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Semantic cross-scale numerical anchoring

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Abstract

Anchoring effects are robust, varied and can be consequential. Researchers have provided a variety of alternative explanations for these effects. More recently, it has become apparent that anchoring effects might be produced by a variety of different processes, either acting simultaneously, or else individually in distinct situations. An unresolved issue is whether anchoring, aside from simple numeric priming, can transcend scales. That is, is it necessary that the anchor value and the target judgment are expressed in the same units? Despite some theoretical predictions to the contrary, this paper demonstrates semantic cross-scale anchoring in four experiments. Such effects are important for the direction of future theorising on the causes of anchoring effects and understanding the scope of their consequences in applied domains.

Keywords: anchoring, heuristics, scale distortion, selective accessibility, anchoring-and-adjustment, bias.

1 Semantic cross-scale numerical anchoring

Tversky and Kahneman (1974) famously asked their participants to estimate the percentage of African countries in the United Nations. Before providing their estimate, participants were asked whether the percentage was larger or smaller than a number that was randomly produced by a wheel of fortune. Participants for whom the wheel produced a larger number estimated a higher percentage of African countries in the United Nations than did those for whom the wheel produced a smaller number. Tversky and Kahneman referred to this as an anchoring effect, which in this instance is clearly irrational, for a random number produced by a wheel of fortune should not influence one's estimates. Since Tversky and Kahneman's seminal work, anchoring effects have been observed in many domains. In the applied arena, these include the pricing of real estate by estate agents (Northcraft & Neale, 1987), sentencing decisions of judges (for a review see Englich, 2006), students' evaluations of course instructors (Thorsteinson, Breier, Atwell, Hamilton & Privette, 2008), negotiations (Galinsky & Mussweiler, 2001; Schaerer, Swaab & Galinsky, 2015), supermarket purchase decisions (Wansink, Kent & Hoch, 1998), and the payment of credit card bills (Navarro-Martinez, Salisbury, Lemon, Stewart, Matthews & Harris, 2011; Stewart, 2009). Despite the obvious implications of such effects, there is no agreed unifying theory for the effects. If anything, debate over the underlying psychological processes appears to be intensifying, as additional theories are advanced (Frederick & Mochon, 2012) and previous influential results revisited (Simmons, LeBoeuf & Nelson, 2010).

Candidate accounts advanced to explain anchoring effects have included anchoring-and-adjustment (Tversky & Kahneman, 1974), numeric priming (Wilson, Houston, Etling & Brekke, 1996; Wong & Kwong, 2000), magnitude priming (Oppenheimer, LeBoeuf & Brewer, 2008; see Sleeth-Keppler, 2013, for a related account), selective accessibility (Mussweiler & Strack, 1999, 2000a, 2000b, 2001; Strack & Mussweiler, 1997; see Chapman & Johnson, 1999, for a related account), and scale distortion (Frederick & Mochon, 2012; Mochon & Frederick, 2013).

Scale distortion is the most recent theory advanced to explain anchoring effects. An important feature of this account is that it is the subjective perception of what values on the response scale mean rather than the subjective impression of the stimulus itself (stimulus distortion) that is altered (as shown in Figure 1). Specifically, scale distortion suggests that, after consideration of a small value (e.g., 5 lbs.), a contrast effect leads larger numbered values (e.g., 1000 lbs.) to appear larger. Thus, the weight of an object that is objectively 1000 lbs. is represented with a value less than this (anchoring) because the perception of the numerical scale has been altered. By contrast, selective accessibility is a theory of stimulus distortion: Upon being asked whether an object (objectively heavier than 5 lbs.) is heavier or lighter than 5 lbs., confirmatory hypothesis testing results in selective recruitment of information more consistent with the object being lighter than it is. When subsequently asked how heavy the object is, this information results in the impression of a lighter object (e.g., Strack & Mussweiler, 1997).

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One source of evidence put forward in support of the scale distortion account of anchoring was a failure to observe anchoring effects where the scale unit of the anchor and the scale unit of the target judgment differed (i.e., cross-scale anchoring was not observed, Frederick & Mochon, 2012; a negative result also observed in Chapman & Johnson, 1994). The aim of the present investigation is to test whether cross-scale anchoring effects can ever be obtained — outside of low-level numeric and magnitude priming effects (Critcher & Gilovich, 2008 [but see Matthews, 2011, for critique]; Mussweiler & Strack, 2001, Study 3; Oppenheimer et al., 2008; Sleeth-Keppler, 2013; Wilson et al., 1996; Wong & Kwong, 2000), which are likely to be less long-lasting and resistant to change than those resulting from semantic processes (see e.g., Blankenship, Wegener, Petty, Detweiler-Bedell & Macy, 2008).

