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Numeric Judgments under Uncertainty: The Role of Knowledge in Anchoring

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Three studies demonstrate that anchoring effects—the assimilation of a numeric estimate to a previously considered standard—depend on judges' knowledge about the target object. Manipulating judges' knowledge by varying the context in which a fictitious target is presented, Study 1 demonstrates that anchor plausibility determines how a given anchor is processed and depends on what knowledge base is used to judge the anchor. Studies 2 and 3 show that the less judges know about the target object, the more they assimilate their estimate to the anchor. These differences in the magnitude of the anchoring effect appear to be mediated by differences in the perceived plausibility of the anchors. Furthermore, Study 3 demonstrates that these effects even hold when the selection of the anchor values is under participants' control. © 2000 Academic Press

Numeric judgments are often made under uncertainty. In such situations, they are easily influenced by a standard or anchor (Tversky & Kahneman, 1974) that may be explicitly (e.g., Cervone & Peake, 1986; Tversky & Kahneman, 1974; Strack & Mussweiler, 1997) or implicitly (e.g., Northcraft & Neale, 1987; Wilson, Houston, Etling, & Brekke, 1996) provided to the judge. Regardless of its source, considering such a standard typically leads to an assimilation of the numeric estimate toward it. For example, deciding whether the percentage of African nations in the UN is higher or lower than 65% (i.e., solving a compar-

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ative anchoring task) leads to higher absolute estimates for this percentage than deciding whether it is higher or lower than 10% (Tversky & Kahneman, 1974).

The very definition of the underlying anchoring heuristic as a tool for judgments under uncertainty (Tversky & Kahneman, 1974) implies that such anchoring effects depend on the degree of uncertainty about the judgment. Supporting this notion, some correlational data suggest that the size of the anchoring effect increases with uncertainty (Jacowitz & Kahneman, 1995). In particular, Jacowitz and Kahneman (1995) demonstrated that the more uncertain judges were about the judgment, the more were numeric estimates assimilated to the provided anchor values. To fully understand the role uncertainty plays in anchoring, however, one has to examine the ways in which it influences how a given anchor is processed. In the current article, we attempt to do so.

Clearly, uncertainty about a judgment depends on what people know about its target: The less judges know about the target, the more uncertain they are about the judgment to be made. Surprisingly, there has been little research that explores this link between anchoring and knowledge. Moreover, the few existing studies provide seemingly contradictory results. For example, a number of studies demonstrated that judges' *general expertise* has no effect on the magnitude of anchoring (e.g., Joyce & Biddle, 1981; Englich & Mussweiler, in press; Mussweiler, Strack, & Pfeiffer, in press; Northcraft & Neale, 1987; Wright & Anderson, 1989), whereas Wilson et al. (1996) found anchoring effects only for judges low in knowledge about the target. To understand this specific discrepancy as well as the general role judges' knowledge plays in anchoring, one has to develop a conceptual framework that links judges' knowledge to the processes that underlie judgmental anchoring.

Knowledge and Anchoring

Recently, we (Mussweiler & Strack, 2000) have suggested that an earlier conceptualization in which categorical judgments are linked to probability distributions of judges' beliefs concerning the target's category membership (Wyer, 1973) provides a useful starting point for the development of such a framework. Wyer (1973) assumes that a judgment along a category scale reflects the "subjective expected value" of these probability distributions. For example, a categorical judgment about the age of a specific target person may be conceptualized as the expected value of the distribution of probabilities that the target belongs to each of the given scale categories.

Applying this conceptualization to absolute judgments, peoples' knowledge about the target may be characterized by a distribution of subjective probabilities for possible values of the target. The absolute judgment then corresponds to the subjective expected value of this probability distribution, which can vary with respect to both its position along the judgmental dimension and its dispersion (see Figs. 1 and 2). Different expected values may be represented by distributions with different *positions along the judgmental dimension.* In particular, if judges' knowledge implies that the target's extension is fairly high, the probability

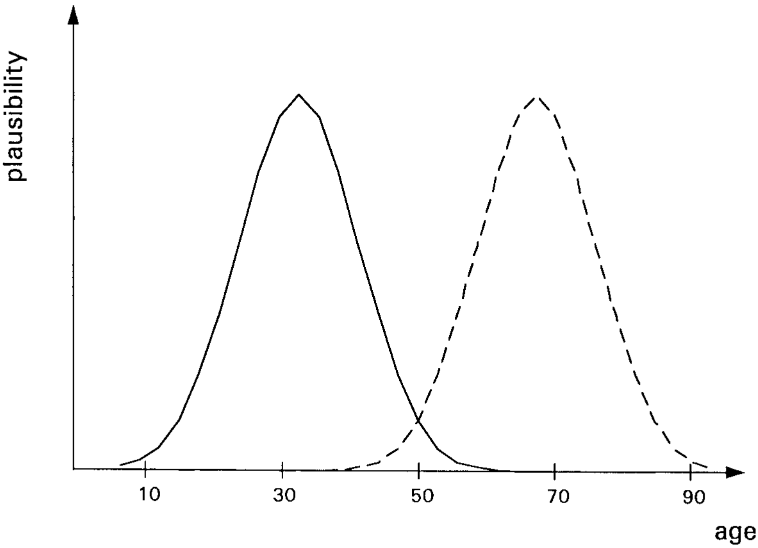

FIG. 1. Hypothetical distributions of plausible values with varying positions along the judgmental dimension for estimates of the age of Mahatma Gandhi.

distribution will be positioned at the upper end of the judgmental dimension. By the same token, if judges' knowledge implies that the target's extension is fairly low, the plausibility distribution will be positioned at the lower end of the judgmental dimension. For example, for a judge whose knowledge implies that Mahatma Gandhi was fairly old, the probability distribution will be positioned at the upper end of the judgmental dimension "age" (e.g., with a subjective expected value of 70 years), whereas for a judge whose knowledge implies that he was rather young, it will be positioned at the lower end (e.g., with a subjective expected value of 30 years) (see Fig. 1).

The *dispersion of the probability distribution* depends on the amount of knowledge a judge has about the target of the judgment. The more a judge knows about judgment-relevant aspects of the target, the narrower his or her range of plausible values.[1] To see the implications of this relation, first consider a person who has maximal relevant knowledge and knows the exact value of the target characteristic (e.g., one's own age). For this person, only the correct estimate itself constitutes a possible value, so that the probability distribution is extremely

[1] Strictly speaking, it is more the ambiguity of a judge's knowledge than its sheer amount that determines the dispersion of the probability distribution. That is, the less ambiguous the implications of a judge's knowledge with regard to the current judgment, the narrower his or her probability distribution will be. In principle, one can construe cases in which the ambiguity and the amount of knowledge are independent of each other. In most cases, however, amount and clarity are closely related. Thus, for reasons of simplicity, we assume that more knowledge also implies that the implications of this knowledge are less ambiguous.

