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Research article

Knowledge matters: Anchoring effects are moderated by knowledge level

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Abstract

Previous research into the relationship between knowledge level and anchoring effects has led to mixed conclusions. This paper presents four studies that used a diverse set of stimuli and paradigms to further investigate this relationship. In Study 1, greater knowledge was associated with smaller anchoring effects—both when knowledge was measured using subjective self-assessments and when using an objective knowledge measure. In Study 2, participants from the USA and India tended to exhibit smaller anchoring effects when answering questions about their own country as compared with questions about the other country. In Study 3, higher knowledge was associated with smaller anchoring effects when examined at an idiographic level. Finally, in Study 4, providing participants with information designed to increase their knowledge led to a decrease in anchoring effects. The consistency of the results across our four studies provides evidence that anchoring effects are moderated by knowledge level in many situations.

When people are estimating a numeric value, the introduction of an irrelevant anchor value will often cause their estimate to assimilate towards the anchor (for reviews, see Chapman & Johnson, 2002; Epley, 2004; Furnham & Boo, 2011). Anchoring effects are quite robust and have been observed in estimates across a wide variety of domains including answers to general knowledge questions (Tversky & Kahneman, 1974) and math problems (Smith & Windschitl, 2011), estimates of real-estate prices (Northcraft & Neale, 1987), decisions about criminal sentences (Englich, Mussweiler, & Strack, 2006), and in the outcomes of negotiations (Galinsky & Mussweiler, 2001). Because anchoring effects have been observed in so many different situations, understanding how people might overcome the biasing influence of anchors is important. It seems plausible that one factor that would moderate anchoring effects is a person's level of knowledge. That is, high-knowledge people would be less influenced by anchors than their low-knowledge counterparts. However, the relationship between knowledge level and anchoring effects is unclear. Some researchers have speculated that high knowledge people "should" be less influenced by anchors (e.g., Mussweiler & Strack, 1999). However, recent research suggests that high-knowledge and low-knowledge people are equally biased by irrelevant anchors (e.g., Englich, 2008; Englich et al., 2006; Englich & Soder, 2009; see also Northcraft & Neale, 1987). Given this discrepancy, the studies described in this manuscript were designed to investigate the relationship between knowledge and anchoring across a variety of domains.

Background of Anchoring Effects and Theory

In their classic study on anchoring effects, Tversky and Kahneman (1974) first asked participants whether the percentage of African countries in the United Nations was higher or lower than an ostensibly random number (predetermined to be 10% or 65%). This anchor value influenced participants' subsequent estimates of the actual number of African countries in the UN (higher estimates when the anchor was 65% rather than 10%). Numerous accounts have been offered to explain why people anchor on such irrelevant values in paradigms such as these. These accounts can be grouped into three categories: (i) enhanced accessibility of select knowledge, (ii) anchoring and insufficient adjustment, and (iii) priming.

The first account suggests that anchors cause people to recruit biased pools of information (Mussweiler & Strack, 1999; Strack & Mussweiler, 1997; see also Chapman & Johnson, 1999). Mussweiler and Strack's "selective accessibility" model explains anchoring by assuming that when participants compare the target estimate to an anchor, they first test whether the target is equal to the anchor value. Because people tend to engage in hypothesis-consistent testing (Klayman & Ha, 1987), they will likely think about information consistent with the anchor value. When participants provide their absolute estimate of the target value, they rely on the biased set of information that has been recruited. Therefore, estimates following a comparison with an anchor tend to assimilate toward the anchor value.

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The second account, “anchoring and insufficient adjustment”, assumes that the anchor provides a starting point that people use when making their judgment (Epley & Gilovich, 2001; Tversky & Kahneman, 1974; see also Simmons, LeBoeuf, & Nelson, 2010). As information is recruited about the target, people adjust their estimate away from the anchor. These adjustments, however, tend to be insufficient (Epley & Gilovich, 2004). That is, people tend to stop adjusting once they reach a plausible estimate (Quattrone, Lawrence, Finkel, & Andrus, 1981). Because there is generally a large range of plausible estimates, adjustments that start from a low anchor stop at the lower end of this range, whereas adjustments from a high anchor terminate at the upper end of the range.

The third category of accounts, numeric and magnitude priming, posits that anchors prime numbers or magnitudes similar to the anchor value. For example, in one study, participants’ arbitrary ID numbers influenced their estimates of the number of physicians in the phonebook (Wilson, Houston, Etling, & Brekke, 1996). Presumably, viewing the ID number increased the accessibility of similar numbers. When participants generated their estimates, these primed numbers were more likely to come to mind, thereby influencing their estimates (see also Critcher & Gilovich, 2007; Wong & Kwong, 2000). The magnitude priming account is similar, but rather than priming numbers, it assumes that anchors prime magnitude concepts (e.g., “large” and “small”), and these concepts influence the estimates that people give (Oppenheimer, LeBoeuf, & Brewer, 2008).

Empirical Findings Regarding Knowledge Level as a Moderator

As previously mentioned, a number of studies have tested for expertise or knowledge level as a moderating factor of anchoring effects, and the findings are mixed. In the next two sections, we review the findings suggesting the knowledge does and does not moderate anchoring effects.

Findings Suggesting Knowledge Moderates Anchoring

Wilson et al. (1996) found that participants who reported they were more knowledgeable about the number of physicians in the phonebook were less influenced by anchors when estimating this value. However, participants were asked about their knowledge level immediately after making their estimate. Therefore, their knowledge judgments could have reflected their confidence in their estimates more so than their knowledge about the topic (Englich, 2008). It is also quite likely that people who felt they were adversely influenced by the anchor might also be less confident in their estimate. Therefore, it is unclear whether the results truly indicate that greater knowledge leads to smaller anchoring effects.

Mussweiler and Englich (2003) tested German participants on anchoring tasks before and after the introduction of the Euro in 2002. Before the introduction of the Euro, German participants showed larger anchoring effects when making price estimates in Euros as compared with German Marks. However, after the introduction of the Euro, the pattern was reversed. Presumably, greater experience with the Euro reduced the participants’ uncertainty when making price estimates, and their decreased uncertainty led to small anchoring effects.