In addition to Frederick and Mochon (2012), Harvey (2011) proposes that anchoring effects might occur as an overgeneralisation of a judgment strategy that is rational for (typically autocorrelated) time series data. Potentially, he suggests, "all that is necessary for two successive values to be treated as part of the same data series is that they be labelled as being on the same scale" (p. 106). Whilst an observation of cross-scale anchoring would not speak directly to the detriment of any particular theory, it would be an important result to be aware of for future theory development and refinement. Furthermore, the applied consequences of anchoring are likely greater if cross-scale anchoring can be observed: decision making is typically dependent upon one's subjective impression of a stimulus, and not the label that one happens to give that impression. Consequently, demonstrations of cross-scale anchoring suggest a more consequential effect than a failure to demonstrate such transfer.

Frederick and Mochon (2012) presented four studies in which an anchoring effect was observed when the anchor was presented on the same scale as the target judgment, but was not observed when the anchor was presented on a different scale. A representative example of these studies was that participants' judgments of a giraffe's weight in lbs. were higher (than a control condition with no anchor) after estimating the weight of a blue whale in lbs, but were unaffected when estimating the weight of a blue whale in tons (Frederick & Mochon, 2012, Study 3B). Such a task differs from standard tasks in the anchoring literature, in which participants are asked to make a comparative judgment between the anchor and the stimulus (e.g., "Is the proportion of African countries greater or less than 80%?" – Tversky & Kahneman, 1974). Inclusion of such a question might lead to cross-scale anchoring effects for one of (at least) two reasons:

1. The comparison question will trigger confirmatory hypothesis testing, consequently leading to greater accessibility of information consistent with the anchor value, generating an anchoring effect via selective accessibility (e.g., Strack & Mussweiler, 1997).
2. The comparison question will lead participants to employ an approximate conversion between the scales, which will allow scale distortion processes to operate. Mochon and Frederick (2013) demonstrate that a comparative question is necessary for anchoring effects when the anchor stimulus and the target stimulus are sufficiently different from one another. Even on the scale distortion account, some comparison between the anchor and target seems necessary, and when such a comparison is not instigated by the nature of the anchor and target themselves, a comparison question may be required.

In the present paper, Experiment 1 allows for both these processes to potentially operate, but either way demonstrates the unique result of cross-scale anchoring (where a numeric priming account predicts an opposite result). Experiments 2 and 3, however, make the second process difficult to envisage, since they demonstrate anchoring that is both cross-scale and cross-dimensional. Experiments 2 and 3 demonstrate that an estimate of weight (in lbs.) can bias an estimate of height (in feet). It is difficult to envisage a straightforward conversion between weight and height, as required for (2) above. Experiment 4, finally, provides support for one consequence of cross-scale anchoring: the failure of a straightforward intervention to avoid anchoring effects of credit card minimum payment information on credit card repayment decisions.

2 Experiment 1

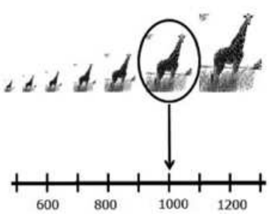
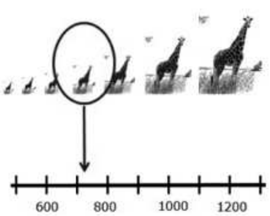
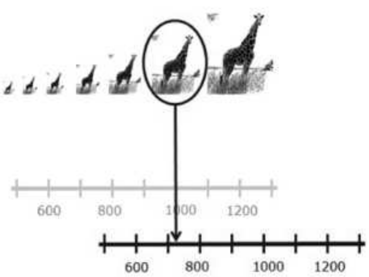
Experiment 1 was based on Frederick and Mochon (2012, Study 3B), but included an additional manipulation of whether or not a comparative question was asked.

2.1 Method

Participants 6 participants were initially removed from the dataset for failing to follow experimental instructions — providing a large range for their best estimate of the giraffe's weight, or they reported estimating the giraffe's weight in tons rather than lbs. 3 additional participants (in line with departmental ethical guidelines) were excluded for not reporting their age, or reporting that they were younger than 18 years old. After these exclusions, there were 857 U.S-based Mechanical Turk workers who participated in this experiment (319 female), aged 18–76 (median = 25).

Design, materials and procedure The experiment was run online through http://www.qualtrics.com. There were 5 (between-participant) experimental conditions. A control condition simply required participants to estimate the weight of an adult male giraffe in lbs. In the 'lbs-no comparison' condition, participants estimated the weight of an adult male African elephant in lbs. before estimating the weight of an

Figure 1: A stimulus and scale distortion based account of the effect of a low anchor on estimates of a giraffe's weight. Adapted from "A scale distortion theory of anchoring," by S. W. Frederick and D. Mochon, 2012, *Journal of Experimental Psychology: General*, *141*, p. 125. Copyright 2011 by the American Psychological Association.