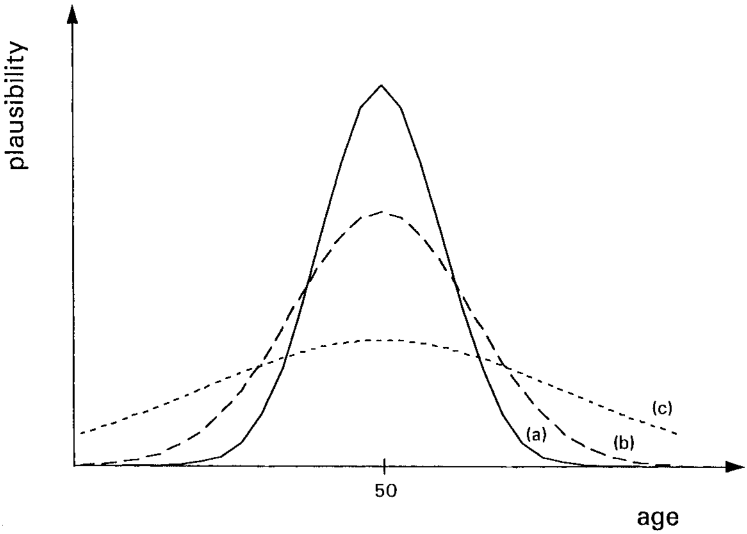

FIG. 2. Hypothetical distributions of plausible values with varying dispersions for estimates of the age of (a) oneself, (b) Mahatma Gandhi, and (c) Xiang Long.

narrow. In contrast, if a person has very limited knowledge about the target object (e.g., the age of an unspecified entity named Xiang Long) the distribution of plausibility is extremely wide. By the same token, the dispersion of the distribution of plausible values for the age of Mahatma Gandhi will be in between these two extremes because most judges will at least have some knowledge about him. Thus, the plausibility of a given anchor depends critically on how much knowledge the judge has about the target. Hypothetical plausibility distributions for the above examples are depicted in Fig. 2.

In sum, the current conceptualization identifies two critical characteristics of judges' knowledge about the target: the *position* and the *dispersion* of the distribution of plausible values. These two variables critically depend on different aspects of judges' knowledge about the target. One important factor is knowledge about the *general category* to which the target belongs. For example, whether an unspecified entity (e.g., Xiang Long) is categorized as a person or as a cultural possession will clearly influence the position of the distribution of plausible values. Moreover, whether one is certain about the category membership of this entity will determine the dispersion of this distribution. Within the boundaries prescribed by such category knowledge, knowledge about the *specific exemplar* constitutes a second potent influence. For example, within the general boundaries defined by Mahatma Gandhi's membership in the category "person," specific knowledge about his age will further determine the position of the distribution, whereas the amount of knowledge will determine its dispersion. It is important to note that—from the current perspective—these different aspects of knowledge (e.g., category knowledge, exemplar knowledge, uncertainty, and expertise) are closely related in that they can all be characterized by their influence on the two critical characteristics of the distribution of plausible values (i.e., its position and distribution).

Plausible and Implausible Standards

Within this conceptual framework a principle distinction between two classes of anchor values can be made. In particular, a given anchor—which typically constitutes a specific value on the judgmental dimension—can either lie within or outside of the distribution of possible values for the target. This distinction is crucial because comparisons with these two types of anchors appear to involve distinct judgmental processes.

Specifically, to compare a target with a value that lies within the distribution of possible values for the target and thus constitutes a *plausible anchor,* judges have to resort extensively to their knowledge about the target. For example, to decide whether Mahatma Gandhi was older or younger than 74 years, judges have to resort to their specific knowledge about Mahatma Gandhi. We have recently proposed (Mussweiler & Strack, 1999a, 1999b, 2000; Strack & Mussweiler, 1997) that in this situation judges construct a mental model (Johnson-Laird, 1983) of the target in which its value along the judgmental dimension is similar to the anchor value. In our example, judges may thus try to construct a mental model of Mahatma Gandhi at the age of 74. According to the Selective Accessibility Model (Mussweiler & Strack, 1999a, 1999b, 2000; Strack & Mussweiler, 1997), they do so by selectively generating knowledge about the target that is consistent with this assumption (e.g., "Mahatma Gandhi was a bold and skinny man who looked rather old," "He fought for India's independence for decades," etc.). As a consequence, the accessibility of anchor-consistent knowledge about the target is increased. In order to generate the final numeric estimate, judges then primarily rely on easily accessible knowledge (cf. the "accessibility principle;" Higgins, 1996; Wyer & Srull, 1989) so that their estimate is influenced by the anchor-consistent knowledge that was generated before. This results in an assimilation of the final estimate to the anchor value.

Such an elaborate construction of an anchor-consistent mental model of the target, however, is unnecessary to compare the target to an anchor value that is *implausible* because it lies outside of the boundaries of the distribution of possible values. For example, to decide whether Mahatma Gandhi was older or younger than 140 years, judges do not have to make extensive use of their specific knowledge about Gandhi. Instead, it is sufficient to compare the anchor to the boundary value of the distribution of possible values (i.e., the most extreme possible value). In our example, participants can easily decide that Mahatma Gandhi was younger than 140 years because no human being is likely to reach this age. Consequently, judges who act as cognitive misers (Fiske & Taylor, 1984) in solving an anchoring task are unlikely to engage in the elaborate and capacity-consuming construction of a mental model of the target while comparing the target to the anchor.[2]

A recent set of studies (Mussweiler & Strack, 1999a, 2000; Strack & Mussweiler, 1997) supports this conceptualization. Specifically, we demonstrated that comparing a target to an implausibly extreme standard requires less processing time than comparing it to a plausible standard. For example, participants were faster in deciding whether Mahatma Gandhi was older or younger than 140 years than whether he was older or younger than 79 years. Most important, this pattern was reversed for the subsequent absolute judgment. Here, participants who had received the plausible anchor were faster than participants who had previously received an implausible anchor.