In addition to the “direct” tests of knowledge and anchoring described earlier, a study by Blankenship, Wegener, Petty, Detweiler-Bedell, and Macy (2008) provided indirect evidence that knowledge can mitigate anchoring effects. Participants answered anchoring questions while either under cognitive load or not. Participants also learned either anchor-consistent or anchor-inconsistent information. Participants exposed to anchor-inconsistent information exhibited smaller anchoring effect, but only when not under cognitive load. In other words, limiting participants’ ability to use their background knowledge influenced the magnitude of anchoring effects.

Finally, Mussweiler and Strack (2000) conducted a study where participants estimated the age of an ambiguous target (“Xiang Long”) after exposure to high or low anchor. Importantly, some participants were led to believe the target was a person, whereas others were given no such information (i.e., the target could be a person, a national monument, or a mountain). Participants exhibited smaller anchoring effects when they could specify the category the target belonged to as compared with when they lacked this information.

Findings Suggesting Knowledge Does Not Moderate Anchoring

Key studies suggesting a different conclusion come from Englich et al. (2006). In these studies, legal experts and non-experts made criminal sentencing decisions after reading hypothetical scenarios. The sentence length decisions of experts and non-experts were equally influenced by comparisons with irrelevant anchors. In a related study, Northcraft and Neale (1987) had real-estate agents and undergraduate students estimate the actual price of a home after exposure to an anchor. Despite the expertise difference between the two groups, real-estate agents and undergraduate students exhibited similar anchoring effects.

Similar results were found in the only anchoring study we are aware of that has manipulated participants’ knowledge level. Englich (2008) had participants estimate the average price of a new midsized car sold in Germany after exposure to a high or low anchor. Before making this estimate, the participants reviewed information that was relevant or irrelevant to their judgments. Specifically, participants saw a series of advertisements from which participants could learn some information about the prices of cars (relevant knowledge) or kitchens (irrelevant knowledge). Englich found that participants in these two conditions were similarly affected by anchors—that is, knowledge did not moderate anchoring effects.

Consistent with the findings described earlier, the predominant opinion in the literature appears to be that knowledge level does not moderate anchoring effects. For example, in a recent literature review of anchoring effects, Furnham and Boo (2011) concluded that the results of studies investigating the influence of expertise on anchoring effects “. . .imply that expertise does not significantly reduce the assimilative bias in decisions that affect inexperienced laypeople” (p. 39). Similarly, Englich and Soder (2009) stated that, “In research to date, expertise was typically found to have little if any influence on anchoring” (p. 48).

Why Expect Knowledge as a Moderator?

Despite others' conclusions that anchoring effects are not moderated by knowledge levels, we feel that the existing literature is inconclusive. Also, we believe there is a strong conceptual rationale for expecting that knowledge would moderate anchoring effects. There are, in fact, at least three reasons to expect moderation.

First, high-knowledge people might be more likely to know the exact answer of the target estimate. Presumably, if a person knows the answer, he will ignore the anchor and provide the known estimate. While this certainly is one way in which knowledge could moderate anchoring effects, the current studies were designed to investigate the influence of knowledge on anchoring effects when people do not know the exact answer to the target question.

A second reason to expect knowledge to moderate anchoring effects is that the range of responses that people will consider plausible is likely to be narrower among high-knowledge people than low-knowledge people. When describing their selective accessibility model, Mussweiler and Strack (1999) speculated that a person's range of plausible responses might determine how an anchor is processed (see also Mussweiler & Strack, 2001). For example, a low-knowledge person who is exposed to an extreme anchor will likely recruit information that is consistent with this extreme anchor. However, a high-knowledge person exposed to the same extreme anchor might not. This person would likely adjust away from the extreme anchor until a plausible value is reached. Then, he or she would recruit information consistent with this plausible value. Consequently, the high-knowledge person would show a smaller anchoring effect than the low-knowledge person.

And third, Mussweiler, Strack, and Pfeiffer (2000) demonstrated that a way to combat anchoring effects is to consider anchor-inconsistent information prior to making a judgment. Because someone with a great deal of knowledge about a target has more overall information, it is more likely that he or she would be more likely to come up with anchor-inconsistent information than a person with little or no knowledge about the target. If this is true, we might expect anchoring effects to be smaller with high-knowledge people.

The prediction that increased knowledge can help limit anchoring effects differs from that recently expressed by other researchers. For example, Englich (2008) suggested that high knowledge may have access to more information, but because the anchor value affects the type of information that is recruited, a high-knowledge person will recruit a greater amount of biased information. That is, even though information that is inconsistent with the anchor might be available to a highly knowledgeable person, it is unlikely that this information will be used to form a judgment because anchor-consistent information is made most accessible by the anchor. Therefore, according to Englich, estimates from high-knowledge and low-knowledge people tend to be similarly biased by an anchor. The current studies were designed to test between these two competing hypotheses.

Current Studies

We conducted four studies to address the unresolved question of whether knowledge level moderates anchoring effects. To create a thorough set of tests, we sought to operationalize knowledge level in a variety of ways, and we used both correlational and experimental methods. In Study 1, we investigated anchoring effects in a domain (American football) with participants who ranged in knowledge from very low to very high. Importantly, we measured football knowledge using subjective self-assessments and using an objective measure (i.e., performance on a football knowledge quiz). In Study 2, we had participants from the USA and India answer questions about US and Indian topics—thereby creating high-knowledge and low-knowledge conditions as a function of the match or mismatch between country and topic. In Study 3, we used a methodology that allowed us to assess the relationship between anchoring and knowledge within participants. Specifically, participants first indicated their level of knowledge about 14 different question domains. Then, they answered two anchored questions in each domain. Whereas the first three studies were correlational (or quasi-experimental), Study 4 used a fully experimental design in which participants were exposed to either relevant or irrelevant information before making an anchored estimate—a methodology similar to that used by Englich (2008).

STUDY 1

Method

Participants

The participants were 105 students enrolled in an elementary psychology course from the University of Iowa who received partial credit towards their research exposure requirement.

Anchor Questions

Because some of our participants would be very knowledgeable about American football, we generated target questions whose answers could not be directly recalled from memory (Table 1). For example, one question was: "What is the total number of points the Chicago Bears scored in all regular season games during the 2007 season?"[1] Although high-knowledge participants would likely not know the exact answer, they would have useful knowledge that could be used to thoughtfully approximate a response. Consistent with the standard anchoring paradigm, a comparative question that introduced the anchor preceded each absolute question (see Table 1 for a list of anchors used).

