The Role of Precise Numbers in Judgments

THESIS

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By

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Abstract

Recent research has demonstrated that products listed with precise prices sell for significantly more than products listed with comparable round prices. In this article I differentiate current theories of the effect of numerical precision on selling prices, demonstrating that the effect of numeric precision on selling prices is an anchoring effect rather than a shift in perceived magnitude. In addition, I demonstrate that individuals infer more believability from precise numbers than from comparable round numbers. Furthermore, I demonstrate that these inferences of greater believability are incidental sources of information that are not used as much when integral sources of believability (e.g., the explicit sources of the information) are available. I conclude the article by discussing how the influence of numeric precision fits into the existing anchoring literature.
Dedication

I would like to dedicate this thesis to my lovely wife Gwenn.
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Chapter 1: Introduction

Would you pay more for a house listed at $364,578 or $364,000? Researchers have demonstrated that homes listed with precise prices sell for significantly more than homes listed with round prices (Janiszewski & Uy, 2008; Thomas, Simon, & Kadiyali, 2010). Round numbers typically refer to numbers which end in 0’s or 5’s and are more tractable for arithmetic (e.g., 100 or 5,000), whereas precise numbers extend additional digits and generally do not end in 0’s or 5’s (e.g., 100.37 or 4,997). In both articles, the authors used regression analyses to investigate Florida real estate data and found significant effects of list price precision, such that more precise listing prices were related to higher final prices than were comparable round listing prices.

Although the two studies demonstrated a similar overall effect, they presented different theories to explain the effect. Thomas et al. (2010) contended that the effect of numeric precision involves a shift in individuals’ perceived magnitudes of the numbers, such that large precise numbers are perceived as smaller than comparable round numbers. In contrast, Janiszewski and Uy (2008) contended that precise numbers work by differentially moderating the anchoring effect, such that individuals adjust less from precise anchors than from round anchors. In subsequent sections, I will differentiate the two theories laid out by Thomas and colleagues (2010) and by Janiszewski and Uy (2008) and extend previous theory in an attempt to explain the influence of numerical
precision on judgments by investigating the role of inferences made about round and precise numbers.

The Price Precision Effect

In early work on numerical cognition, Dehaene and Mehler (1992) analyzed the frequency of numeric words (e.g., one, seven, etc.) in several languages. Results indicated that small magnitude numbers were typically round or precise in nature (e.g., 10, 13, 50, 24, etc.) whereas large magnitude numbers were typically expressed in a rounded form (e.g., 1,000) and rarely in precise form (e.g., 1,003). Thomas and colleagues (2010) reasoned that because precise numbers occur more frequently in smaller magnitudes, individuals infer a smaller subjective magnitude from the large precise number. Therefore, individuals would perceive large precise numbers (e.g., $364,578) to be smaller than comparable, but smaller, round numbers ($364,000).1

According to Thomas et al. (2010), when a home is listed with a precise listing price, it will be perceived as smaller than a comparably priced home with a round listing price. As the home with the precise listing price is perceived as less expensive, the listing price will be seen as more fair and attractive. Therefore, buyers should be more likely to purchase the house with a precise listing price, or counter offer with a smaller reduction from the list price, as compared to when they are faced with a house with a round listing price. Thus, Thomas et al. (2010) contend that individuals infer smaller subjective magnitudes from precise numbers; the resulting effect is a magnitude shift, such that large precise numbers should always be perceived as smaller than comparable round numbers.

To test their proposed theory, Thomas et al. (2010) presented participants in their Study 1 with six home listing prices; the three largest prices were either round (e.g.,
$391,534, $395,425, $401,298, $500,000, $505,000, $510,000) or precise (e.g., $390,000, $395,000, $400,000, $501,298, $505,425, $511,534). The precise listing prices were always slightly larger than the comparable round prices in the other condition.

Participants in both conditions judged the subjective magnitude of each of the six prices (e.g., 1 = Low to 11 = High). Results indicated that participants, on average, judged the objectively larger precise numbers to be smaller than the comparable round numbers.