This pattern of response latencies suggests that the implausible anchor was processed without extensively generating specific knowledge about the target to construct a mental model. More specifically, the comparative task that included an implausible anchor may have been processed faster because simply comparing this value to the closest boundary value of the distribution of possible values requires less time than constructing a mental model of the target. The consequence, however, is longer response latencies for implausible anchors because the accessibility of specific knowledge that facilitates the solution of the subsequent absolute task is only increased for plausible, but not for implausible, anchor values.

Thus, depending on the plausibility of the anchor, comparing the target to the anchor may or may not involve the construction of an anchor-consistent mental model of the target. Whether a given anchor is plausible depends on the relative position of the anchor value and the probability distribution of possible values for the target. That is, the plausibility of a given anchor value—and thus the way it is processed—depends critically on judges' knowledge about the target. For example, an anchor value of 45 years may be seen as plausible by a judge whose knowledge implies that Mahatma Gandhi died at an early age. The very same anchor value, however, may be seen as implausible by a judge whose knowledge implies that he was rather old. Study 1 was designed to illustrate this relation of judges' knowledge about the target and the plausibility of the anchor.

[2] Note that although judges do not appear to construct such a mental model while comparing the target to an implausible anchor, such anchors typically produce robust anchoring effects (e.g., Mussweiler & Strack, 1999a; Strack & Mussweiler, 1997). This may be the case because, when generating the final estimate, judges use the boundary value of the distribution of plausible values (e.g., 100 years) to construct a mental model of the target. More specifically, when confronted with an implausible anchor, judges may first select an appropriate standard of comparison by adjusting from the provided value (Tversky & Kahneman, 1974) until the boundary of the distribution of plausible values is reached. They may then use this boundary value as a self-set standard in the selective accessibility mechanism (for a more detailed discussion of this possibility, see Mussweiler & Strack, 1999a) and construct a mental model of the target in which its value is similar to this standard.

STUDY 1

To examine this relation, one has to manipulate judges' knowledge about the target object. This, however, is difficult to achieve because for most targets, participants' knowledge varies substantially before they enter the experimental situation. Such differences in preexisting knowledge are difficult to control for actual objects. Therefore, we adopted a methodology that leaves the target itself ambiguous, so that the context determines which knowledge is used to judge the target (Strack, Schwarz, & Wänke, 1991). Specifically, we used fictitious targets that were presented in different contexts: Participants were asked to estimate the height of "Lowumbo." Before receiving this question, they had to answer eight context questions that either pertained to mountains ("K2," "Mount Everest," etc.) or to animals ("rhino," "tiger," etc.). We assumed that, depending on the context, the fictitious object would be categorized either as a mountain or as an animal. As a consequence, the height of Lowumbo should be estimated in the light of general knowledge about mountains or animals, respectively.

If this is true, perceptions of the plausibility of the anchor should depend on the context manipulation. In particular 3000 m should be seen as plausible for Lowumbo the mountain but as implausible for Lowumbo the animal, whereas the reverse should be true for 2 m. Given that plausible and implausible anchors are processed differently, these differences in perceived plausibility should be apparent in the differential patterns of response latencies that plausible and implausible standards typically yield for the comparative and the absolute task (cf. Strack & Mussweiler, 1997, Study 3): In the mountain context, comparative response latencies should be longer for the anchor of 3000 m than for the anchor of 2 m. Consequently, absolute response latencies should be shorter for 3000 m than for 2 m. In the animal context, however, the reverse pattern should occur. This reasoning was tested in Study 1.

It is important to note that the described context manipulation influences one specific aspect of judges' knowledge, namely knowledge about the category membership of the target. The current framework, however, conceptualizes the influence of category knowledge in the same way as influences of other aspects of judges' knowledge (e.g., exemplar knowledge). As a consequence, influences of the current manipulation are likely to generalize to those of other aspects of knowledge.

Method

Because the general procedure used in Studies 1 through 3 are similar, Study 1 will be described in more detail, and only procedural deviations will be noted for the subsequent studies.

Participants. Sixty-three male and female students (not enrolled in psychology courses) at the University of Würzburg were recruited as participants. They were contacted via phone and asked to participate in a series of studies that would last about 2 h. As a compensation, they were offered 25 German Marks (about $16). Participants were randomly assigned to one of four experimental groups.

Materials. Participants received pairs of general-knowledge questions. Comparative and absolute questions were presented in an abbreviated form so that participants could not infer from their grammatical structure to which category the targets belonged. For example, participants were asked, “Kilimanjaro </> 4950 m?” and “Kilimanjaro: How high?” Participants received nine question pairs. Pairs 1 through 8 constituted the context manipulation, whereas pair 9 was the critical one that pertained to “Lowumbo.” The objects used in the context questions varied in familiarity. Thus, well-known instances of the two categories mountain and animal such as “Mount Kilimanjaro,” “Mount Everest,” “Tiger,” and “Rhino” were interspersed with little-known instances such as “Mount Choke” and “Emu.” This was done to reduce participants’ scepticism when confronted with the fictitious target “Lowumbo.”

The anchors used for the context questions were identical for both context conditions. In order to familiarize participants with plausible and implausible anchors, both anchor types were used. For example, participants in the mountain-context condition were asked whether Mount Kilimanjaro was higher or lower than 4950 m (i.e., a plausible anchor) as well as whether Mount Everest was higher or lower than 2.5 m (i.e., an implausible anchor). For the eight context questions, the anchors were identical in both conditions. However, the anchors used in the critical “Lowumbo” question depended on the experimental condition. Thus, participants were either asked whether “Lowumbo” was higher or lower than 2 or 3000 m. The order of the questions was kept constant so that participants answered the eight context questions in the same order before receiving the critical “Lowumbo” question. In sum, the four experimental conditions represented all four combinations of Context (animal vs mountain) and Anchor (high vs low).

Procedure. To allow for an assessment of response latencies, the questions were presented on a personal computer. Participants took part in the experiment in groups of up to four. Upon arrival, they were led to the computer lab and started with the first task, which was unrelated to the current study. After completion of this task, they were escorted to the computers and told to read the instructions carefully. There, participants were informed that they were taking part in a pretest for the construction of a general-knowledge questionnaire. It was emphasized that the purpose of the pretest was to find the best wording for general-knowledge questions. Moreover, participants were told that some of the questions would require a comparison with a given standard and that these standards were randomly selected by using a mechanism similar to that of a wheel of fortune. It was pointed out that this was necessary to minimize a possible influence the standards may exert on the answers and to identify the impact of different question formats. The random selection of the anchor values was emphasized to reduce their ascribed informativeness (cf. Grice, 1975) and thus to ensure that the obtained effects were not mediated by conversational inferences (see Jacowitz & Kahneman, 1995). Furthermore, participants were informed that the questions they were going to be asked would be formulated in the abbreviated form described above. It was explained that this was necessary for the computerized assessment of general knowledge.