Procedure

The participants were told that they would be answering questions presented in two stages; the first stage required a comparison of the target value with a "randomly determined" number, and the second stage required an estimate of the target value. After a practice question, participants answered the six target questions (always preceded by its respective comparative question) in a random order. Each participant answered three questions with

[1]Study 1 was conducted between the 2007 and 2008 National Football League seasons.

Table 1. List of questions, answers, anchors, and means (and standard deviations) for anchored estimates in Study 1

Question	Answer	Low anchor	High anchor	Low estimate	High estimate
What is the total number of points the Chicago Bears scored in all regular season games during the 2007 season?	334	85	850	127.97 (73.19)	619.32 (281.80)
What is the total weight of all the players in the starting offensive line for the Green Bay Packers?	1814	450	4500	1,077.61 (578.30)	3,450.40 (146.42)
What is the total number of touchdown passes for all the quarterbacks in the AFC during the first game of the 2007 season?	22	11	110	44.65 (130.40)	113.07 (77.10)
How many points did the Minnesota Vikings' kicker score (field goals and PATs) in the 2007 season?	99	37	370	48.57 (33.30)	261.97 (127.11)
How many yards did the Kansas City Chiefs' punter punt for during all regular season games in the 2007 season?	4322	720	7200	842.35 (406.73)	5,337.54 (2,367.58)
How many yards did opposing teams rush for against the New York Giants during all playoff games of the 2007 postseason?	296	82	820	124.56 (83.38)	671.18 (238.36)

a high anchor and three with a low anchor (order counterbalanced across participants).

After answering the six target questions, participants completed three types of measures that we used to index their football knowledge. First, they indicated their self-perceived football knowledge by clicking on a continuous scale with four equally spaced labels (not at all, somewhat, moderately, and extremely). Second, on the same type of scale, they indicated their level of knowledge about each target question (e.g., "How knowledgeable are you about the total number of points the Chicago Bears scored in all regular season games during the 2007 season?"). And finally, the participants completed a 14-item football quiz (see APPENDIX A for the list of questions).

Results

Anchoring Effects

To examine the anchoring effects, we first dropped the responses (2 of 630 total estimates or $< 1\%$) that were equal to the correct answer to ensure that our results were not simply due to high-knowledge participants knowing the correct answers.[2] Next, we standardized the participants' estimates—separately for each target question (see Table 1 for unadjusted estimates). Then, we calculated an anchoring index for each participant by subtracting his/her average response for the low-anchor questions from his/her average response for the high-anchor questions. A positive anchoring index indicates that the participants gave higher estimates after high rather than low anchors. As expected, there was a robust anchoring effect in the overall sample; the average anchoring index ($M = 1.40$, $SD = 0.75$) was significantly larger than zero, $t(104) = 19.23$, $p < .001$, $d = 1.87$.

Knowledge and Anchoring

To compute a knowledge index for the participants, we standardized the participants' overall knowledge estimate, the average of their estimates of knowledge about the specific questions, and their quiz performance. These three measures were highly correlated (alpha = .92), so they were averaged together to create an overall knowledge index for the participants with higher numbers indicating greater football knowledge. A bivariate correlation between participants' knowledge index and anchoring index indicated a significant negative correlation, $r(105) = -.56$, $p < .001$. In other words, high-knowledge participants tended to show smaller anchoring effects.[3] It should be noted that the participants' anchoring index was significantly negatively correlated with each of the three knowledge measures (rs = −.53, −.59, and −.44, for correlations with overall knowledge estimate, average of knowledge on specific questions, and quiz score, respectively; all ps < .001).

Discussion

As expected, we found that participants with higher knowledge exhibited smaller anchoring effects. This was true regardless of whether knowledge was assessed with self-report or with objective measures of quiz performance. If only subjective measures related to anchoring effect, this would be ambiguous. It could be explained by assuming that participants' knowledge judgments reflected their confidence in their estimates, not their true knowledge about the topic area. And it could even be assumed that the magnitude of the anchoring effects influenced how participants felt about their confidence. These interpretations are not applicable to explaining the relation between objective quiz performance and anchoring.

A limitation of this study is that there could be a factor (other than knowledge) that is responsible for the decreased anchoring effects. It is possible that people who tend to be knowledgeable about football also tend to be resistant to judgmental biases for reasons other than their football knowledge. While it is unclear what this other factor might be, Study 2 was designed to address this limitation.

STUDY 2

In Study 2, we again investigated anchoring effects across high-knowledge and low-knowledge people. Importantly, however, we used two topic areas and two samples of people such that a

[2]The results of the analyses for this and the later studies were very similar when conducted on the full data set (i.e., not dropping accurate responses).

[3]While high knowledge participants did show smaller anchoring effects, it is worth noting that even the most knowledgeable 20% of participants showed robust anchoring effects, $t(20) = 4.16$, $p < .001$, $d = 0.91$.

given sample would be high knowledge about one topic and low knowledge about the other. Specifically, we recruited participants from the USA and India who answered anchored target questions about US topics and Indian topics. We expected that US participants would be more knowledgeable about the US topics. Therefore, they would be less influenced by anchors when answering US questions than when answering Indian questions. The opposite was expected for the Indian participants—smaller anchoring effects with Indian questions than with US questions.

Method

Participants

Participants were recruited from the USA ($n = 30$, 21 women, mean age = 35.7) and India ($n = 34$, 15 women, mean age = 29.8) using Amazon's Mechanical Turk (MTurk) and were paid $0.15 upon completion of the survey (for information on using MTurk for participant recruitment and experimentation, see Buhrmester, Kwang, & Gosling, 2011; Paolacci, Chandler, & Ipeirotis, 2010).

Procedures and Materials

The study was advertised on MTurk and directed people to an online survey. The participants were informed that they would be answering questions about a wide variety of topics and that the anchor values were uninformative. Specifically, they were told that the numbers used were "…completely arbitrary and, therefore, not informative as to the actual answer to the question." The participants were also given explicit instructions about not looking up the answers to the questions.

Each participant answered eight target questions in an individually randomized order. See Table 2 for a complete list of the questions and the anchors that were introduced before the respective questions. Four of the questions covered US domains (e.g., "How many US states are west of the Mississippi River?") and four covered Indian domains (e.g., "How old was Dr. Kalam when he became president of India?").

For a given participant, high anchors were introduced before two questions in each domain and low anchors before the other two questions. Counterbalancing of the anchors did not affect the results. At the end of the study, participants were asked where they currently live and where they were born. The survey site also recorded the geographic location of the participants.

