SNS	0.41***	-	0.46***	-
3. SMap	0.50***	0.34***	0.32***	0.35***

Anchoring Tasks

For the experimenter-given anchor task, we used the same eight stimuli used in Study 2 of Brandt et al. (2014) for Experiment 1, while we used six items used in Jacowitz and Kahneman (1995) for Experiment 2. For the self-generated anchor task, we used the six questions used in Epley and Gilovich (2006). For the valuation task, we used the six market goods used in previous studies on valuation anchoring (Ariely et al., 2003; Yoon, Fong, & Dimoka, 2013). An example of each task is presented in Table 2. In the valuation task, participants were asked to state the maximum amount they would be willing to pay (WTP). We calculated individual-level anchor susceptibility with two procedures: first, we calculated the distance from the given anchor (anchor distance) and rank-transformed the anchor distance to correct right skewedness (Brandt et al., 2014; Klein et al., 2014). After rank-transformation, we rescaled the score to be within a range from 0 to 1. This rescaled anchor distance was a dependent variable in both experiments. In Experiment 1, we explicitly presented the direction of adjustment (e.g., the length of Mississippi River is longer/shorter than 70 miles), as used in previous studies on anchor susceptibility (Brandt et al., 2014). In Experiment 2, we used classic anchors in which the direction of adjustment is uncertain (e.g., do you think the length of Mississippi River is longer or shorter than 70 miles?), since it has been shown that anchoring effect is stronger when the direction of adjustment is uncertain than when it is certain (Simmons, LeBoeuf, & Nelson, 2010).

Table 2: An Example of Experimenter-Given, Self-Generated, and Valuation Anchor Task

Experimenter-Given Anchor Task
What is your best estimate for the length of the Mississippi River? (low: 70 miles; high: 2,000 miles)

Self-Generated Anchor Task
What is the freezing point of vodka?
(self-generated anchor: 32F, the freezing point of water)

Valuation Task
What is the most you would be willing to pay for this cordless mouse?

Experiment 1

Methods

Participants: A total of 216 participants (M_{age} = 35.75, SD = 10.80, Female = 42%) were recruited from Amazon MTurk, receiving 50 cents in exchange for participating in a 15-minute study. Participants were recruited with the criteria that location is U.S. only, approval rate is greater or equal to 97%, and the number of times approved is greater or equal to 1,000 times.

Procedure: Participants were randomly assigned to one of the three conditions: experimenter-given anchor (N = 75), self-generated anchor (N = 70), or valuation tasks (N = 71). For experimenter-given anchor and valuation tasks, half of the questions were given with high anchors, and the other half was given with low anchors (a within-subject design). The order was counterbalanced across participants. After completing anchoring task, participants responded to the three numeracy tests in a randomized order. At the end of the study, participants were asked to provide demographic information (e.g., age and gender). To test the anchoring effect, we regressed numeric estimates (or WTP) on anchoring condition (categorical variable, coded 0 for low anchor and 1 for high anchor) and question fixed effects. To examine the role of numeracy in anchoring, we used hierarchical linear regression analysis with random coefficients for each participant, using Stata 14 software.

Results

Experimenter-Given Anchor Task: We found a significant anchoring effect: the answer for high anchor questions was significantly higher than that for low anchor questions (b = 0.16, p < .001). Similar to previous studies (Welsh et al., 2014), ONS was not associated with anchor distance. Indeed, the other numeracy scales (SNS and SMap) were not significantly associated with anchor distance in experimenter-given anchor task (Table 3, column 1).

Self-Generated Anchor Task: The result shows that ONS is negatively associated with anchor distance, while SNS and SMap were not. This implies that participants with higher score in ONS are more susceptible to self-generated anchoring (Table 3, column 2).

Valuation Task: For the valuation task, similar to previous valuation tasks, we found a weaker anchoring effect compared to the experimenter-given anchor task (b = 0.06, p = .090). The results of hierarchical linear regression analysis for the effect of numeracy on anchoring effect showed that ONS and SNS were significantly associated with anchor distance (positively), while SMap was not (Table 3, column 3). This implies that high ONS and SNS predict lower anchor susceptibility in valuation task.