The experimenter then demonstrated how to report answers on the keyboard. Participants were instructed to answer the comparative question by pressing either the “q” key, which was marked with a red sticker or the “p” key, which was marked with a green sticker. For each comparative question, the keys corresponding to the two possible answers (e.g., higher or lower) were depicted on the bottom of the computer screen. To generate answers to the absolute questions, participants were instructed to use the number pad on the keyboard. They were warned that comparative and absolute questions would alternate. Finally, participants were told to answer the questions as accurately and as fast as possible.

After the instructions, participants were presented with nine pairs of general knowledge questions. Before each question, a focus point appeared in the center of the screen for 400 ms, followed by the question, which remained on the screen until the first answer key was pressed. After a pause of 3 s, the next question was presented in the same sequence.

Upon completion of the questionnaire, participants were given four final questions, which constituted the manipulation check. The central purpose of these questions was to assess the category to which “Lowumbo” was ascribed. Accordingly, using an open-question format, the critical question read: “What do you think Lowumbo refers to? (If you’re not certain, please guess!)”

Results

Categorizations. Our predictions hinge upon the fact that “Lowumbo” is actually categorized in line with the context in which it is presented. An analysis of the responses to the manipulation check question clearly demonstrates that this was the case: In the mountain context, 15 participants described “Lowumbo” as a mountain, whereas only two did so in the animal context. Similarly, in the animal context, 21 participants described the target as an animal, whereas only four did so in the mountain context, $\chi^2(1, N = 42) = 21.31$, $p < .001$.[3] At the same time, categorizations of “Lowumbo” proved to be independent of the anchor manipulation, $\chi^2(1, N = 42) = .68$, $p > .4$.

Absolute estimates. Five participants were excluded from the analysis because they failed to answer the absolute question. One additional participant was excluded because her estimate deviated from the mean by more than 2 standard deviations. Consequently, the remaining analyses were based on the responses of 57 participants.

As expected, the typical anchoring effect was replicated. Inspection of Table 1 reveals that for both context conditions, the high anchor of 3000 m led to higher

[3] In the mountain context 12 participants ascribed “Lowumbo” to a category other than mountain or animal; in the animal context, nine participants did so.

TABLE 1
Absolute Estimates for the Height of "Lowumbo" by Anchor and Context

	Context	
Anchor	Mountain	Animal
High	2459.27 (n = 15)	401.58 (n = 12)
Low	1493.21 (n = 14)	34.49 (n = 16)

Note. Estimates are given in meters.

estimates than the low anchor of 2 m, $F(1, 53) = 5.54$, $p < .02$, for the main effect of Anchor and, $F(1, 53) = 1.12$, $p > .25$, for the interaction. In addition, absolute estimates depended on the context in which "Lowumbo" was presented: Higher estimates resulted for the mountain context than for the animal context, $F(1, 53) = 38.52$, $p < .001$.[4]

Response latencies. As suggested by Fazio (1990), we conducted logarithmic transformations of the response latencies to reduce the skewness of the response distribution. For ease of interpretation, however, we report the untransformed means (in milliseconds). In line with our earlier results (Strack & Mussweiler, 1997), we expected for the comparative question that response latencies would be shorter for implausible than for plausible anchors, whereas for the absolute question that the reverse pattern would occur. Here, latencies should be longer for implausible than for plausible anchors. Remember that in the mountain context, the high anchor of 3000 m is plausible and the low anchor of 2 m is implausible, whereas the reverse is true in the animal context.

The means depicted in Table 2 are consistent with our predictions. In fact, for the mountain context, responses for the *comparative task* were faster for the low anchor of 2 m (i.e., the implausible anchor) than for the high anchor of 3000 m (i.e., the plausible anchor). In contrast, the opposite was true for the animal context. Here, response latencies were shorter for the high anchor (i.e., the implausible anchor) than for the low anchor (i.e., the plausible anchor). For the *absolute task,* this pattern is reversed. In the mountain context, response latencies were shorter for the high anchor of 3000 m than for the low anchor of 2 m, whereas in the animal context, the latencies were shorter for the low anchor than for the high anchor. This pattern was borne out in a significant three-way interaction in a three-factor mixed-model ANOVA using the logarithmic transformations of the response latencies to the comparative and the absolute question

[4] Note that the mean estimates in the animal context are too extreme to characterize the height of an animal adequately. This may be due to extreme estimates stemming from participants who were uncertain about the category membership of "Lowumbo." In line with this assumption, the mean estimate is 3.80 m for those of the participants included in the analysis of the absolute estimates who categorized "Lowumbo" as an animal ($N = 18$).

TABLE 2
Response Latencies for the Comparative and Absolute Questions by Anchor and Context

	Comparative question		Absolute question	
Anchor	Mountain context	Animal context	Mountain context	Animal context
High	5843 (n = 15)	5749 (n = 12)	4254 (n = 15)	5090 (n = 12)
Low	5019 (n = 14)	6339 (n = 16)	6606 (n = 14)	3696 (n = 16)

Note. Response latencies are given in milliseconds.

as dependent variables, $F(1, 53) = 5.72$, $p < .02$. Moreover, response latencies were shorter for absolute than for comparative questions, $F(1, 53) = 7.24$, $p < .01$. No other effects reached significance, $F(1, 53) = 1.59$, $p > .2$, for the interaction of Context and Question Type, $F < 1$, for all remaining effects. Finally, controlling for the categorization of "Lowumbo" by using it as a covariate in an ANCOVA that included all participants who categorized "Lowumbo" as either a mountain or an animal substantially reduced the magnitude of the critical three-way interaction, $F(1, 35) = 1.8$, $p > .18$. This suggests that the pattern of response latencies we obtained is at least partially mediated by which category "Lowumbo" is ascribed to.