In a second study, the authors manipulated participants’ prior experience with round and precise numbers. In the priming task, participants were presented with 32 numbers (half round and half precise, range = 1,000 to 10,000) and were asked to indicate whether each number was greater than or less than 5,000. Participants were randomly assigned to the small or large precise number condition. In the large precise number condition, the precise numbers were all greater than 5,000 whereas in the small precise number condition, the precise numbers were all less than 5,000. That is, the authors primed participants with either larger magnitude precise numbers or smaller magnitude precise numbers. After receiving the priming manipulation, participants were presented the same magnitude judgment task as they had previously completed in Study 1. Results indicated that participants primed with large precise numbers judged the precise listing prices to be larger in magnitude than comparable round prices. In addition, participants indicated lower willingness to pay (WTP) for homes listed with precise prices, as compared to round prices. The opposite result occurred when participants were primed with small precise numbers. The authors reasoned that participants infer magnitude information from the precision of the number. Because participants in the large precise number condition were primed with larger magnitude precise numbers, they inferred
larger magnitudes when judging the precise listing prices. Thus, the influence of precise numbers depends upon the particular inference made about the magnitude of price numbers.

One feature of the theory championed by Thomas et al. (2010) is that it only allows for the effect of numerical precision to manifest in large magnitude numbers (unless primed as in the second study above). Because both small precise and round numbers are common, there should be no difference between inferences made of small precise numbers versus small round numbers. Thus, according to Thomas et al. (2010), there should be no difference in judgments that concern precise and round numbers with small magnitudes. However, this theory cannot account for the results obtained by Janiszewski and Uy (2008). In their Study 1, the authors presented participants with several products and told them that the true value of the product was less than a given price and asked them to estimate the true value of the produce. One of the products was a block of cheese that was presented either with a precise price (e.g., $4.85 or $5.15) or a round price (e.g., $5.00). Thomas et al. (2010) would predict a null effect of numeric precision, as the values are small in magnitude. In contrast, participants in both of the precise conditions (i.e., either higher or lower precise price) produced higher estimates as compared to participants in the round condition. These results contrast the predictions made by Thomas et al. (2010), which contend that the influence of precise numbers should occur only for high magnitudes, where they are more infrequent. Therefore, it appears that there may be other inferences made by individuals, independent of perceived magnitude. In this paper I will investigate other possible inferences made by individuals when presented precise numbers.
Precise Numbers Moderate the Anchoring Effect

In contrast to the inference-based shift in perceived magnitude proposed by Thomas et al. (2010), Janiszewski and Uy (2008) contended that the effect of numerical precision is one of assimilation (i.e., greater assimilation of judgments toward the provided number when the number is precise than when the number is round). The authors reasoned that precise numbers result in a differential moderation of the anchoring effect. Anchoring effects refer to the incorporation of seemingly irrelevant numbers in the formation of subsequent judgments (Tversky & Kahneman, 1974; Jacowitz & Kahneman, 1995). In a relevant example, real estate appraisers and laypersons appraised the values of a series of homes. When participants were presented high list prices for the homes (i.e., anchors), their subsequent judgments were higher than those made by participants who were presented low listing prices (Northcraft & Neale, 1987). Furthermore, the anchoring effect occurred for both novices and real estate experts, demonstrating that the anchoring effect is robust in real world environments. Galinsky and Mussweiler (2001) suggested more generally that the first offer of a negotiation serves as an anchor, such that the final negotiated outcome correlates significantly with the first offer.

In their paper, Janiszewski and Uy (2008) employ an explanation of anchoring-and-adjustment that supposes that individuals anchor on given anchor values and iteratively adjust away from the anchor value (Tversky & Kahneman, 1974). After each adjustment, the individual stops and considers whether the current value is appropriate for the target judgment. If the current value is acceptable, then an estimate is produced; if not, another adjustment occurs. This process continues until an estimate is produced. Previous research has questioned the validity of the anchoring-and-adjustment theory.
because of a lack of empirical evidence for the elaborative but arbitrary adjustment process. (Strack & Mussweiler, 1997; Mussweiler & Strack, 1999; Wegener, Petty, Blankenship, & Detweiler-Bedell, 2010).

Janiszewski and Uy (2008) contended that the presentation of a precise anchor (e.g., a listing price) shifts the subjective scale individuals use to make adjustments (see also Frederick & Mochon, 2012). Particularly, participants infer a response scale with a more fine-grained resolution from precise anchors than from round anchors (i.e., individuals infer smaller acceptable adjustment units from precise anchors than from round anchors). The authors assumed that the number of adjustments would be the same for round and precise anchors (see Gilbert 2002, for a discussion on the number of adjustments). If an individual makes \( X \) units of adjustment from a provided anchor, \( X \) units of adjustment on a more fine-grained scale (i.e., from a precise anchor) would be objectively smaller than \( X \) units of adjustment on a less fine-grained scale (i.e., from a round anchor). Thus, the authors expected that precise anchors would result in greater assimilation of subsequent judgments to the anchor than would comparable round anchors. Unlike in Thomas et al.’s (2010) theory, the small versus large magnitude of anchors is irrelevant. A graphical representation of this theory is presented in Figure 1.