Table 3: Multilevel Regression Results in Experiment 1 (each numeracy scale was run separately) (* p < .05, ** p < .01, standard errors are in parentheses)

	(1) Experimenter-Given	(2) Self-Generated	(3) Valuation
ONS	0.119	-0.185**	0.152**
	(0.064)	(0.055)	(0.055)
SNS	0.131	-0.145	0.211**
	(0.077)	(0.078)	(0.072)
SMap	0.170	-0.132	0.038
	(0.116)	(0.072)	(0.079)
N	575	420	374

Discussion

In Experiment 1, we explored the relationships between three facets of numeric competencies and three types of anchoring tasks. For the experimenter-given anchor task, we found a null effect of the three numeracy scales on anchoring biases. This result is in line with the previous literature on the role of ONS on anchoring effect (Stanovich & West, 2008; Welsh et al., 2014). We additionally found that SNS and SMap are not significant predictors of anchoring biases. For the self-generated anchor task, ONS significantly predicted anchor distance, but the direction was toward self-generated anchor, which indicates higher anchor susceptibility. This might be due to the fact that high ONS participants may have considered self-generated anchors more and may have been influenced by self-generate anchors, similar to the result of higher decision bias in the Bets task in Peters and Bjalkebring (2015). Peters and Bjalkebring (2015) explained that the stronger bias for high ONS participants in the bets task might be driven by increased processing of available meaningful numerical information (comparing $9 gain and losing 5 cents) for the high ONS participants. We conjecture that more active use of self-generated anchors by high ONS participants might contribute to their higher susceptibility to self-generated anchors. For the valuation task, both ONS and SNS were positively associated with anchor distance, which indicates less anchor susceptibility, while SMap was not a significant predictor of anchor distance.

In Experiment 1, we explicitly specified the direction of adjustment for the comparison question (anchor) in experimenter-given and valuation tasks. Simmons et al. (2010) showed that participants were less susceptible to anchors when the direction of comparison question is explicitly specified. Brandt et al. (2014) also showed a stronger or similar anchoring effect when the direction of adjustment is uncertain than when it was certain. Moreover, the directed anchor in valuation task was informative to the given task (e.g., the market price of the item higher than $10) by informing participants about market price or by having participants consider market price of the market goods used in this study. In Experiment 2, we examined the role of numeracy in anchoring biases using classic uncertain direction comparison questions as anchors and employing a between-subject design for high/low anchors to rule out the possibility that the results were contributed from the characteristics of within-subject design.

Experiment 2

Participants and procedure: A total of 353 (M_{age} = 35.73, *SD* = 11.77, Female: 46%) participants were recruited from Amazon MTurk with the same recruitment criteria as in Experiment 1. Overall procedures were similar to Experiment 1, except that high/low anchor was a between-subject factor and the direction of adjustment for the anchor question was not explicitly specified. Therefore, participants were randomly assigned one of the five conditions: experimenter-given low anchor (*N* = 69), experimenter-given high anchor (*N* = 75), self-generated anchor (*N* = 64), valuation low anchor (*N* = 72), and valuation high anchor (*N* = 73).

Results

Experimenter-Given Anchor Task: We found a significant anchoring effect (b = 0.58, $p < .001$): the answer for the high anchor group was significantly greater than that for the low anchor group. We found that both ONS and SNS are positively associated with anchor distance, while SMap was not (Table 4, column 1). This indicates that high ONS and SNS participants may be less susceptible to experimenter-given anchor.

Self-Generated Anchor Task: Consistent with Experiment 1, only ONS was negatively associated with anchor distance, while the other two numeracy measures were not associated with anchor distance (Table 4, column 2). This result replicates the finding that higher ONS predicts higher susceptibility to self-generated anchor.