As an alternative strategy to examine the role that the categorization of "Lowumbo" plays in determining how a given anchor is processed, one may introduce categorization ("mountain" vs "animal") as an independent factor in the described ANOVA. Doing so produced a similar pattern of response latencies as the one depicted in Table 2: If participants categorized "Lowumbo" as a mountain they answered comparative questions including the high anchor slower ($M = 5044$ ms) than those including the low anchor ($M = 4608$ ms). If they categorized "Lowumbo" as an animal, however, they responded faster to the high anchor ($M = 5874$ ms) than to the low anchor ($M = 6732$ ms). For the absolute question, this pattern reverses such that participants who categorized "Lowumbo" as a mountain respond faster if they had received the high ($M = 4257$ ms) rather than the low anchor ($M = 8497$ ms), whereas the opposite is true for participants who categorized "Lowumbo" as an animal ($M = 5147$ vs $M = 3311$). This pattern of response latencies produced a significant three-way interaction in a three-factor mixed-model ANOVA using the logarithmic transformations of the response latencies as dependent variables, $F(1, 36) = 10.83$, $p < .002$.

Discussion

These findings support the current conceptualization. They demonstrate that how a given anchor is processed depends critically on judges' knowledge about the target. Thus, the very same anchor value of 3000 m may yield quicker comparative judgments and slower absolute judgments if evaluated on the basis of knowledge about animals rather than mountains. The fact that the response latencies for the comparative and the absolute judgment that were obtained in both context conditions parallel the pattern that is characteristic for the processing of plausible vs implausible anchors (Mussweiler & Strack, 1999a; Strack & Mussweiler, 1997) further suggests that the knowledge participants brought to bear on their judgments about “Lowumbo” determined the plausibility of the given anchor values.

In sum, the results of Study 1 provide a first demonstration that judges’ knowledge about the target determines how this target is compared with a given standard. From the current conceptual perspective (see Figs. 1 and 2), Study 1 manipulated where along the judgmental dimension participants’ distribution of possible values for the target is positioned. Specifically, suggesting that Lowumbo may be a mountain shifts this distribution to the upper end of the judgmental dimension “height,” whereas suggesting that it may be an animal shifts this distribution to the lower end of the dimension. Whether a given standard lies within or outside of the distribution of possible values and thus constitutes a plausible or an implausible value, however, does not only depend on the position of this distribution along the judgmental dimension. In addition, the dispersion of the probability distribution, which depends on the amount of knowledge a particular judge has about the target, is critical. Consider the distributions with varying dispersions depicted in Fig. 2 as illustrations. For a distribution that is extremely narrow, because the judge has maximal knowledge about the target, almost any anchor value lies beyond its boundary value. In contrast, for a distribution that is extremely wide, because a judge has minimal judgment-relevant knowledge, almost any anchor lies within these boundaries.

Building on the above differentiation of the processes that underlie the solution of anchoring tasks with such plausible and implausible standards, this possibility has interesting implications. This can be recognized by considering the case where a judge has minimal knowledge about the target object so that the underlying probability distribution is extremely wide. In this case, an anchor-consistent mental model of the target should be constructed for any anchor value. For example, a judge may be asked to estimate the age of a fictitious target named “Xiang Long.” Presumably, the probability distribution that represents a judge’s knowledge about “Xiang Long” will be so wide that it covers any anchor value. Thus, presented with an anchor value of 2000 years, our judge would attempt to generate an anchor-consistent mental model of “Xiang Long.”[5] Because an age of 2000 years is

[5] Note that the construction of such a mental model is possible even when the judge has only minimal knowledge about the target itself. In this case, knowledge about the superordinated category or related objects can be used. For example, to construct a mental model of Xiang Long as a cultural object, participants may use their knowledge about Chinese history or the age of other cultural objects

most representative of cultural possessions like a Chinese temple or an ancient Chinese city, this judge is likely to construct a mental model of such a cultural possession. By the same token, the judge should construct a model of a Chinese person, if an anchor value of 60 years is presented. Thus, a construction of an anchor-consistent mental model of the target should be initiated even for two extremely disparate anchor values. Consider now the case where a judge has more knowledge about "Xiang Long" because he or she assumes that it is a Chinese person. In this case, the anchor value of 60 years constitutes a plausible standard, whereas 2000 years is likely to be implausible. Thus, an anchor-consistent model should only be constructed in the first case.

The above reasoning implies that, depending on the width of the underlying distribution of possible values, the same anchor value may or may not be processed by constructing a mental model of the target. This has important implications for the magnitude of the resulting anchoring effect. Specifically, a strong effect is likely to occur if judges' distribution of possible values is so wide that anchor-consistent mental models of the target are even constructed for two largely disparate values. In this case, the absolute estimates would be based on the implications of two mental models that belong to different categories of objects (e.g., a Chinese person vs a Chinese cultural object). To the extent that both categories differ sufficiently along the judgmental dimension, this is likely to produce largely disparate estimates for the absolute value of the target. Such a construction of two very distinct mental models, however, is unlikely to occur for judges with more knowledge about the target. These judges are likely to construct a mental model of the target only for the plausible, not for the implausible, anchor value. As a consequence, absolute estimates are likely to stay within the range of values that is plausible for this one mental model (e.g., Chinese person) so that a less extreme anchoring effect should result. We tested these implications in Studies 2 and 3.

STUDY 2

To manipulate rather than assess the amount of knowledge judges have about the target object, we used a technique similar to the one applied in Study 1. Specifically, the critical question concerning the age of "Xiang Long" was either presented in a specific context, in which all preceding questions pertained to a famous person (the age of Mahatma Gandhi, the year of birth of Sese Mobutu, etc.), or in an unspecific context, in which the preceding questions pertained to objects that belong to different categories (the mean temperature on Hawaii, the maximum length of a whale, etc.). We assumed that participants in the specific-context condition would infer the category membership of "Xiang Long" from

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such as the Chinese wall to construct a model that is informative with respect to the critical question concerning the age of Xiang Long.

the context questions, whereas participants in the unspecific-context condition would be unable to do so. Consequently, the latter participants should have minimal knowledge about the target object (i.e., extremely wide probability distributions).

As in Study 1, this manipulation focused on judges' category knowledge about the target. Specifically, the certainty with which "Xiang Long" could be assigned to a specific category was manipulated by providing contextual cues that either did or did not imply a particular category membership. Because—from the current perspective—this context manipulation influences the same conceptual parameter (i.e., the dispersion of the distribution of plausible values) as variations in other aspects of judges' knowledge (e.g., amount of exemplar knowledge, uncertainty), its consequences are likely to generalize to these other aspects.