In support of their contention, Janiszewski and Uy (2008) presented participants with a series of products. For each product, participants were told that the value of the product was less than the given price (i.e., the anchor). In a set of control conditions, participants were presented round or precise prices and were asked to estimate the true value of each product by providing a number. Because Janiszewski and Uy (2008) contended that individuals infer more fine-grained scales from precise numbers,
participants in the experimental condition were presented a round anchor and randomly assigned to either a fine-grained or coarse-grained response scale. That is, participants were asked to estimate the true value of each product by indicating its value on a demarcated line. In the fine-grained condition (i.e., analogous to the fine-grained scale inferred from a precise anchor), the line had 9 evenly spaced and numerically labeled hatch marks. In the coarse-grained condition (i.e., analogous to the round anchor) the line had 5 evenly spaced and numerically labeled hatch marks. In the control conditions, results demonstrated the previously discussed effect of numerical precision: higher estimated prices when the products were presented with precise prices than when the products were presented with round prices. Furthermore, results of the experimental conditions indicated that participants adjusted less (i.e., provided higher estimates) in the fine-grained condition than in the coarse-grained condition. The authors contended that the presentation of a precise number provides incidental information about how fine-grained a response scale is. Therefore, explicitly providing a more fine-grained response scale produced equivalent effects to those produced by numerical precision. In the current article, I test whether the effect of numerical precision may be due to individuals making inferences about more than just the granularity of the response scale from precise numbers. Instead, I suggest that they make inferences about the believability of the information provided by the anchor as well.

The theories proposed by Thomas et al. (2010) and Janiszewski and Uy (2008) both predict that products listed with precise prices would sell for more than products listed with round prices. The former theory contends that individuals infer magnitude information about the precise listing price, such that large precise prices are perceived as
smaller than comparable round prices. In contrast, the latter theory is silent with respect to magnitude and contends that individuals infer more fine-grained response scales from precise numbers, such that precise listing prices will result in responses that are closer to the listing price, as compared to round listing prices.

Because Thomas et al. (2010) predict a downward magnitude shift with precise versus round numbers and Janiszewski and Uy (2008) predict greater assimilation to the anchor with precise versus round numbers, the two accounts have differential predictions when an initial price is low and requires an upward adjustment of price (e.g., the seller attempts to negotiate a price up). According to Thomas et al. (2010), the precise initial price will still be perceived as a smaller magnitude than the comparable round price. Because the seller perceives the precise price as smaller, they will see it as less fair, requiring greater upward adjustment, as compared to a round price. That is, the effect of precise numbers is directional, such that large precise numbers will be perceived as smaller than comparable round numbers, which should result in a higher negotiated outcome regardless of the direction of negotiation. In contrast, by employing anchoring and adjustment, Janiszewski and Uy (2008) contend that the effect of precision should always assimilate toward the initial value (i.e., listing price). Therefore, if a seller attempts to negotiate a price up from a buyer’s initial offer, a precise initial offer should result in a lower negotiated outcome than a comparable round initial offer. Given the previous research on the influence of anchors on home prices and negotiations (see Northcraft & Neale, 1987 and Galinsky & Mussweiler, 2001), I contend that the outcomes should assimilate toward the listing price. I test this prediction in Study 1.
Hypothesis 1: Regardless of the direction of adjustment, precise numbers will result in greater assimilation toward the given initial value than comparable round numbers (Studies 1 and 2).

Previous research has demonstrated that although numbers are objective by some definitions, the form of these numbers nonetheless can greatly influence individuals’ judgments. In a classic example, Levin and Gaeth (1988) demonstrated that individuals perceived “75% lean” ground beef to be healthier than “25% fat” ground beef. One explanation of this effect is that individuals infer choice-relevant information from the frame (i.e., the ground beef was described as 25% fat to highlight its unhealthy features, Sher & McKenzie, 2006). Said another way, the receiver of the information infers that the frame of the message contains information about the positive or negative qualities of the item of discussion that the communicator wants the receiver to know (for a related discussion see Grice, 1975).