Results

Anchoring Effects

As before, we first dropped responses that were equal to the actual answer (29 of 512 total estimate or 5.7%). We then created an anchoring index within each domain by standardizing the participants' estimates (see Table 2 for unstandardized values) and then subtracting the average of the standardized responses to the low-anchor questions from the average of the standardized responses to the high-anchor questions. As expected, the anchoring index was greater than 0 for both the US questions ($M = 0.97$, $SD = 1.01$) and Indian questions ($M = 0.76$, $SD = 1.02$; $ts > 6.01$, $ps < .001$). In other words, participants exhibited significant anchoring effects in both domains.

Knowledge and Anchoring

To investigate the relationship between knowledge and anchoring, we conducted a 2 (Question Domain: US vs. India) × 2 (Participant Location: US vs. India) analysis of variance on participants' anchoring indices. Most importantly, this analysis revealed the predicted interaction, $F(1, 62) = 9.48$, $p = .003$, $\eta^2_p = .13$. This interaction is depicted in Figure 1. Tests of simple effects revealed that the Indian participants exhibited significantly larger anchoring effects for the US questions than the Indian questions, $F(1, 62) = 9.63$, $p = .003$, $\eta^2_p = .13$. Although in the predicted direction, the anchoring effects for the US participants were not significantly different across the two question domains, $F(1, 62) = 1.72$, $p = .20$, $\eta^2_p = .03$.

Discussion

Similar to Study 1, Study 2 suggests that knowledge is inversely related to the size of anchoring effects. Recall that in Study 1, participants who were knowledgeable about football showed smaller anchoring effects than people who were not knowledgeable. This left open the alternative explanation that some other difference between people with high versus low football knowledge could account for the results. In Study 2, however, it was not simply the case that one group of people showed larger anchoring effects than another group. The key effect was an interaction between participant location and

Table 2. List of questions, answers, anchors, and means (and standard deviations) for anchored estimates in Study 2

Question	Answer	Low anchor	High anchor	Low estimate	High estimate
On average, how long (in minutes) would it take to drive from Los Angles to San Diego?	124	30	300	99.90 (69.87)	245.04 (127.67)
How many US states are west of the Mississippi River?	24	4	40	11.38 (8.31)	29.21 (9.81)
How many American Idol winners have there been?	9	3	15	8.41 (3.62)	17.08 (13.13)
In what year did the US Civil war start?	1861	1775	1925	1814.03 (100.33)	1870.63 (66.29)
How many states in India have a population of more than 25 million people?	14	3	25	5.11 (3.62)	18.14 (12.38)
How old was Dr. A. P. J. Abdul Kalam when he became president of India?	70	48	92	54.00 (11.87)	71.04 (10.87)
How many years was the Indian soap opera Kyunki Saas Bhi Kabhi Bahu Thi on television?	9	2	16	7.50 (9.78)	12.22 (8.19)
What is the most number of runs scored by cricket player Mahendra Singh Dhoni in a single match?	183	110	250	150.24 (109.58)	189.78 (93.12)

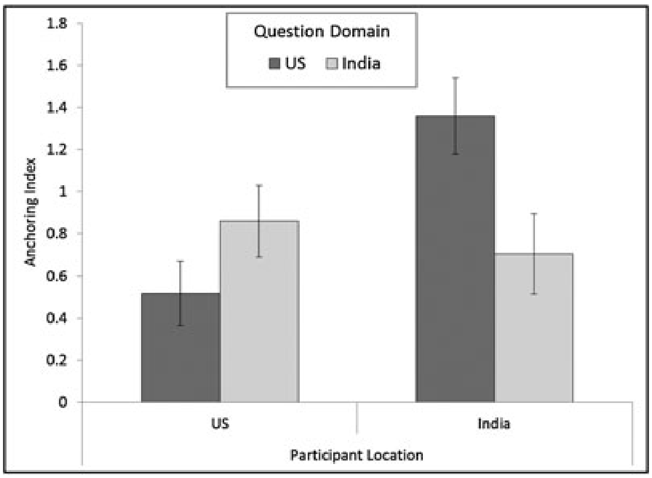

Figure 1. Anchoring indices for Study 2 as a function of participant location and question domain. A larger anchoring index indicates a larger anchoring effect. Error bars represent ±1 standard error

question domain, which essentially showed that the participants tended to exhibit smaller anchoring effects for questions from their high-knowledge domain rather than low-knowledge domain. This more convincingly implicates knowledge level, rather than some other factor, as the moderator of the anchoring effects.

One potential issue with this study is that, although participants were instructed not to, they could have looked up the answers to the questions. If participants selectively looked up answers to the questions they felt they should be knowledgeable about, we might see a similar pattern of results. There are, however, a number of reasons to doubt this occurred. First, very few estimates were the correct answers (<6%). Second, we observed the predicted pattern when we took out all correct estimates. And finally, if some participants looked up the answers to the questions, we might expect that participants who took longer to provide their answers (i.e., spent time searching for the correct answer) would be less biased. However, the amount of time taken did not correlate with the anchoring index for the US and India domains. This was true when examining all participants together ($r = .12$, $p = .36$ and $r = .06$, $p = .65$, respectively) and when conducting separate analyses for participants from the USA ($r = .01$, $p = .96$ and $r = -.11$, $p = .58$) and India ($r = -.13$, $p = .45$ and $r = .17$, $p = .34$).

STUDY 3

In Study 3, we took an even more fine-grained approach to directly linking knowledge to anchoring effects. We had participants answer a number of anchored target questions across 14 different domains. Importantly, before answering any questions, the participants indicated their knowledge level in each of the 14 domains. Therefore, we were able to test for within-participant relationships between knowledge level and anchoring effects (i.e., we could do idiographic-statistical analyses of the results).

Method

Participants

Sixty-four participants (45 women, mean age = 37.8) from the USA were recruited using MTurk and were paid $0.20 for their participation.

Procedure and Materials

After viewing initial information on MTurk, participants were directed to the survey website. They first rated their knowledge about 14 different domains in a random order (see APPENDIX B for list of domains). The ratings required the participants to compare their knowledge level with the average person (e.g., “Compared to the average person your age and gender, how knowledgeable are you about baseball statistics”).