In principle, the expected effects could well be mediated by conversational inferences (Grice, 1975). It has been suggested (e.g., Jacowitz & Kahneman, 1995) that judges who assume that the experimenter obeys conversational norms of informativeness (Bless, Strack, & Schwarz, 1993; Schwarz, 1994; Strack, Martin, & Schwarz, 1988) may see the anchor value as a deliberate hint about the actual value of the target. Such inferences seem especially likely under situations of extreme uncertainty. To preclude conversational inferences as the underlying mechanism, two additional precautions were taken: In Study 2, the instructions emphasized that the anchor values were determined at random. This was justified by telling participants that in order to test the appropriateness of different question formats, we had to control for a possible influence of the given standards of comparison. To go even further, Study 3 put the anchor selection under the control of the participants themselves. Here, participants determined the anchor values by rolling dice.

Method

Participants. Sixty-four male and female students (not enrolled in psychology courses) at the University of Würzburg were recruited as participants and received a chocolate bar as compensation. They were randomly assigned to one of four experimental conditions.

Materials. The questionnaire consisted of nine pairs of comparative and absolute questions. Pairs 1 through 8 constituted the context manipulation, whereas pair 9 included the critical questions about "Xiang Long." All questions were formulated as complete sentences because in contrast to Study 1, the grammatical structure did not reveal the nature of the target. The order of the questions was kept constant. For the specific-context condition, the targets of the context questions all belonged to the same category. In particular, all eight questions pertained to persons of varying familiarity such as the age of Mahatma Gandhi, the year Leonardo da Vinci died, and the year Sese Mobutu was born. In contrast, for the unspecific context condition, all context questions pertained to targets from different categories such as the

TABLE 3
Categorizations of “Xiang Long” as a Person or a Cultural Possession by Context and Anchor

	Specific context		Unspecific context	
	High anchor	Low anchor	High anchor	Low anchor
Person	6	8	3	10
Cultural possession	6	4	9	5

mean temperature in the Antarctic, the length of the river Elbe, the number of languages spoken in the world.

Both plausible and implausible anchors were used in the context questions. The anchors of the context questions were kept constant, whereas the anchors for the critical question were varied. Half of the participants received the high anchor of 2000 years; the other half received the low anchor of 60 years. Thus, the four experimental conditions resulted from a combination of Context (specific vs unspecific) and Anchor (high vs low).

Procedure. Participants were recruited in the university cafeteria and were then led to an adjacent room. Upon arrival, they received the questionnaire and were told to read the instructions carefully. They answered the questionnaire in groups of up to four. The instructions were similar to those used in Study 1. After completion of the questionnaire, participants answered five additional questions including one which assessed the category to which “Xiang Long” was ascribed.

Results

Five participants had to be excluded from the analysis because of missing data. One additional participant was excluded because her absolute estimate deviated from the mean by more than 2 standard deviations. Consequently, the following analysis is based on 58 participants.

Categorizations. The critical categorizations for “Xiang Long” as a person and a cultural possession for both context conditions are depicted in Table 3. Those participants who described Xiang Long as a Chinese politician, statesmen, and so on were included in the first group, whereas those who described the target as a Chinese school of philosophy, monument, and so on were included in the latter group. Seven participants were excluded from this analysis because they either explicitly stated that “Xiang Long” is a fictitious word ($N = 3$) or their answers did not fit either category.

For the specific context, categorizations did not depend on the anchor, $\chi^2(1, N = 24) = .69$, $p > .2$. Note that the high number of participants who categorized “Xiang Long” as a cultural possession here indicates that a priori “Xiang Long” is more strongly associated with this category. For the unspecific context, however, categorizations depended on the anchor: More participants described “Xiang Long” as a person than as a cultural possession if the anchor

TABLE 4
Absolute Estimates for the Age of "Xiang Long" by Anchor and Context

	Context	
Anchor	Specific	Unspecific
High	436.07 (n = 15)	1536.83 (n = 12)
Low	63.00 (n = 15)	127.00 (n = 16)

Note. Estimates are given in years.

was 60 years, whereas more participants described the target as a cultural possession than as a person if the anchor was 2000 years, $\chi^2(1, N = 27) = 4.64$, $p < .02$.

Absolute estimates. As is apparent in Table 4, the typical anchoring effect was replicated: The high anchor of 2000 years led to higher estimates than the low anchor of 60 years, $F(1, 54) = 22.11$, $p < .001$. More interesting, this effect was stronger for the unspecific than for the specific context, $F(1, 54) = 7.48$, $p < .008$, for the interaction of Anchor and Context. Controlling for categorizations of "Xiang Long" by entering categorization as a covariate in an ANCOVA that included all participants who categorized "Xiang Long" either as a person or a cultural possession reduced the critical interaction effect substantially, $F(1, 46) = 3.98$, $p < .05$. This suggests that the obtained pattern is at least partially mediated by how the target is categorized.

To further examine how the width of the distribution of plausible values for the target influences the size of the resulting anchoring effect, we conducted an additional analysis. Specifically, we compared the magnitude of anchoring for participants who categorized "Xiang Long" as a person with those who categorized it as a cultural possession. Note that the distribution of plausible values for the category "cultural possession" is considerably wider than for the category "person." As a consequence, larger anchoring effects should result for participants who saw the target as a cultural possession than for those who saw it as a person. Consistent with this prediction, the difference between estimates given by participants who received the high versus low anchor was larger for those who categorized "Xiang Long" as a cultural possession ($M = 1409.4$ vs $M = 176.89$) than for those who categorized it as a person ($M = 399.67$ vs $M = 63.67$),[6] $F(1, 47) = 3.95$, $p < .05$.

[6] Note that the implausibly high estimate of 399.67 years in the high anchor condition results because one of the participants who categorized "Xiang Long" as a person gave an estimate of 3000 years for his or her age. Excluding this participant from the analysis yields a more plausible mean of 74.62 years.

STUDY 3

Method

Participants. Sixty-four male and female students (not enrolled in psychology courses) at the University of Würzburg were recruited as participants and were offered a chocolate bar as compensation. They were randomly assigned to one of four experimental conditions.

Materials. Again, the questionnaire consisted of eight context questions and one critical question that pertained to "Xiang Long." The targets of the context questions were identical to Study 2. However, the format of these questions was changed. In particular, three different formats were used which (i) consisted of either comparative and absolute questions or absolute questions alone, (ii) were formulated in complete sentences or in an abbreviated form, and (iii) required answers on a rating scale or in an open format. These variations of the context questions were included to reduce participants' scepticism about the one critical question. Here, no anchor value was provided. Instead, a blank occurred at the corresponding place in the comparative question, and participants were instructed to fill in their self-determined value. As in Study 2, the four experimental conditions resulted from a combination of specific vs unspecific context and high vs low anchor.