Much in the same way that individuals infer positive or negative qualities from the frame of a number, the numeric precision of a number can carry inferences as well. Zhang and Schwarz (2012) demonstrated that uncertain outcomes presented in smaller more precise units, resulted in smaller ranges of plausible values (e.g., minimum and maximum) than uncertain outcomes presented in larger more coarse units. For instance, participants were told that a project was to be completed in either 52 weeks, 12 months, or 1 year, and were asked to produce an interval containing the likely completion time of the project. Participants reported smallest range intervals in the 52-weeks condition and the largest range intervals in the 1-year condition. The authors further demonstrated that this was a product of inference made through conversational norms. Participants appeared
to infer additional specificity from the smaller unit because quantities communicated in fine-grained units typically provide more information than quantities communicated in coarse-grained units. For instance, information about a man standing 6 feet tall may be more ambiguous than information about a man standing 72 inches tall. In conversation, an individual who is 5 feet 9 inches or 6 feet 3 inches may be rounded to 6 feet, for simplicity. In contrast, if an individual is 69 or 75 inches tall, they will likely not be rounded to 72 inches, as dictated by common conversational conventions. Six feet can imply a range of values around 6 feet, whereas 72 inches expresses a more specific height.

Although Zhang and Schwarz (2012) investigated ranges of values rather than anchoring effects, in the current article I test whether individuals make similar inferences about the believability of the information provided by anchors. Wegener, et al. (2010) have argued that anchors can be seen as “hints” imbued with information about the target item (see also Wegener, Petty, Detweiler-Bedell, & Jarvis, 2001; Blankenship, Wegener, Petty, Detweiler-Bedell, & Macy, 2008). Therefore, individuals should be more likely to use information that originated from a credible source than information from a non-credible source. I contend that when presented a precise number, individuals infer more “believability” about the number than when presented a comparable round number. I use the label “believability” as a parsimonious way to convey a sense of accuracy, credibility, authenticity, or validity, and because it can be easily generalized to be appropriate in different paradigms (e.g., the term credibility is appropriate for statistics, but not necessarily for home sales). When provided numbers (e.g., listing prices, statistics, and anchors), individuals must consider how close the provided number is to the unknown
true value of the judgment. For example, when purchasing a home, the buyer does not know the home’s true value (e.g., the amount of utility that they will derive from the purchase of the home). I contend that when the list price of the home is precise, buyers are more likely to infer that the list price is closer to the true value of the home than a comparable round list price. Although there are several possible inferences to be made (e.g., the seller used a precise number to convey the sense that they are non-negotiable or because the price was derived by a computational technique employed by home appraisers) the result of precise versus round numbers is an inference of greater believability in the number (i.e., judgments made about the precise number should assimilate more toward the provided number than when the provided number is round). A related example can be made for statistics. Individuals encounter many statistics that may deviate from the true value. For example, a report may claim that 60% or 60.37% of American households recycle regularly. I contend that individuals infer a sense of greater believability from the precise statistic. This believability is likely derived from inferences about the source of the precise statistic being more believable. For example, an individual may infer that 60.37% was carefully calculated whereas 60% is a value that could be made up by anyone.

Hypothesis 2: Individuals will infer greater credibility in the source of a precise number than the source of a round number. Because the source of the precise number is perceived as more credible, individuals will be more likely to believe and therefore anchor on precise numbers than comparable round numbers (Studies 3 and 4).
Recent research has begun investigating the role of inferences in the anchoring effect (Frederick, Mochon, & Danilowitz, 2012). For instance, Frederick et al. (2012) demonstrated that individuals infer information about the usefulness of an anchor, even when it is presented as a random number. When the authors made the inherent randomness of the anchor more transparent (e.g., the last two digits of the participant’s phone number), the anchoring effect attenuated, but did not disappear. Chapman and Johnson (1999) demonstrated that participants were more influenced by random anchors (e.g., the last two digits of their social security number) when the participants rated the anchor as more consequential (i.e., individuals infer relevance in the anchor, resulting in its substantial influence on subsequent judgments).