	Control (no anchor) With no anchor, people form an internal representation of the giraffe's size (represented by the top row) which they map onto an overt response on the scale (pounds).
	Stimulus Distortion A low anchor results in a smaller internal representation of the size of a giraffe, leading to a smaller numerical estimate of its weight.
	Scale Distortion A low anchor results in large numbers on the scale feeling larger, which consequently then correspond to larger exemplars (shifting the mapping from the original greyed out scale, to the distorted one below). This distortion implies that a smaller number is sufficient to communicate the (unchanged) internal representation of the giraffe's size.

adult male giraffe in lbs. The 'tons-no comparison' condition was the same, except that participants estimated the elephant's weight in tons. The lbs-comparison condition and the tons-comparison condition replicated the latter two conditions, but also required participants to indicate, after estimating the weight of an elephant and before estimating the weight of a giraffe, whether a giraffe weighs more or less than an elephant. The dependent variable was the estimate of the giraffe's weight (lbs.).

All participants subsequently provided their age and gender.

2.2 Results and Discussion

Data preparation Before further analysis, 11 additional participants were excluded for estimating the giraffe's weight as less than 10 lbs. All these participants were in a condition that had first estimated the weight of an elephant in tons. Given that 4 participants in this condition had explicitly reported misreading the question and providing an estimate in tons, it was assumed that these participants had made the same mistake. One participant (from the lbs-comparison condition, where higher estimates were predicted) was excluded for estimating the giraffe's weight at 1 million lbs. (as well as an estimate of the elephant's weight of 200 million lbs.(!)).Following these initial exclusions, the mean and standard deviation of the data were calculated, and participants whose estimates of the giraffe's weight were more than 3 standard deviations from the mean were excluded (the cut-off for inclusion was an estimate that was less than 10, 621 lbs.). This excluded 10 further participants (3 estimated 12,000 lbs.; 1 estimated 14,500 lbs.; 3 estimated 15,000 lbs.; and estimates of 16,000; 20,000 and 70,000 lbs.).

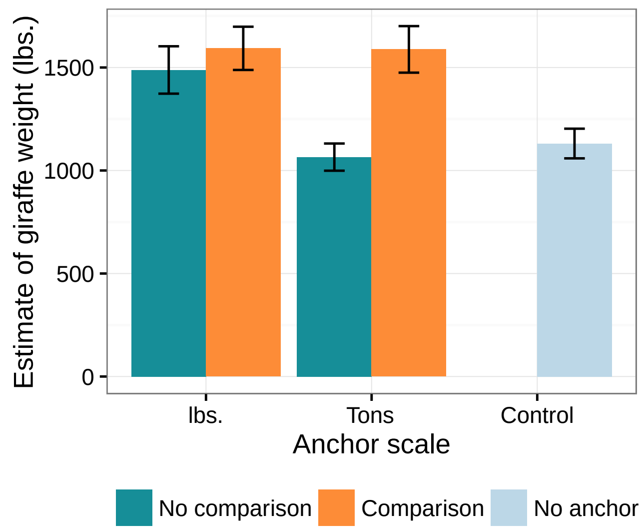
835 participants (308 female) were thus retained for analysis, with an age range of 18 to 76 years (median = 25). Remaining participants were fairly evenly distributed across conditions, with between 161 and 171 in each condition. Analyses without these exclusions are presented in the supplementary materials, and any analysis for which an exclusion alters the pattern of significance is noted with a footnote below.

Analysis Because responses were positively skewed, all responses were log transformed for inferential analyses, although for clarity we report the non-transformed descriptive statistics (all patterns of significance were the same when non-transformed data were analysed). We initially followed Frederick and Mochon (2012), comparing each of the experimental groups with the control condition. The mean estimate of the giraffe's weight in the control condition was 1131 lbs. (SE = 72). We replicated Frederick and Mochon's results, observing an anchoring effect in the 'lbs-no comparison' condition (mean = 1488, $SE = 115$, $t(337) = 3.15$, $p = .002$, Cohen's $d = 0.34$), and no anchoring effect in the 'tons-no comparison' condition (mean = 1065, SE = 66, $t(330) = 0.32$, $p = .75$, $d = -.03$).

In the comparison conditions, 327/335 participants answered the comparison question as predicted (elephant heavier than giraffe), confirming that an elephant's weight is a high anchor for a giraffe's weight. The critical analysis of estimates of a giraffe's weight concerned the 'tons-comparison' condition. Here, a significant (cross-scale) anchoring effect was observed (mean = 1588, $SE = 113$, $t(335) = 3.59$, $p < .001$, $d = 0.39$).[1] A numerical priming explanation would predict the opposite result, since the median estimate of the elephant's weight in tons was 3 tons (a small numeric anchor).[2] Moreover, a magnitude priming explanation would not predict the lack of an effect with the absence of a comparative question. To complete the pairwise tests with the control condition, the 'lbs-comparison' condition was compared with the control group, and again a significant anchoring effect was observed (mean = 1593, $SE = 105$, $t(338) = 4.17$, $p < .001$, $d = 0.45$). The complete descriptive statistics are shown in Figure 2, and a table summarising the anchoring effects observed across all experiments can be found in the Appendix.