Procedure. Participants were recruited in the university cafeteria and were led to an adjacent room. Here, they were told that before getting to the actual questionnaire a random number had to be selected. This number would later be used in one of the general knowledge questions. Participants were instructed to role twelve 10-sided dice with numbers ranging from 0 to 9. After that, they received a 6-sided die with the numbers 2, 4, 6, 8, 10, and 12 on it. Participants were informed that the number they roled with the second die would determine the number of digits of their random number. They were then allowed to choose as many of the 10-sided dice as were indicated by the 6-sided die. The numbers indicated by the chosen 10-sided dice were then arranged in descending sequence so that the largest number constituted the first digit. For example, the resulting random number for four selected dice indicating 5, 3, 9, and 2 was 9532.

The 6-sided die was manipulated (i.e., loaded) so that it always indicated the number 2 in the low anchor condition and the number 4 in the high anchor condition. Consequently, the anchor values in the low anchor condition consisted of two digits with a possible maximum value of 99, whereas the anchor values in the high anchor condition consisted of four digits with a maximum value of 9999. None of the participants expressed any suspicion about this procedure. The final number was written down and given to the participants who were then sent to the next room. Here they answered the questionnaire in groups of up to 10. After completion of the questionnaire, they were asked five final questions including one that assessed the categorization of "Xiang Long."

TABLE 5
Categorizations of "Xiang Long" as a Person or a Cultural Possession by Context and Anchor

	Specific context		Unspecific context	
	High anchor	Low anchor	High anchor	Low anchor
Person	6	7	3	9
Cultural possession	5	6	7	4

Results

We excluded five participants from the analysis because their estimates deviated from the mean by more than 2 standard deviations. Consequently, the following analysis is based on the responses of the remaining 59 participants.[7]

Categorizations. The categorizations for "Xiang Long" as a person vs a cultural possession are depicted in Table 5. Twelve participants were excluded from this analysis because they either explicitly stated that Xiang Long is a fictitious word ($N = 3$) or their answers did not fit either category. Paralleling the results of Study 2, for the specific context, categorizations were independent of the anchor, $\chi^2(1, N = 24) = .001, p > .5$. Again, the relatively high number of participants who categorized "Xiang Long" as a cultural possession in both anchor conditions indicates that a priori it is more strongly associated with this category. For the unspecific context, however, categorizations depended on the anchor: More participants described "Xiang Long" as a person than a cultural possession when the low anchor was presented, whereas the opposite was true for the high anchor. Here, more participants saw "Xiang Long" as a cultural possession than a person, $\chi^2(1, N = 23) = 3.49, p < .03$.

Absolute estimates. As is apparent from Table 6, the typical anchoring effect was replicated. In both conditions, high anchors yielded higher estimates than low anchors, $F(1, 55) = 6.42, p < .015$. Moreover, inspection of the means reveals that the difference between estimates in the high and low anchor condition is more pronounced for the unspecific than for the specific context. Thus, there is a tendency for stronger anchoring effects in the unspecific context condition. However, in the current analysis, the described difference did not prove to be significant, $F(1, 55) = 1.39, p < .25$, for the interaction of Anchor and Context.

Note, however, that the above analysis does not control for the variability in the anchor values that resulted from their random selection. In fact, the anchor values ranged from 4321 to 9965 ($M = 8043$, $SD = 1441$) in the high anchor condition and from 11 to 99 ($M = 64$, $SD = 23$) in the low anchor condition. To control for this substantial variability, we used an additional measure for anchoring. Specifically, the deviations of absolute estimates from the respective

[7] Including these participants did not change the obtained pattern of results.

TABLE 6
Absolute Estimate for the Age of "Xiang Long" by Anchor and Context

	Context	
Anchor	Specific	Unspecific
High	458.62 (n = 13)	881.71 (n = 14)
Low	188.00 (n = 16)	127.13 (n = 16)

Note. Estimates are given in years.

random anchor values were used as an indicator for the magnitude of anchoring. The larger the calculated difference score (anchor value − absolute estimate), the larger the deviation from the anchor value and thus the smaller the anchoring effect. In line with the observed tendency in the untransformed absolute estimates, larger differences resulted in the specific- (M = 3992.51) than in the unspecific-context condition (M = 3369.73), $F(1, 55) = 4.88$, $p < .03$, indicating that the size of the anchoring effect was indeed smaller in the former than in the latter case.[8] As in Study 2, entering categorization as a covariate in an ANCOVA that included all participants who categorized "Xiang Long" either as a person or a cultural possession substantially reduced the magnitude of the effect, $F(1, 42) = 2.9$, $p < .1$.

As in Study 2, we also examined the magnitude of anchoring depending on the categorization of "Xiang Long." This analysis revealed that—as in Study 2—larger anchoring effects resulted for participants who categorized the target as a "cultural possession" (M = 3073.64) than for those who categorized it as a "person" (M = 4277.05), $F(1, 43) = 18.82$, $p < .001$.

Discussion

In line with the current analysis, Studies 2 and 3 demonstrate that more pronounced anchoring effects occur, if judges have very minimal knowledge about the target. Furthermore, our data hint at the mechanism underlying this effect. In particular, the categorization data suggest that the more pronounced anchoring effect in the unspecific context condition is mediated by differential categorizations of "Xiang Long." Apparently, participants with minimal knowledge about the target used the anchor value to disambiguate "Xiang Long." Thus, if "Xiang Long" was presented with a high anchor of 2000 years, the majority of participants stated that they thought of "Xiang Long" as a Chinese temple, city,

[8] Note that the described difference scores may also be calculated for the preceding studies. However, in these studies they do not provide additional insights because the anchor values did not differ within conditions. Subtracting a constant value from the absolute estimates does not affect the reported results. Consequently, difference scores are only used for the analysis of Study 3.

or the like. In contrast, participants who received the low anchor of 60 years saw "Xiang Long" as a Chinese person.

From the current perspective, the effects the anchor values had on the categorization of the fictitious object suggest that participants constructed an anchor-consistent mental model of "Xiang Long" in order to solve the comparative task. Thus, whether the presented anchor values influenced these categorizations indicates whether an anchor-consistent mental model of the target was constructed for both anchors. Our analyses demonstrate that categorizations of "Xiang Long" depended more strongly on the anchor when participants had minimal knowledge about the target (i.e., in the unspecific-context condition). This suggests that in this condition they were more likely to construct a mental model for both anchors. Our earlier findings (Study 1; Mussweiler & Strack, 1999a, 2000; Strack & Mussweiler, 1997) demonstrate that such a mental model is constructed only for plausible but not for implausible standards. In light of this dependency, the categorization data suggest that for participants with minimal knowledge about the target, even the two extremely disparate anchors constituted plausible values for the extension of the target. Consequently, participants constructed anchor-consistent mental models of "Lowumbo" for both anchors. Because the absolute estimates are then based on the implications of these mental models, they are largely discrepant (i.e., an extreme anchoring effect results). In combination with our earlier findings, the current data thus suggest that the amount of knowledge judges have about the target (i.e., the width of the distribution of possible values for the target) critically influences how a given anchor is processed and what effect it has.