Valuation Task: In Experiment 2, we found a significant positive effect of anchoring on WTP (b = 0.32, $p < .001$). In Experiment 1 where anchor was market price, we found a marginally significant anchoring effect, while in Experiment 2 where anchoring was their willingness-to-buy for a random price, we found a significant anchoring effect. This might imply that providing price information or leading participants to think about the market price of an item seem to reduce anchoring effects in valuation tasks. For the effect of numeracy on anchoring, none of the numeracy measures were associated with anchor distance (Table 4, column 3).

Table 4: Multilevel Regression Results in Experiment 2 (each numeracy measure was run separately) (* $p < .05$, standard errors in parentheses)

	(1) Experimenter-Given	(2) Self-Generated	(3) Valuation
ONS	0.161*	-0.196*	-0.020
	(0.058)	(0.091)	(0.083)
SNS	0.187*	-0.095	0.149
	(0.072)	(0.095)	(0.083)
SMap	0.071	-0.010	0.158
	(0.074)	(0.089)	(0.116)
N	848	384	788

Discussion

In Experiment 2, we examined the role of three facets of numeracy on anchoring biases, with an uncertain anchor where the direction of adjustment was not clear. While participants generally adjusted their estimates in the direction specified in the description in Experiment 1, participants could adjust both higher or lower than a given anchor in Experiment 2. Previous literature has shown that anchoring effect is stronger when a comparison question is uncertain than when the comparison anchor specifies a certain direction to be adjusted (Brandt et al., 2014; Simmons et al., 2010). Therefore, in Experiment 2, we tried to replicate findings in Experiment 1 with a study design wherein experimenter-given anchor shows stronger effect. Compared to Experiment 1, we found slightly different patterns regarding the role of numeracy on anchoring biases. Consistent with Experiment 1, we found that only ONS significantly predicted higher susceptibility to self-generated anchor. In contrast, we found the opposite pattern in experimenter-given anchor and valuation tasks. ONS and SNS significantly predicted lower anchor susceptibility in experimenter-given anchor task, which is inconsistent with previous studies (Stanovich & West, 2008; Welsh et al., 2014) and Experiment 1. For the valuation task, unlike Experiment 1, we did not find significant effects of ONS and SNS on anchor distance. The results seem to imply that different types of anchor comparison might interact with ONS and SNS in experimenter-given anchor and valuation tasks.

General Discussion

In this study, we examined the distinctive role of three facets of numeracy (objective, subjective, and symbolic number mapping) in anchoring biases by conducting two experiments. In Experiment 1, we examined three different anchoring tasks with a certain anchor where the direction of adjustment was explicitly stated, and found that ONS was associated with higher anchor susceptibility in the self-generated anchor task, and was associated with lower anchor susceptibility in the valuation task. SNS was associated with lower anchor susceptibility in the valuation task, but was not associated with the other two anchoring tasks. Finally, SMap was associated with none of the anchoring tasks used in this study.

In Experiment 2, we tried to replicate the findings of Experiment 1 with an uncertain anchor where the direction of adjustment was not stated. Since previous literature has shown that the anchoring effect is weaker when the direction of adjustment is clear (Brandt et al., 2014; Simmons et al., 2010), to rule out the possibility that the findings were contributed by the characteristics of the specified direction of adjustment, we employed the classic anchoring paradigm where the direction of adjustment is uncertain. We found the same result for the self-generated anchor task: only ONS significantly predicted higher susceptibility to self-generated anchoring, replicating the findings of Experiment 1. Therefore, we conclude that ONS is associated with higher anchor susceptibility in self-generated anchor tasks. For the other two tasks, however, we found the opposite patterns. Contrary to Experiment 1, ONS and SNS significantly predicted lower anchor susceptibility in the experimenter-given anchor task, while they did not predict anchor susceptibility in the valuation task. The conflicting results seem to imply that there could be a possible interaction between informativeness of an anchor (e.g., direction of adjustment, market price) and the two numeracy scales (ONS and SNS). Future research may be required to clarify the relationship between informativeness of an anchor and numeracy competencies in experimenter-given and valuation tasks.