In terms of comparing the results of the experimental conditions with the control group, the data were in line with experimental predictions. To better ascertain the relative contributions of scale consistency and the comparison question, a 2x2 ANOVA was conducted between the 4 experimental conditions. All 3 effects were significant in this analysis. The strongest effect was a main effect of comparison question, such that higher estimates (i.e., a stronger anchoring effect) were observed in the presence of the comparison question than in its absence (see Figure 2, $F(1, 660) = 12.65$, $p < .001$, MSE = 0.11, $\eta_p^2 = .019$). There was also a main effect of scale, such that a stronger anchoring effect was observed when the anchor was on the same scale as the target judgment (i.e., lbs.) ($F(1, 660) = 7.36$, $p = .007$, MSE = 0.11, $\eta_p^2 = .011$), and an interaction between the variables, ($F(1, 660) = 4.33$, $p = .038$, MSE = 0.11, $\eta_p^2 = .007$).[3] Simple effects tests confirmed what is suggested in Figure 2. The scale on which the anchor was judged had an effect only when no comparison was required between the anchor and the target, ($F(1, 660) = 11.42$, $p < .001$, MSE = 0.11; other $F < 1$). The presence of a comparison question had a significant effect only when the anchor was judged in tons, ($F(1, 660) = 15.69$, $p < .001$, MSE = 0.11; for lbs.: $F[1, 660] = 1.11$, $p = .29$, MSE = 0.11).

Figure 2: Estimates of the giraffe's weight (lbs.) across all conditions of Experiment 1. The control group did not judge an anchor, but is included for comparison. Error bars represent plus and minus 1 standard error.



Thus, when participants are required to make a comparison between the anchor and the target, it makes no difference whether they estimate the size of the anchor using the same scale as the target or a different one, the size of the anchoring effect is indistinguishable (see Figure 2). As mentioned in the Introduction, the cross-scale anchoring effect observed in this experiment could have arisen as a result of participants distorting the lbs. scale after first having translated the judgement of the whale onto this scale (e.g., by multiplying the number of tons by 2000). Regardless, the present experiment still demonstrates that cross-scale anchoring effects can occur. However, it is an open question as to whether such effects can occur when such a translation is not feasible, for instance when the judgments about the anchor and target are about different dimensions, not just on different scales. Experiment 2 was designed to answer this question.

3 Experiment 2

Experiment 2 is based on Frederick and Mochon's (2012) Study 4 and tests whether cross-dimensional anchoring (estimates of a giraffe's *height* being lower having first judged

[1]This result is dependent on excluding five participants with estimates of the giraffe's weight of less than 10 lbs. This exclusion is justified above, and further justified in the supplementary materials, where a histogram demonstrates the degree to which these responses were outliers.

[2]The mean was 130, suggesting that some participants had misread the question and reported their estimates in lbs. Removing these participants (either estimates of the elephant's weight ≥ 50 'tons' or ≥ 10 'tons') did not affect the results.

[3]The interaction term was not significant in an analysis without exclusions (see supplementary materials).

a wolf's *weight*) can be observed once a comparative question is included. On the selective accessibility account, the introduction of the comparison question means that when determining whether a giraffe weighs more or less than a wolf, participants will engage in a search for information about a giraffe consistent with it weighing the same as a wolf (Mussweiler & Strack, 1999). Hence, when they come to estimate the giraffe's height, their representation of a giraffe is smaller and so an anchoring effect could be observed. It is useful to note that early support for the selective accessibility theory of anchoring (Strack & Mussweiler, 1997) was obtained from an observation that judgments of the height of the Brandenburg Gate did not influence estimates of the width of the Brandenburg Gate (though Frederick & Mochon, 2012 and Mochon & Frederick, 2013, observed such cross-dimensional transfer when estimates used the same scale in an experiment with increased power). Here, we purport that selective accessibility could predict an influence of weight on height judgments (which are, by necessity, presented on different scales) because the height and weight of animals tend to be correlated in the real world. Whilst Experiment 1 employed a high anchor, Experiment 2 employed a low anchor.

3.1 Method

Participants 325 U.S. participants (107 female) aged 18–69 (median = 26) were recruited via Amazon Mechanical Turk.

Design, materials and procedure Participants were randomly assigned to 1 of 2 experimental conditions. All participants estimated the height of an adult giraffe in feet. Participants in the anchor condition first judged the weight of an adult wolf in lbs., then indicated whether an adult giraffe weighs more or less than an adult wolf, before judging the height of a giraffe.