Interestingly, these effects were even obtained when the anchor selection was under the control of the participants. Thus, judges appear to construct an anchor-consistent mental model of the target, even when the anchor value is clearly uninformative. Although counterintuitive at first sight, an analysis of the judgmental task participants' face in the unspecific-context condition reveals that the construction of such a model may be the only way to solve this task. In order to compare the target to the anchor value, participants necessarily have to categorize it first. With minimal information about the target object available, participants may spontaneously assume that the target belongs to a category for which the anchor at least constitutes a possible extension. This may be the case because—regardless of its source—the anchor value renders categorizations that are consistent with it more accessible (e.g., person for 60 years), so that alternative categorizations (e.g., cultural possessions) may initially not come to participants' minds.

GENERAL DISCUSSION

In the present set of studies we have examined the role judges' knowledge about the target object plays in the mediation of anchoring effects. We conceptualized judges' knowledge as a distribution of subjective probabilities for possible values of the target (Mussweiler & Strack, 2000; Wyer, 1973). The position of this distribution along the judgmental dimension depends on what value for the target judges' knowledge implies (see Fig. 1). Its dispersion depends on how much knowledge a judge has about the target (see Fig. 2). In this conceptual framework, the anchors' position along the judgmental dimension relative to the distribution of possible values determines how a given anchor is processed. Our earlier findings (Mussweiler & Strack, 1999a, 2000; Strack & Mussweiler, 1997) suggest that to compare the target with a plausible anchor (i.e., an anchor that lies within the distribution of possible values), participants construct an elaborate mental model based on specific knowledge about the target. To compare the target with an implausible anchor (i.e., an anchor that lies outside of this distribution), however, such a mental model is not constructed.

From this perspective, judges' knowledge about the target determines how a given anchor is processed. In this respect, two aspects of judges knowledge can be differentiated: the expected value for the target that is implied by judges' knowledge and the amount of knowledge judges have about the target. Study 1 demonstrates that the same anchor values were processed differently by participants who were induced to use different knowledge bases to solve the anchoring task. In this case, the subjective expected value for the target (i.e., the position of the distribution of possible values along the judgmental dimension) differed for the two respective knowledge bases. Studies 2 and 3 reveal that the amount of knowledge a judge has about the target (i.e., the dispersion of the distribution) constitutes a second determinant of how a given anchor is processed. Furthermore, these studies demonstrate that the amount of knowledge determines the magnitude of the anchoring effect. Specifically, judges with minimal knowledge show more substantial anchoring than judges who know more about the target.

The finding that the magnitude of the observed anchoring effect thus increased with the width of judges' probability distributions of possible values for the target also holds interesting implications for the impact of *uncertainty* on the anchoring effect. Wyer (1973) demonstrated that the dispersion of the probability distribution of possible values is inversely related to judgment certainty. Given this relation, our data suggest that the magnitude of the anchoring effect increases with uncertainty. This assumption is also consistent with some correlational data (Jacowitz & Kahneman, 1995) demonstrating that the more uncertain participants are about the judgment, the more their absolute estimates are assimilated toward the anchor. Because these authors merely assessed uncertainty after the absolute judgment was made, however, the present results provide more direct support for an inverse relation of uncertainty and the magnitude of anchoring.

Acknowledging the importance of uncertainty in the mediation of anchoring effects may also help explain the discrepant findings that previous studies yielded with respect to the impact of knowledge on anchoring. As mentioned before, some studies found that experts and novices are equally susceptible to anchoring (e.g., Englich & Mussweiler, in press; Northcraft & Neale, 1987), whereas another study (Wilson et al., 1996) found anchoring effects only for participants who judged themselves to know little about the target. This discrepancy may be due to different levels of uncertainty involved in both paradigms. Specifically, experts may still be uncertain about the target value so that they are influenced by it, whereas participants who judge themselves to be knowledgeable, for example, because they know the actual value, may be certain about their judgment, so that they remain uninfluenced.

The present set of studies has examined fairly extreme differences in the knowledge judges use to solve anchoring tasks. For example, Study 1 induced judges to interpret the anchors based on two knowledge bases which vary extremely with respect to their implications for the absolute extension of the target (i.e., mountains vs animals). Similarly, Studies 2 and 3 examined cases in which participants had very minimal knowledge about the target. It is important to note, however, that although the present conceptualization can be best illustrated using such extreme examples, its implications equally apply to less extreme cases. Specifically, the fundamental distinction between plausible and implausible anchors and the different processes these anchors involve is also valid for anchoring tasks with actual objects about which participants have substantial knowledge. No matter whether the age of Xiang Long, Mahatma Gandhi, or a family member has to be estimated, the plausibility of a given anchor depends on the expected value that is implied by ones knowledge as well as the amount of knowledge one has available. Consequently, the same dependencies that we have established in the current research are likely to hold.

Still, one obvious limitation exists. In order for the present conceptualization to be fruitfully applied, the subjective probabilities have to be distributed over several values. That is, participants have to display a minimal level of uncertainty. To the extent that judges *know* the actual value of the target, so that only this one value itself constitutes a plausible anchor, the present model is difficult to apply. A minimal level of uncertainty, however, is a precondition for anchoring effects to occur in the first place. After all, anchoring is explicitly defined (Tversky & Kahneman, 1974) as a bias in judgments under *uncertainty.*

CONCLUSION

For more than 25 years, judgmental anchoring (Tversky & Kahneman, 1974) has constituted one of the most robust and ubiquitous effects in psychological research (for a discussion, see Mussweiler & Strack, 1999b). Despite the fact that the very definition of anchoring as a bias in judgments under uncertainty clearly suggests that the phenomenon critically depends on judges' knowledge, this dependency has never been studied systematically. The present research attempted to take a closer look at the role judges' knowledge about the target plays in the mediation of anchoring effects. Doing so allowed us to derive novel predictions about the determinants of anchoring. This suggests that in order to further our understanding about human judgment under uncertainty, it may be fruitful to closely examine those factors that determine uncertainty in the first place.

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