Next, the participants received instructions about the anchor questions, were told that the anchors were arbitrarily determined, and were given instructions not to look up any of the answers. Each participant then answered a total of 28 anchored target questions—two from each of the 14 domains (see APPENDIX B for a list of the questions). The questions were presented to the participants in a block-randomized fashion. Specifically, the questions were distributed across seven survey pages; the order of the pages was randomized for each participant, but the order on each page remained constant for everyone. Each participant answered one question within each domain after a high anchor and one after a low anchor. This was counterbalanced across participants such that, for a given question, approximately half of the participants saw a low anchor and half saw a high anchor.

Results

Anchoring Effect

We again dropped responses that were equal to the actual answer (44 of 1764 total estimate or 2.5%).[4] We then calculated anchoring indices—one for each domain for each person. Specifically, we standardized the raw estimates separately for each question (see APPENDIX B for unstandardized estimates). Then, within each domain, we subtracted a participant’s standardized estimate for their low-anchor question from their standardized estimate for their high-anchor question. Therefore, larger values for this difference score/index reflect larger anchoring effects. Each of the 14 domains produced a significant anchoring effect. That is, the average anchoring index was greater than 0 for each of the domains (all $ts \geq 2.86$, $ps \leq .006$).

[4]For some questions, an answer was not readily available (e.g., “On average, how much does a large Coach handbag cost?”). For these questions, no responses were dropped. Additionally, data from one participant were dropped because of apparently disingenuous responding. Ten estimates of Ichiro Suzuki’s batting average were converted from whole numbers into percentages (e.g., an estimate of “350” converted to “.350”).

Knowledge and Anchoring Effect

To assess the relationship between knowledge and anchoring, we performed a mixed model analysis (as described by Judd, Westfall, & Kenny, 2012) testing participants' knowledge indices, with the participants' knowledge as the fixed effect and treating participants and question domain as random effects. This analysis revealed the expected effect of knowledge, $b = -.08$, $t(49.1) = -2.90$, $p = .006$; anchoring effects decreased as participants' reported knowledge increased. Additionally, the intercept for participants showed marginally significant variability ($p = .056$), suggesting that the magnitude of the anchoring effect varied across the participants. No other effects were significant. Overall, this analysis supports our prediction that knowledge level moderates anchoring effects.[5]

Discussion

Similar to the results of Studies 1 and 2, Study 3 provides support for the notion that higher knowledge is associated with smaller anchoring effects. Given that the association was detected using an idiographic-statistical analysis, we can rule out explanations for the association that might otherwise need to be entertained. For example, we can rule out the possibility that characteristics of the participants could, as third variables, account for the relation between knowledge and anchoring (e.g., that fatigue caused participants to give low estimates of knowledge and to be more affected by anchors).

STUDY 4

The first three studies shared an important limitation—namely the studies were all correlational or quasi-experimental. Therefore, our ability to draw causal conclusions is limited. To our knowledge, there has only been one study that has examined the relationship between anchoring and knowledge by manipulating participants knowledge level (Englich, 2008)—a study that failed to find a relationship between knowledge level and standard anchoring effects. The target judgment in that study was for the participants to estimate the cost of the average new midsized sedan sold in Germany. At the beginning of that study, some were given relevant knowledge (via viewing car advertisements), whereas others learned irrelevant information (via viewing kitchen advertisements). This created what Englich considered high-knowledge and low-knowledge participants. After reviewing the advertisements, the participants were assigned to either a basic anchoring or standard anchoring condition. In the basic anchoring condition, the participants wrote high or low numbers numerous times before providing their estimate. Participants in the standard anchoring condition directly compared their estimate to a high or low anchor. Finally, participants provided their estimate for the target judgment about the cost of the average new midsized sedan.

Englich (2008) found that the knowledge manipulation did reduce basic anchoring effects but had no impact on anchoring effects resulting from standard anchoring. Englich explained that this difference occurred because of the different mechanisms thought to produce basic anchoring and standard anchoring effects. Although this might be true, it should be noted that basic anchoring effects are notoriously fragile (Brewer & Chapman, 2002). Standard anchoring effects, on the other hand, have been described as some of the most robust in psychology (Chapman & Johnson, 2002). Therefore, it seems quite possible that a relationship between anchoring (using the standard anchoring paradigm) and knowledge exists, but the knowledge manipulation used in the study of Englich (2008) was not strong enough to perturb the very robust anchoring effects.

In Study 4, we used a standard anchoring paradigm that was generally similar to that in the study of Englich (2008), but we created a stronger manipulation of knowledge. We had three knowledge groups. One group, analogous to the kitchen condition in the study of Englich (2008), was given information that was not relevant to the target judgment that would be solicited later. A second group was given relevant information, but instructions introducing that information simply asked participants to read the information. A third group was given relevant information with much stronger instructions for learning the information. We expected that this latter group, relative to the other two groups, would be less influenced by anchors presented for consideration before target judgments were made.

Method

Participants and Design

One-hundred thirty-two participants (72 women, mean age = 34.1) from the USA were recruited using MTurk. The participants were paid \$.15 for their participation. This study was a 3 (Knowledge Condition: irrelevant, relevant-weak, and relevant-strong) $\times$ 2 (Anchor: high vs. low) between-subjects design.

Procedure

After viewing the study information on MTurk, the participants were directed to the survey website, where they read some initial instructions. All groups were then given an opportunity to learn some information, but the type of information and accompanying instructions differed as a function of the knowledge condition. In the "irrelevant" condition, participants saw a list of five cars, and numbers purported to be their worldwide sales frequencies (which are irrelevant because the later target judgment would be about a car price). Accompanying instructions indicated that participants should look over the list before moving on (see APPENDIX C for the exact instructions for all conditions). In the "relevant-weak" condition, participants saw the same instructions and the same list of cars and figures, except that figures were labeled as prices, which made that information clearly relevant for the later target judgment. In the "relevant-strong" condition, participants saw the same list of cars and prices. However, the instructions encouraged

[5]In addition to the mixed-model analysis, we also performed a separate regression analysis for each participant, predicting his/her anchoring index in the 14 domains from his/her 14 knowledge judgments. We then submitted the unstandardized beta coefficients from these analyses to a one-sample *t*-test. The average of these coefficients ($M = -.06$, $SD = .22$) was significantly less than zero, $t(62) = 2.37$, $p = .02$, $d = 0.27$. Consistent with the other analysis, this indicates that participants exhibited smaller anchoring effects in the domains for which they reported higher knowledge.

participants to carefully review the information because it would be useful later in the study (again, see APPENDIX C).