All other aspects of the procedure were the same as in Experiment 1.

3.2 Results and Discussion

2 participants were excluded from the analysis because their estimates of the giraffe's height were more than 3 standard deviations above the mean (120 and 300 feet — the 'cut-off' was 77 feet). An additional participant was excluded for reporting the impossible result of a giraffe's height being zero. In the anchor condition, 160/164 participants answered the comparison question as predicted (giraffe heavier than wolf), confirming that a wolf's weight is a low anchor for a giraffe's weight.

Because responses were positively skewed, all responses were log transformed for inferential analyses, although we report the non-transformed descriptive statistics (all patterns of significance were the same when non-transformed data were analysed). An anchoring effect was observed in this experiment. Estimates of the giraffe's height were lower in the anchor condition (mean = 16.46; SE = 0.60) than the control condition (mean = 19.84; SE = 0.82, $t(320)$ = 3.89, $p < .001$, d = 0.43). Thus, once the comparative question was included, an anchoring effect was observed on estimates of a giraffe's height when the anchor concerned the semantically related property of weight. Once again, a numerical priming explanation would predict the opposite result, since the median estimate of the wolf's weight was a high absolute number (100 lbs — the mean was 115 lbs).

Experiment 3 sought to replicate this key result, but included information stating that the anchor was randomly generated. Such instructions are common in anchoring research and designed to highlight the sub-optimality of the anchoring effect, as results cannot be interpreted as participants perceiving the anchor as an informative conversational 'environmental suggestion' (Epley & Gilovich, 2010).

4 Experiment 3

4.1 Method

Participants 482 U.S. participants (153 female; 1 participant did not answer this question) aged 18–70 (median = 26) were recruited via Amazon Mechanical Turk.

Design, materials and procedure Participants were randomly assigned to 1 of 3 experimental conditions. All participants estimated the height of an adult giraffe in feet. Participants in the anchor conditions were instructed to start and then stop a 'random number generator' (four very fast spinning wheels). In the low anchor condition, these reels stopped at a number between 0101 and 0129 (the mean estimate of a wolf's weight in Experiment 2 was 113 lbs.). This value was lower than the 5th percentile of giraffe weight estimates in the control condition of Experiment 1 (300 lbs.). The 95th percentile of giraffe weight estimates in the control condition of Experiment 1 was 3380 lbs. We therefore chose a high anchor that was higher than this value and so, in the high anchor condition, the reels displayed a number between 4001 and 4029. In both conditions, the absolute value of the number would provide a high anchor for the height of a giraffe on a numeric priming account. These participants were subsequently asked whether a giraffe weighed more or less than this number of lbs., and subsequently estimated the height of a giraffe in feet.

All other aspects of the procedure were the same as in Experiment 1.

4.2 Results and Discussion

9 participants were excluded from the analysis because their estimates of the giraffe's height were more than 3 standard deviations above the mean (the cut-off was 40 feet). In the comparison questions, 133/146 reported that a giraffe's weight is less than the high anchor, whilst 144/151 reported that a giraffe's weight is more than the low anchor ($\chi^2(1)$ = 222.7, $p < .001$), confirming the status of the high and low anchors.

Because responses were positively skewed, all responses were log transformed for inferential analyses, although we report the non-transformed descriptive statistics (unless otherwise noted, patterns of significance were the same when non-transformed data were analysed). A significant effect of anchor condition on participants' estimates of giraffe height was observed ($F(2, 470) = 3.50$, MSE = 0.021, $p = .031$, $\eta_p^2 = .015$). Planned pairwise comparisons demonstrated that estimates in the low anchor condition (mean = 15.30; $SE = 0.41$) were lower than in the control condition (mean = 17.05; $SE = 0.47$, $t(325) = 2.48$, $p = .014$, $d = 0.28$). Estimates in the high anchor condition (mean = 15.69; $SE = 0.43$) did not significantly differ from estimates in the control condition ($t(320) = 1.83$, $p = .067$, $d = -0.21$). Unexpectedly, estimates in the high anchor condition were (directionally) lower than those in the control condition.[4]

Experiment 3 therefore replicated the cross-dimensional effect of a low anchor observed in Experiment 2, in a setup in which the potential influence of environmental suggestion was controlled. Despite the significant result in the overall ANOVA, the support for cross-scale, cross-dimensional anchoring in this experiment is tempered by the fact that only the low-anchor and control conditions differed from one another. The two anchor conditions did not differ from each other, $t(295) < 1$. The (directional) contrast effect with the high anchor was not predicted. The selective accessibility account has, however, been advanced to predict contrast effects where extreme anchors are used (see Strack & Mussweiler, 1997), so it is possible that the high anchor we used was too extreme in this case. 9% of participants did not, however, appear to view the high anchor as a high anchor (from their responses to the comparative question), whilst only 5% failed to view the low anchor as a low anchor on the same metric. If, however, one considers the distance from the median value of a giraffe's weight in the control condition of Experiment 1 (800 lbs.), the high anchor (approx. 4000) appears somewhat more extreme than the low anchor (approx. 100). Whilst Experiment 3 provides some support for cross-scale, cross-dimensional anchoring, the lack of predicted effects between certain cells might provide fruitful investigation for future research.