Janiszewski and Uy (2008) contended that the role of numerical precision on anchoring was independent of the anchor’s reliability. In Study 3 of Janiszewski and Uy (2008), the authors randomly assigned participants to either a precise, round, or reliable round anchor condition. In the task, participants were presented with a long paragraph discussing a product (e.g., a television). Within the paragraph, the authors inserted either a round or precise anchor (e.g., $5,000 or $5,012, respectively) and told participants that the true value of the product was less than the provided anchor. Participants’ task was to estimate the true value for each product. In the reliable round condition, participants were also presented a supplemental paragraph where they were told that the price of the product was equal to the anchor value (e.g., $5,000) at three stores in the area and online. The authors measured “anchor reliability” by averaging participants’ ratings of informativeness of the anchor, how much they relied on the anchor, and how confident they were in their estimate. Results indicated that participants in the reliable round
condition perceived the anchor as more reliable than in the other two conditions. Participants adjusted less in the precise condition than in either of the round conditions and did not report statistical differences between the round condition and the reliable round condition. The authors reasoned that the reliability of the anchor had no influence on the size of the anchoring effect. This clearly contradicts the assertions made in the current article and by Wegener et al. (2010). I will discuss possible reasons for these discrepancies later in this article.

With regard to the particular inferences derived from precise and round numbers, the effects observed by Zhang and Schwarz (2012) only occurred when the inference was appropriate for the communicator. For example, a more precise unit influenced participants’ plausible ranges of values (e.g., minimum and maximum) when the source was credible (e.g., the chief research officer of a company) but not when the source lacked credibility (e.g., an opinion website). In line with Wegener et al.’s (2010) contention, that individuals view the anchor as a hint, I would consider precise numbers as an incidental source of information. For example, when individuals are presented a precise anchor, I contend that individuals infer believability in the number, as numerical precision is the only cue available to make a judgment about the believability of the anchor. When an explicit source is made available (e.g., a doctor), the incidental information provided by the precision of the number is subsumed by more integral sources of information derived from the explicit source of the number. That is, these incidental sources will become irrelevant when actual source believability is made explicit and is either believable or not believable; this integral source of believability will (quite rationally) be used instead of the incidental believability inferred from the
precision of the number. Therefore, I contend that numeric precision will be a relevant
cue for judging the believability of the source when it is ambiguous, but will be null
when the believability of the source is provided and is believable or non-believable.

Hypothesis 3: Individuals will infer greater credibility from precise anchors than
from round anchors when no explicit source is available. The influence will
diminish when the source of the anchor is made explicit and is credible or non-
credible.

In four experiments I investigate the influence of numeric precision on judgments.
In Study 1 I test whether the influence of numeric precision is a product of differential
anchoring effects, rather than a magnitude effect, as hypothesized by Thomas et al.
(2008). In Study 2 I examine whether precise numbers produced larger anchoring effects
than round numbers even when controlling for the objective response scale. Study 3
investigates the particular inferences derived from precise numbers and round numbers.
Particularly, whether individuals infer greater credibility from precise numbers than
round numbers and are more likely to attribute precise numbers to more credible sources.
Finally, in Study 4, I manipulate the source of the anchors and investigated whether the
influence of precise numbers persists when more integral sources of credibility are made
available.
Chapter 2: The Current Studies

Study 1

In Study 1, I test an anchoring mechanism against Thomas et al.’s (2010) magnitude shift hypothesis by setting a buyer’s initial price low and allowing participant sellers to negotiate the price upward. According to Thomas et al. (2010), because large precise numbers are perceived as smaller than comparable round prices, the seller will seek to increase the price of precise initial prices more than round initial prices. In contrast, a mechanism of anchoring would result in assimilation toward the initial price. Thus, Thomas et al. (2010) predict Willingness to Accept (WTA) offers should be higher with precise initial prices; I predict the opposite result.

Method

One hundred one adult participants (55% female, $M_{age} = 33.4$ years, ranging from 18-79) were recruited from Amazon’s Mechanical Turk website and paid $0.50 for completing the study. Participants were asked to imagine that they were attempting to sell a variety of their belongings. The products to be sold included a pair of roller skates, a home, and a car. For each item, participants were told that a buyer had come forward and presented an offer. Participants were randomly assigned to a round price condition (e.g., $10.00 for the roller skates, $250,000 for the house, and $10,000 for the car) or to a precise price condition (e.g., $10.13, $251,287, and $10,139, respectively). For each
offer, participants were asked to accept the offer or to counter offer. If the participant
counter offered, they were asked to name a price that they would be willing to accept.