After reviewing the information, the participants were told they would be answering questions regarding their thoughts about new cars and that they should not look up any as we were interested in "...what you currently know, not what you can look up." The participants were told they would be asked about randomly determined and completely arbitrary numbers (i.e., our anchors). Next, the participants compared the average price of a new midsized sedan to either a high ($41,100) or low anchor ($14,100) (e.g., "Do you think the average price of new midsized sedan sold in the USA is more or less than $14,100?"). The anchor values used in this study were similar (after converting from Euros to US dollar) to those used by Englich (2008). Finally, participants provided an estimate of the average price of a new midsized sedan sold in the USA.

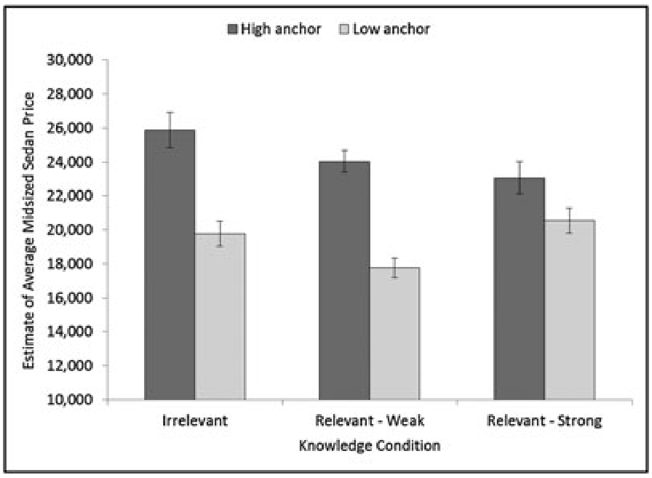

Figure 2. Estimates given in Study 4 as a function of knowledge condition and anchor. Error bars represent ±1 standard error

Results

We conducted a 3 (Knowledge Condition) × 2 (Anchor) analysis of variance on participants' estimates of the average price of a new midsized sedan.[6] This analysis revealed a robust anchoring effect, $F(1, 126) = 60.37$, $p < .001$, $\eta_p^2 = .32$, such that participants who saw higher anchors gave higher average price estimates. More importantly, there was a significant Knowledge Condition × Anchor interaction, $F(2, 126) = 3.51$, $p = .03$, $\eta_p^2 = .05$ (Figure 2). To follow up on this interaction, we conducted two interaction contrasts comparing (individually) the anchoring effects in the relevant-strong condition to the other two conditions (Abelson & Prentice, 1997). As expected, participants in the relevant-strong condition were less influenced by anchors than participants in the irrelevant condition, $F(1, 126) = 5.03$, $p = .027$, and the relevant-weak condition, $F(1, 126) = 5.67$, $p = .019$. Tests of simple effects revealed robust anchoring effects for the irrelevant ($p < .001$, $\eta_p^2 = .20$) and relevant-weak ($p < .001$, $\eta_p^2 = .21$) knowledge conditions. Although much smaller, participants in the relevant-strong condition also exhibited significant anchoring effects ($p = .03$, $\eta_p^2 = .04$).

We also examined the amount of time it took participants to provide their estimates. Overall, there were no differences between the time participants in the irrelevant ($M = 23.67$ seconds, $SD = 21.84$), relevant-weak ($M = 25.47$ seconds, $SD = 11.74$), and relevant-strong ($M = 23.44$ seconds, $SD = 11.12$) conditions took to give their estimates, $F(2, 126) = 0.21$, $p = .81$, $\eta_p^2 = .003$.

Discussion

The results of Study 4 are consistent with the findings of the first three studies in that high-knowledge participants were less influenced by anchors than low-knowledge participants. As predicted, the decrease in anchoring effects occurred when the participants were given relevant background information, and they were encouraged to process this information.

In addition to supporting the claim that knowledge moderates anchoring effects, the results of Study 4 also potentially explain why previous investigations have failed to find this relationship (e.g., Englich, 2008). That is, because the influence of anchors is so robust, manipulations designed to reduce anchoring effects must be quite strong in order to be effective. The knowledge intervention used by Englich (i.e., presenting some participants with advertisements about cars) was not strong enough to overcome the anchoring effects. Similarly, in Study 4, the participants in the relevant-weak condition exhibited virtually identical anchoring effects as those participants in the irrelevant condition. It was not sufficient to simply present these participants with information that was relevant to their later judgment. Instructions encouraging the participants to process the information were also necessary to help reduce the biasing influence of anchors.

An attentive reader might notice that the instructions in our relevant-strong condition not only encouraged participants to process the relevant information but might have also increased the effort put forth by the participants. Therefore, it is possible that the decrease in anchoring effects exhibited in the relevant-strong condition was not a result of increased attention while learning information but simply because the participants were trying harder while providing estimates. While this is certainly possible, we feel it is unlikely given that numerous studies have demonstrated that manipulations designed to increase effortful processing tend to not influence anchoring effects from experimenter-provided anchors (e.g., Epley & Gilovich, 2005; Tversky & Kahneman, 1974; Wilson et al., 1996). A recent exception to the previous research is a series of studies described by Simmons et al. (2010). In their studies, incentives for accuracy did increase adjustment from provided anchors (i.e., reduce anchoring effects), but only when participants were certain of the directions they should adjust away from the anchor value. The concept of certainty about the direction of adjustment of Simmons et al. (2010) is related to knowledge level. That is, someone who is more knowledgeable will also be better able to judge the direction he or she should adjust from a given anchor. Although the account of Simmons et al. (2010) does help specify when incentives for accuracy might influence adjustment, it does not predict that high-knowledge participants—without any incentives for accuracy—will be less influenced by anchors than low-knowledge participants.

[6]We did not drop any participants' responses for being exactly accurate because no participants gave an estimate within $1000 of the average price of a new midsized sedan sold in the USA in 2011 (approximately $32,000).

Therefore, it would appear that increased effort while estimating most likely did not produce the pattern of results observed in Study 4. In all likelihood, the strong instructions encouraged participants to pay attention to the relevant information, thereby increasing their knowledge about the topic area.

GENERAL DISCUSSION

We designed four studies that used a variety of methodologies investigating the relationship between knowledge level and anchoring effects. In all four studies, higher knowledge was associated with smaller anchoring effects. In Study 1, greater knowledge of football was correlated with smaller anchoring effects on football-related judgments. Importantly, this was true whether knowledge was measured using subjective self-assessments or by using an objective measure of football knowledge. In Study 2, participants in India exhibited smaller anchoring effects for questions about India than questions about the USA. In Study 3, once again, higher knowledge was associated with smaller anchoring effects. This time, however, the main analyses examined the relationship within participant and across domains. Finally, in Study 4, manipulating participants' knowledge levels successfully reduced anchoring effects when the participants had been instructed to carefully review the provided information. The consistency of the results across our four studies provides evidence that there are many situations where anchoring effects are moderated by knowledge level.