[4]This result attained significance in the non-transformed data ($t(320)$ = 2.09, $p = .037$, $d = -0.24$).

5 Experiment 4

As mentioned in the Introduction, the observation of cross-scale anchoring suggests a greater applied importance of anchoring than implied by scale distortion. Moreover, it is a consequential result for policy makers seeking to minimise potential harmful effects of anchors. There have been numerous demonstrations of potentially consequential anchoring effects in applied situations. One potentially costly example is in the context of credit card repayments. Both British (Stewart, 2009) and American (Navarro-Martinez et al., 2011) credit card holders reported they would repay less of their bill in a condition where a minimum payment was provided than in one where the minimum payment information was absent. In Stewart's experiment, mean repayments decreased from 40% to 23% of the overall balance when minimum payment information was included.[5] For a typical consumer, with a bill of $4,000 and an annual percentage rate of interest of 20%, such an effect corresponds to a two-fold increase in interest payments from $49 to $109 (Stewart, 2009). The elimination of such an effect would therefore convey considerable economic benefit to consumers. Were cross-scale anchoring to never occur, the beneficial effects of low anchors (ensuring that no debtors default on a monthly payment) could be maintained, without the undesirable anchoring effect, simply by providing the anchor on a different scale.

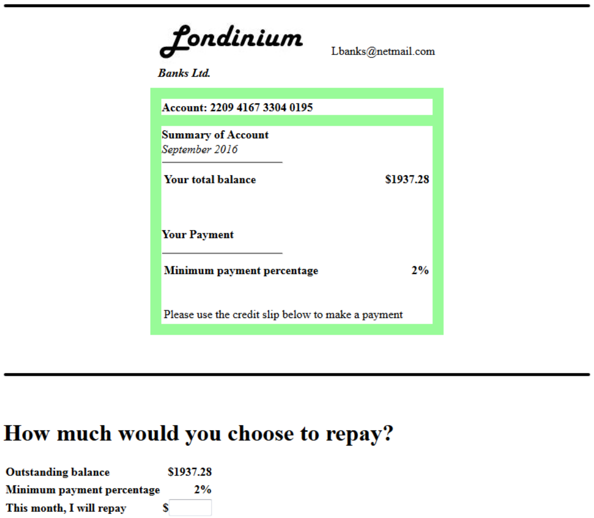
The results reported in Experiments 1–3 suggest that anchoring would not be eliminated by providing the minimum payment in a different scale (percentage of balance) to the payment requested ($). Experiment 4 provided a direct test of this, and consequently a further test of cross-scale anchoring.

5.1 Method

Participants After excluding 2 participants who did not report an age greater than 18 years, 604 (215 female) U.S. based Mechanical Turk workers aged between 18 and 75 (median = 26) were retained for analysis. 332 reported having paid off a credit card bill 'virtually every month' in the course of the past year, whilst 132 reported never having paid off a credit card bill in the course of the past year. 136 participants reported paying off a credit card bill between 1 and 10 times in the past year (4 did not answer this question).

[5]These figures result from an analysis of those who did not pay the full amount owed. The proportion of people paying the full amount was unaffected by the presence or absence of minimum payment information.

Figure 3: A screenshot of the credit card bill and response question presented to participants in the 'minimum payment percentage' condition.



Design Participants were presented with a mock credit card statement showing a total balance of $1937.28 (as in Navarro-Martinez et al., 2011). They were instructed to imagine that they had just received this credit card statement, and were to think about the money they currently had and the amount they could afford to pay before making a decision as to how much of the credit card bill to repay.

Below the instructions, the credit card bill was presented (Figure 3). The total amount due was always shown. Participants were assigned to one of three experimental conditions. In the 'no minimum' group, there was no mention of a minimum payment. In the 'minimum $' group, the "minimum payment amount" was $38.74 (2% of the balance). In the 'minimum %' group, the "minimum payment percentage" was 2%. Participants reported the amount they would repay in dollars. In all three conditions, if participants entered an amount that was less than $38.74, they were presented with an error warning stating "You must pay at least $38.74". Thus, the minimum payment required in all conditions was the same, but this information was differentially available to participants before they attempted to submit their response.

Materials and procedure The experiment was programmed in html and JavaScript and run via Amazon Mechanical Turk. Having provided their responses to the repayment question, on the next screen participants provided demographic information pertaining to their age and gender as well as asking them how many times in the past year they had paid a credit card bill (Never; 1–3 times; 4–6 times; 7–10 times; Virtually every month). Finally, to guard against computer 'robots' completing the experiment, participants typed out a 4-digit number shown in a photograph.[6]

Table 1: Percentage of participants repaying the full debt on their credit card statement in Experiment 1.