In this study, the results of two experiments showed that the three different facets of numeracy were associated with different anchoring tasks, but there are still several limitations. First, even though we showed that ONS predicted higher anchor susceptibility to self-generated anchors, it is not clear that participants actually used the self-generated anchor in the task. Future research may be needed to test how actively participants use self-generated anchor depending on numeracy. Second, we did not find any association between SMap and the three anchoring tasks. The main distinctive feature of approximate numeracy is non-symbolic number-related capability, but the SMap task we used in this study is involved in symbolic number processing (mapping symbolic numbers to non-symbolic magnitudes). Even though SMap is highly correlated with other types of approximate numeracy tasks (e.g., dot-discrimination, dot-line, dot-ratio tasks), a recent study showed that they are separable (Chesney, Bjalkebring, & Peters, 2015). Future research is needed to test the relationship between approximate numeracy and anchoring biases using other approximate numeracy tasks where only non-symbolic mapping is involved. Indeed, a previous study showed that higher SMap was associated with a less concave shape in value function (Schley & Peters, 2014) but we did not find a significant effect in the valuation task. One limitation of the valuation task in this study is that the task was not incentive compatible. Non-incentive compatible methods might reduce participants' commitment to the valuation task. Future research may be required to more precisely investigate whether SMap moderates the relationship between anchoring and WTP using incentive compatible methods as other anchoring valuation studies used (Ariely et al., 2003; Fudenberg et al., 2012; Yoon et al., 2013). Indeed, further research is needed to test whether SMap is associated with other anchoring tasks using informal math questions (e.g., physical length estimation (LeBoeuf & Shafir, 2006), or time estimation (Thomas & Handley, 2008)).

References

Ariely, D., Loewenstein, G., & Prelec, D. (2003). "Coherent arbitrariness": Stable demand curves without stable preferences. *Quarterly Journal of Economics, 118*(1), 73-105. doi:Doi 10.1162/00335530360535153

Bennett, G. K., Seashore, H. G., & Wesman, A. G. (1947). Differential Aptitude Tests.

Bergman, O., Ellingsen, T., Johannesson, M., & Svensson, C. (2010). Anchoring and cognitive ability. *Economics Letters, 107*(1), 66-68.

Bodenhausen, G. V., Gabriel, S., & Lineberger, M. (2000). Sadness and susceptibility to judgmental bias: The case of anchoring. *Psychological Science, 11*(4), 320-323.

Brandt, M. J., Evans, A. M., & Crawford, J. T. (2014). The unthinking or confident extremist? Political extremists are more likely than moderates to reject experimenter-generated anchors. *Psychological Science*, 0956797614559730.

Burns, W. J., Peters, E., & Slovic, P. (2012). Risk perception and the economic crisis: a longitudinal study of the trajectory of perceived risk. *Risk Analysis, 32*(4), 659-677.

Chesney, D., Bjalkebring, P., & Peters, E. (2015). How to estimate how well people estimate: Evaluating measures of individual differences in the approximate number