How Does Increased Knowledge Lead to Smaller Anchoring?

Earlier, we described three ways in which increased knowledge could lead to smaller anchoring effects. First, high-knowledge participants may be more likely to have the exact answer to the posed questions stored in memory. While this would certainly mitigate anchoring effects, in the current studies, we chose questions for which very few participants knew the exact answers, and we only analyzed estimates when participants did not give the correct answer. Second, high-knowledge participants are likely to have a narrower range of plausible responses than their low-knowledge counterparts (Mussweiler & Strack, 1999). Therefore, even though their estimates were influenced by anchors, they were also confined to some degree by their narrow range of plausible responses (see also Mussweiler & Strack, 2000, 2001). And third, high-knowledge participants likely have access to more information that is inconsistent with the anchor. Mussweiler et al. (2000) demonstrated that considering anchor-inconsistent information is a way to reduce the biasing influence of anchors. Therefore, if a person has access to a greater amount of anchor-inconsistent information, he/she could use this information to mitigate the influence of anchors. The current studies were not designed to test between these explanations. However, now that links between knowledge level and anchoring effects have been established in our various paradigms, future research can address this issue.

Will Knowledge Always Moderate Anchoring Effects?

Although the current studies demonstrate that knowledge can, and likely often does, moderate anchoring effects, we do not assume that this will always be the case. As described by Mussweiler and Strack (1999), it is possible that anchor extremity is an important variable for determining the degree to which knowledge will moderate anchoring effects. Imagine a study where a variety of anchor values that differ in their extremity are used. It seems possible that the difference between an estimate given by a high-knowledge and low-knowledge participant would increase as the anchor gets more extreme. Figure 3 plots hypothesized estimates from high-knowledge (solid black line) and low-knowledge (dashed gray line) participants after a comparison with a high (right side of the figure) or low anchor (left side of the figure). Notice that as the high anchor gets higher and the low anchor gets lower, the difference between high-knowledge and low-knowledge participants increases. Also note the decreasing slope of both lines. This reflects the assumption that, for example, a high anchor of 100 million might produce a larger anchoring effect than a more moderate anchor (e.g., 20 million) when estimating the population of Ohio. However, 100 million will produce a similar anchoring effect as compared with 300 million. As shown in Figure 3, high-knowledge participants would be expected to reach the plateau earlier than low-knowledge participants.

Interestingly, the hypothesized pattern of results described earlier could potentially account for some of the discrepant findings regarding the relationship between knowledge and anchoring effects. Namely, if a study used moderate anchors, the difference between anchoring effects for high-knowledge and low-knowledge participants might be quite small or even nonexistent. On the other hand, if extreme anchors are used, the difference between anchoring effects of high-knowledge and low-knowledge participants might be quite pronounced. In fact, two of the most widely cited anchoring studies that show no difference between high-knowledge and low-knowledge participants used moderate anchors (Englich et al., 2006; Northcraft & Neale, 1987). Northcraft and Neale (1987) had realtors and university students estimate the price of a house (appraised at $135,000) after comparisons with anchors ($119,000, $129,000, $139,000, and $149,000). The estimates

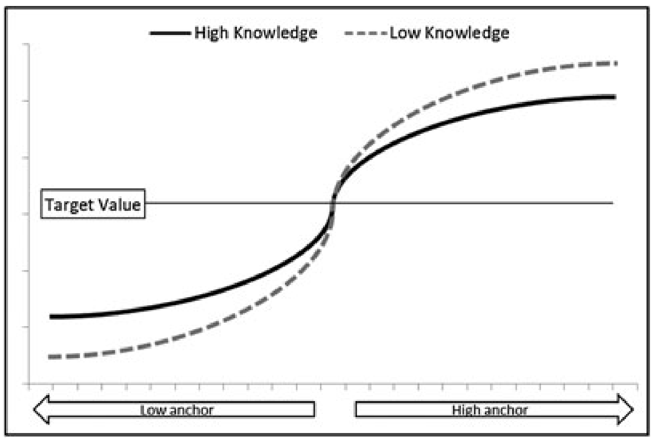

Figure 3. Hypothesized relationship between anchor extremity and knowledge level

following the low anchors were lower than the estimates following the high anchors; the magnitude of the anchoring effect did not differ substantially for experts and novices. However, it seems possible that the difference between experts and novices would have been evident if more extreme anchors were used (e.g., $89,900 and $179,900).

Similarly, Englich et al. (2006) had legal experts and non-experts read a hypothetical scenario about a woman convicted of shoplifting. The experts gave recommendations about the length of probation the woman should receive after considering a high (9 months) or low (3 months) anchor. The participants gave higher estimates after considering a high anchor than a low anchor. Again, the magnitude of the anchoring effect did not significantly differ between experts and non-experts. However, if the high anchor was more extreme (e.g., 36 months), there might have been a different conclusion. The experts may have rejected this value as clearly too high and given a response of 10 months. The non-experts, on the other hand, might not know what constitutes an appropriate probation length and, therefore, give an estimate of 20 months.

It is also notable that the studies described in this manuscript used estimates with objectively correct answers (e.g., "How many US states are west of the Mississippi River?"). This is, of course, in contrast to the questions asked in the studies described earlier (e.g., estimating the value of a house). At this point, it is unknown whether the decrease in anchoring effects that is associated with greater knowledge is restricted to estimates with correct answers.

Final Thoughts

As noted earlier, there are conclusions in the published literature that doubt the notion that knowledge levels moderate anchoring effects (Englich & Soder, 2009; Furnham & Boo, 2011). Our work demonstrates that under fairly common conditions, knowledge level can moderate anchoring effects (for similar findings, see Mussweiler & Strack, 2000). In addition to being an important conceptual clarification, this has potential implications for real-world situations. Robust anchoring effects have been observed in numerous important domains such as doctors' diagnoses (Brewer, Chapman, Schwartz, & Bergus, 2007), consumers' willingness-to-pay for products (Ariely, Loewenstein, & Prelec, 2003; Simonson & Drolet, 2004), and personal injury damages awards (Chapman & Bornstein, 1996; Marti & Wissler, 2000). At the same time, anchoring effects have been shown to be resistant to debiasing strategies such as forewarning (e.g., Wilson et al., 1996) and incentives for accuracy (e.g., Epley & Gilovich, 2005; Tversky & Kahneman, 1974; but see Simmons et al., 2010). Therefore, it is possible that knowledge interventions, such as the one we used in Study 4, can help reduce susceptibility to anchoring effects in applied settings.