Condition	Percentage repaying the full amount
No minimum	25%
Minimum $	18%
Minimum %	19%

5.2 Results and Discussion

6 participants were excluded whose repayments either contained inappropriate characters, or were greater than the balance of $1937.28. After these exclusions, 209 participants were in the 'no minimum' condition, 193 in the 'minimum $' condition and 196 in the 'minimum % condition.' Table 1 shows the number of participants repaying the full amount ($1937.28) in each condition. Although more participants paid the full amount in the 'No minimum' condition, an overall chi-squared contingency test was not significant ($\chi^2(2) = 3.39$, $p = .18$).

Following Stewart (2009), when participants made partial repayments (i.e., excluding full repayers), the amount of repayment made in each condition yielded the same anchoring effect reported in Stewart (2009) and Navarro-Martinez et al. (2011). Participants paid off more in the 'No minimum' condition (mean = 339.69; median = 200, Interquartile range [IQR] = $400), than the 'Minimum $' condition (mean = $220.62; median = $93.64, IQR = $156.25, Mann-Whitney $U = 8115.0$, $p < .001$).[7] Of more interest, the anchoring effect was also observed in the 'Minimum %' condition (mean = $232.24; median = $150, IQR = $240, $U = 10360.5$, $p = .009$). Finally, partial repayments in the 'Minimum %' condition were significantly higher than those in the 'Minimum $' condition ($U = 10022.0$, $p = .002$). The pattern of results remains the same if those participants who did not report paying off a credit card bill in the last year are excluded.

Thus, although the cross-scale anchoring effect was smaller than the same-scale anchoring effect, mean repayments of people not paying off the full amount were still smaller in the 'Minimum %' condition than in the condition without a minimum payment, demonstrating cross-scale anchoring.

[6] 4 further participants would have been excluded based on incorrectly typing out this number. In the end, we decided against using this as an exclusion criterion on the advice of the editor who indicated that a single question constitutes a rather insensitive attention check, which will result in both misses and false positives.

[7] Repayments were highly skewed and log transformation did not result in a normal distribution, so we follow Stewart (2009a) in performing non-parametric inferential statistics. The patterns of significance are the same if parametric statistics are undertaken on log transformed responses.

6 General Discussion

Across three experiments, we observed consistent evidence for semantic cross-scale numerical anchoring. In a final experiment investigating hypothetical credit card repayments, we demonstrated a cross-scale anchoring effect of minimum payment information, further demonstrating the applied importance of this result. Experiments 2 and 3 went somewhat further than Experiments 1 and 4 in demonstrating cross-scale, cross-dimensional anchoring.

We argued that there was no potential for scale distortion processes to operate in Experiments 2 and 3, since there is no direct translation of height (in feet) into weight (in lbs.). In response, a proponent of scale distortion could argue that the correlated nature of height and weight means that one can provide a reasonable estimate of height once one has an estimate of weight – consequently, although there is not a straightforward translation between feet and lbs., a 'reasonable' conversion could be made. A subsequent anchoring effect could then be attributed to scale distortion.[8] Whilst such an account is possible, and indeed could be induced by the experimental pragmatics associated with the experimenter asking participants to first consider the giraffe's weight, it seems unlikely to us. Moreover, the correlation between height and weight is inherently a feature of the stimuli (animals), not one inherent in the scale. The inferential steps involved in first translating and then distorting the scale of the target judgment are thus much more involved than a simple scale distortion account would assume. We believe an account in terms of stimulus distortion is both more parsimonious and more likely.

In addition to demonstrating the applied importance of cross-scale anchoring, Experiment 4 demonstrated cross-scale anchoring in the absence of a comparative question. We posit that, in contrast to the majority of laboratory anchoring studies that highlight the randomness of an anchor value (e.g., the present Experiment 3), in this real-world situation, in which the minimum payment is clearly not entirely irrelevant to the decision at hand, it is this relevance which facilitates a cross-scale anchoring effect. Whether this is due to an anchoring-and-adjustment process, an implicit comparison giving rise to selective accessibility processes, or even a conversion of the percentage into a dollar amount, which is then susceptible to scale distortion processes, is a question for future research. The result, however, is clear. Presenting the minimum payment on a different scale does not eliminate the anchoring effect on payment amounts, although it does attenuate it (and could consequently be of economic benefit to consumers). That the cross-scale anchoring effect seems not always to require a comparison question (see also Oppenheimer et al., 2008, who observed 'magnitude priming' in the absence of a comparison question), is perhaps beneficial in reconciling the current result with seemingly contradictory findings reported in Mochon and Frederick (2013). Mochon and Frederick reported evidence that a comparative question was neither a necessary nor sufficient condition for anchoring effects to occur. By contrast, an explicit numerical value on a consistent scale was a necessary condition. Having observed cross-scale anchoring without a comparison question in Experiment 4, the result we now turn attention to concerns the necessity of a consistent scale.