system. *Attention, Perception, & Psychophysics, 77*(8), 2781-2802.
Dieckmann, N. F., Slovic, P., & Peters, E. M. (2009). The use of narrative evidence and explicit likelihood by decisionmakers varying in numeracy. *Risk Analysis, 29*(10), 1473-1488.
Epley, N., & Gilovich, T. (2001). Putting adjustment back in the anchoring and adjustment heuristic: Differential processing of self-generated and experimenter-provided anchors. *Psychological Science, 12*(5), 391-396.
Epley, N., & Gilovich, T. (2005). When effortful thinking influences judgmental anchoring: differential effects of forewarning and incentives on self-generated and externally provided anchors. *Journal of Behavioral Decision Making, 18*(3), 199-212.
Epley, N., & Gilovich, T. (2006). The anchoring-and-adjustment heuristic Why the adjustments are insufficient. *Psychological Science, 17*(4), 311-318.
Fagerlin, A., Zikmund-Fisher, B. J., Ubel, P. A., Jankovic, A., Derry, H. A., & Smith, D. M. (2007). Measuring numeracy without a math test: development of the Subjective Numeracy Scale. *Medical Decision Making, 27*(5), 672-680.
Fudenberg, D., Levine, D. K., & Maniadis, Z. (2012). On the robustness of anchoring effects in WTP and WTA experiments. *American Economic Journal: Microeconomics, 4*(2), 131-145.
Furnham, A., Boo, H. C., & McClelland, A. (2012). Individual differences and the susceptibility to the influence of anchoring cues. *Journal of Individual Differences, 33*(2), 89.
Jacowitz, K. E., & Kahneman, D. (1995). Measures of anchoring in estimation tasks. *Personality and Social Psychology Bulletin, 21*, 1161-1166.
Klein, R., Ratliff, K., Vianello, M., Adams Jr, R., Bahník, Š., Bernstein, M., & Nosek, B. (2014). Investigating variation in replicability: The "many labs" replication project. Retrieved from Open Science Framework.
LeBoeuf, R. A., & Shafir, E. (2006). The long and short of it: Physical anchoring effects. *Journal of Behavioral Decision Making, 19*(4), 393-406.
Liberali, J. M., Reyna, V. F., Furlan, S., Stein, L. M., & Pardo, S. T. (2012). Individual differences in numeracy and cognitive reflection, with implications for biases and fallacies in probability judgment. *Journal of Behavioral Decision Making, 25*(4), 361-381.
Maniadis, Z., Tufano, F., & List, J. A. (2014). One Swallow Doesn't Make a Summer: New Evidence on Anchoring Effects. *The American Economic Review, 104*(1), 277-290.
McElroy, T., & Dowd, K. (2007). Susceptibility to anchoring effects: How openness-to-experience influences responses to anchoring cues. *Judgment and Decision Making, 2*(1), 48-53.
Miron-Shatz, T., Hanoch, Y., Doniger, G. M., Omer, Z. B., & Ozanne, E. M. (2014). Subjective but not objective numeracy influences willingness to pay for BRCA1/2 genetic testing. *Judgment and Decision Making, 9*(2), 152-158.
Oechssler, J., Roider, A., & Schmitz, P. W. (2009). Cognitive abilities and behavioral biases. *Journal of Economic Behavior & Organization, 72*(1), 147-152.
Peters, E. (2012). Beyond comprehension the role of numeracy in judgments and decisions. *Current Directions in Psychological Science, 21*(1), 31-35.
Peters, E., & Bjalkebring, P. (2015). Multiple numeric competencies: When a number is not just a number. *Journal of personality and social psychology, 108*(5), 802.
Schley, D. R., & Peters, E. (2014). Assessing "economic value" Symbolic-number mappings predict risky and riskless valuations. *Psychological Science*, 0956797613515485.
Simmons, J. P., LeBoeuf, R. A., & Nelson, L. D. (2010). The effect of accuracy motivation on anchoring and adjustment: do people adjust from provided anchors? *Journal of personality and social psychology, 99*(6), 917.
Stanovich, K. E., & West, R. F. (2008). On the relative independence of thinking biases and cognitive ability. *Journal of personality and social psychology, 94*(4), 672.
Thomas, K. E., & Handley, S. J. (2008). Anchoring in time estimation. *Acta Psychol (Amst), 127*(1), 24-29.
Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *science, 185*(4157), 1124-1131.
Weller, J. A., Dieckmann, N. F., Tusler, M., Mertz, C., Burns, W. J., & Peters, E. (2013). Development and testing of an abbreviated numeracy scale: A Rasch analysis approach. *Journal of Behavioral Decision Making, 26*(2), 198-212.
Welsh, M. B., Delfabbro, P. H., Burns, N. R., & Begg, S. H. (2014). Individual differences in anchoring: Traits and experience. *Learning and Individual Differences, 29*, 131-140.
Wilson, T. D., Houston, C. E., Etling, K. M., & Brekke, N. (1996). A new look at anchoring effects: basic anchoring and its antecedents. *Journal of Experimental Psychology: General, 125*(4), 387.
Yoon, S., Fong, N. M., & Dimoka, A. (2013). The Robustness of Anchoring Effects on Market Good Valuations. *Available at SSRN 2352692*.