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APPENDIX A

Questions Used in Football Quiz for Study 1

Question	Answers
How many games does each team play during the regular season?	16
How many regular season games did the New England Patriots win during the 2007 season?	16
Who was the head coach of the Chicago Bears during the 2007 season?	Lovie Smith
How many teams are in the AFC?	16
How many players are on the field at one time for both teams combined?	22
What jersey number did Brett Favre wear while playing for the Green Bay Packers?	4
What player led the league with the most passing yards during the 2007 season?	Tom Brady
What player led the league with the most rushing yards during the 2007 season?	LaDainian Tomlinson
What player led the league with the most sacks during the 2007 season?	Jared Allen
What player led the league with the most interceptions during the 2007 season?	Antonio Cromartie
What player led the league with the most tackles during the 2007 season?	Patrick Willis
What team led the league with the most passing yards during the 2007 season?	New England Patriots
What team led the league with the most rushing yards during the 2007 season?	Minnesota Vikings
What team gave up the fewest total yards per game during the 2007 season?	Pittsburgh Steelers

APPENDIX B

List of Domains, Questions, Anchors, and Means (and Standard Deviations) for Anchored Estimates in Study 3

Domains	Questions	Answers	Low anchors	High anchors	Low-anchor estimates	High-anchor estimates
Cost of food items	How much does a pound of ground beef cost	~$3.50	1.00	6.00	2.97 (1.06)	4.05 (1.23)
	How much does a gallon of milk cost	~$3.50	1.00	6.00	2.79 (0.73)	3.51 (0.76)
Number of calories in food	How many calories are in a Twinkie	150	30	300	160.69 (104.20)	311.76 (157.91)
	How many calories are in a McDonald's Big Mac	540	150	1200	570.68 (277.98)	1749.00 (2403.40)
Population of cities in Iowa	What is the population of Cedar Rapids, IA	126,326	25,000	250,000	87,882 (88,692)	214,489 (158,682)
	What is the population of Sioux City, IA	82,684	5000	200,000	60,779 (69,995)	179,721 (146,278)
Number of countries in each continent	How many countries are in South America	12	5	30	15.00 (6.71)	22.82 (11.93)
	How many countries are in Africa	53	10	80	29.71 (14.17)	44.76 (21.47)
Medal counts at 2010 Winter Olympics	How many medals (gold, silver, and bronze) did Norway win in the 2010 Winter Olympics	23	5	45	9.82 (7.36)	22.62 (19.13)
	How many medals (gold, silver, and bronze) did Canada win in the 2010 Winter Olympics	26	5	50	14.10 (8.44)	32.82 (19.05)
Baseball statistics	How many home runs did Albert Pujols hit during the 2009 MLB season	47	15	90	23.07 (14.57)	48.44 (33.01)
	What was Ichiro Suzuki's batting average for the 2009 MLB season	.352	.100	.550	.300 (.23)	.408 (.14)

(Continues)

Table . (Continued)

Domains	Questions	Answers	Low anchors	High anchors	Low-anchor estimates	High-anchor estimates
Cost of clothes and accessories	On average how much does a large Coach handbag cost	~$300	50	700	237.76 (145.16)	629.12 (486.95)
	On average how much does a pair of Christian Louboutin heels cost	~$400	50	800	301.00 (195.74)	666.38 (489.64)
Albums released by classic rock bands	How many Rolling Stones albums have gone platinum	28	4	40	8.83 (4.58)	31.79 (20.35)
	How many albums (live and studio) has U2 released	19	4	30	14.65 (6.55)	22.10 (10.26)
Specs of cars	What is the horsepower of a 2010 Mustang GT	315	75	600	205.44 (153.66)	572.59 (237.23)
	What is the top speed of a 2010 Porsche Boxster S	160	100	300	170.86 (123.74)	186.50 (43.46)
Cooking times and temperatures	How long does it take to bake an 8 × 8 pan of brownies	~40	15	75	28.56 (10.67)	33.14 (11.86)
	When cooking pork what is the minimum internal temperature that is considered safe	145	115	315	165.69 (69.12)	245.06 (99.07)
Grammy awards given to pop stars	How many Grammy awards has Alicia Keys been nominated for	24	3	30	6.66 (3.75)	14.79 (7.58)
	How many Grammy awards has Beyonce won	16	2	25	6.18 (4.67)	10.07 (6.13)
Computers and technology	How many gigabytes of hard drive space does the average new desktop computer have	~500	50	1500	155.66 (172.57)	1058.25 (1341.04)
	How many minutes does it take to download a 100 MB file over a DSL connection	~8	1	20	5.97 (8.06)	15.86 (18.06)
Agricultural information	How many pounds does a large round bale of hay weigh	1500	100	2000	269.12 (288.33)	6129 (27680)
	How many bushels of corn can you get from 1 acre of farmland	180	20	400	134.83 (364.25)	533.09 (822.71)
US Civil War	How many people died during the Civil War	625,000	30,000	800,000	189,706 (241,949)	695,345 (476,637)
	What year did the Civil War start	1861	1825	1895	1848 (31.05)	1864 (24.96)

APPENDIX C

Instructions Used in Study 4

Irrelevant and relevant-weak conditions:

Thank you for agreeing to participate in this survey. You will be asked questions regarding your thoughts and feelings about a variety of cars. To give you a frame of reference when going through this survey, we have provided you with a list of five new cars currently sold in the US. Please take a couple minutes and review the information below. Once you have done this, click on the Next button below.

Relevant-strong condition:

Please read carefully. Thank you for agreeing to participate in this survey. This survey consists of two parts. In the first part, you will see information about a number of cars currently sold in the US. In the second part, you will be asked questions regarding your thoughts and feelings about a variety of cars.
Make sure to review the information below carefully as we will ask you questions about this information later. This is a short survey, so please take your time when reviewing the information and answering questions. Please take some time now and review the information below. Once you have done this, click on the Next button to proceed to the second part of the survey.