In the critical conditions (for the present discussion) of Mochon and Frederick's (2013) Study 1, participants were asked whether a camera costs more or less than either: $6, $900, 'a pack of AA batteries' or 'a washing machine', before estimating the price of a camera. Based on the current results, one might predict that comparing a camera to a pack of batteries would lead to lower estimates of the camera's price than comparing it to a washing machine. Mechanism '1' in the Introduction, for example, would predict that comparing a camera to a pack of batteries would prime information consistent with a cheap camera, which would then result in lower estimates of the camera's price. There was, however, no significant difference in estimates between the 'batteries' (mean = $158) and 'washing machine' (mean = $189) conditions. Where the anchor was an explicit value ($6 vs. $900), however, estimates of the camera's price were higher following the high anchor (mean = $376) than the low anchor (mean = $164).

Estimates following the '$6' anchor were no lower than those following the 'batteries' anchor. The result that anchoring is observed with explicit numerical anchors (on the same scale) and not implied values (the LG washing machine and AA batteries had objective retail prices of approximately $900 and $6) is driven by the increased estimate following the explicit $900 anchor, which was not observed for the washing machine.

Explanation '1' in the Introduction is based on the selective accessibility account of anchoring (e.g., Strack & Mussweiler, 1997). According to this account, when asked whether a camera costs more or less than a washing machine, participants will seek for evidence consistent with the hypothesis that these are the same price. Note that this evidence could come from thinking about more expensive cameras, but it could also come from thinking about cheaper washing machines. If perceptions of washing machine prices are more uncertain than perceptions of camera prices (and note that this seems plausible, as larger prices are typically less discriminable than smaller prices [e.g., Lambert, 1978]), the perception of the washing machine is likely to be shifted more than the perception of the camera – theories of information aggregation predict that when combining two values (estimates for example), the resulting posterior judgment will be closer to the value with the lower variance (read 'uncertainty'; for direct application of such theories to anchoring, see Turner & Schley, 2016). Consequently, any anchoring

[8] We thank Shane Frederick for this suggestion made in the course of the reviewing process.

effect on the price of the camera will be attenuated. In the present experiments, such an effect is less likely as participants are first asked to report the value for the anchor, potentially 'locking in' a specific exemplar for future comparisons, meaning that future comparisons are more likely to influence perceptions of the target object than the 'locked in' anchor.

The above explanation is but one possibility and we should highlight the speculative nature of it. Nonetheless, we suggest that an investigation of the effect of the uncertainty of the anchor value on cross-scale anchoring effects would be a worthwhile endeavour for future research. Note that this question has not arisen previously in anchoring research since anchors are typically precise numerical values, with no associated uncertainty. By contrast, one's perception of the value of an LG washing machine is likely to be associated with a degree of uncertainty. Thus, we propose (tentatively) that uncertainty of the anchor value might be one boundary condition for anchoring effects on a target judgment (a similar argument might be relevant to Chapman & Johnson, 1994, Experiment 2).

Our attempts to explain the different results obtained in the current experiments and in Mochon and Frederick (2013) seem, to us, to be in line with Mochon and Frederick's own theorising. Different anchoring effects might exert differential influence across different situations (or internal characteristics of the individual – Blankenship et al., 2008; Wegener, Petty, Blankenship & Detweiler-Bedell, 2010). Identifying those different situations is an important goal of future research, especially given a move towards more integrative theories of anchoring (in addition to the citations immediately above, see also, Chaxel, 2014; Simmons, LeBoeuf & Nelson, 2010). The potential explanations proferred here are not exhaustive, and arbitrating between competing accounts in behavioral experiments is clearly a far from straightforward challenge for future research. The current research does demonstrate, however, that such future research and theorising must entertain the reality of cross-scale numerical anchoring effects transcending mere numeric priming effects.

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Appendix:

Summary of the anchoring effects observed across all experiments.

	Was an anchoring effect observed relative to the control condition?	Additional notes
EXPERIMENT 1 Consistent scale, no comparison	✓	
Consistent scale, comparison	✓	
Cross-scale, no comparison	×	
Cross-scale, comparison	✓	
EXPERIMENT 2 Cross-scale, cross domain, comparison, high anchor	✓	
EXPERIMENT 3 Cross-scale, cross domain, comparison, high anchor	×	Estimates did not differ between the conditions of Experiment 3.
Cross-scale, cross domain, comparison, low anchor	✓	
EXPERIMENT 4 Consistent scale	✓	There was a larger anchoring effect with the consistent scale.
Cross-scale	✓	