Results and Discussion
Participants in the precise condition accepted 65% of initial offers whereas those
in the round condition accepted 58% of initial offers; this difference was not significant.
For each question, I calculated an anchor-estimate gap (i.e., the absolute difference
between the buyer’s initial price and a participant’s WTA response). As these gaps were
positively skewed, I applied a log transformation to improve the normality of the data. As
the three items differed drastically in magnitude, I also standardized these gaps within
each product (mean WTA = 0; SD = 1). See Table 1 for average standardized price
increases by item. Employing a repeated measures fixed-effects regression and testing the
influence of the between participant manipulation of numerical precision, I found that
participants’ counter offers were significantly lower when initial prices were precise
$M_{\text{precise}} = -.21$, than when the initial prices were round, $M_{\text{round}} = .18$, $t(70) = 2.59, p = .01$.
These results support H1 by demonstrating that precise numbers assimilate WTA
responses toward the initial value. These results are consistent with our predictions and
those made by Janiszewski and Uy (2008) and are in direct contrast to the predictions of
Thomas et al. (2010).

Study 2

Results of Study 1 provided evidence against the magnitude shift argued by
Thomas et al. (2010) and in favor of an anchoring based mechanism. In subsequent
studies, I further investigated how precise numbers may moderate the anchoring effect. I
also attempted to elucidate the underlying psychological processes which produce
differential influences of precise and round numbers on judgments.

Janiszewski and Uy (2008) contended that precise numbers shift the arbitrary
scale that individuals use to adjust when producing a judgment. Although I do not
disagree that precise numbers influence individuals’ subjective response scales, I contend
that precise numbers provide additional information on top of that scale. In Study 4 of
Janiszewski and Uy (2008) the authors demonstrated that they could produce the same
effect of precise anchors by changing the objective response scale. In Study 2 I employed
a similar procedure in an attempt to demonstrate that precise numbers result in larger
anchoring effects (i.e., less adjustment) even when the response scale is objective and
fixed (i.e., individuals should not infer different response scales from round and precise
numbers because the response scale is explicitly provided).

Method

One hundred adult participants (46% female, \( M_{\text{age}} = 33.0 \) years, ranging from 18-
66) were recruited from Mechanical Turk and paid $0.50 for completing a study similar
to Study 1. Participants were told that they were attempting to sell a variety of
belongings. The products to be sold included a bicycle, a home, and a car. For each item
participants were told that a buyer had come forward and presented an offer. Participants
were randomly assigned to either the round price condition (e.g., $50 for the bicycle,
$252,000 for the house, and $10,000 for the car) or the precise price condition (e.g.,
$50.15, $252,313, and $10,172, respectively). In contrast to Study 1, participants in Study
2 were told that they must produce a counter offer by increasing the price. This was done
to ensure full data for each participant (i.e., participants who accepted the offer in Study 1
did not produce a counter offer). Participants responded on a seven-point scale with price increasing linearly in magnitude. For example, the bicycle could be increased in price by $2 to $14 with $2 increments between. The incremental price increase (and price range) for the house was $5,000 (from $5,000 to $40,000) and for the car was $250 (from $250 to $1,750).

**Results and Discussion**

Because participants’ counter offers were positively skewed, responses were log transformed in an attempt to normalize the data; I present the average untransformed scores in Table 1. Results of a repeated measures fixed-effects regression indicated that participants in the precise condition increased their sale price, $M_{\text{precise}} = 2.41$, less than participants in the round condition $M_{\text{round}} = 2.74$, $t(98) = 2.15$, $p = .03$. Therefore, even when participants responded on an identical objective scale, precise numbers appear to result in greater assimilation toward the initial price (i.e., the anchor) than round numbers. I should note that the results were nonsignificant for the house question. This is likely the result of the intervals on the response scale being too large (i.e., participants adjusted the least for the house question).

Primary results of the current study provide evidence of an additional effect of numeric precision. Participants had no need to infer anything about the granularity of the response scale as it was explicitly provided. The smaller price increases in the precise price condition may indicate that precise numbers carry additional information relevant to the judgment. An alternative explanation, consistent with Janiszewski and Uy (2008), is that individuals decide the price increase using their subjective scale and map it onto the provided objective scale. If precise numbers shift participants’ subjective scales, then the
resulting responses on the objective scale will reflect these differences. While this account is plausible, I examine inferences of greater credibility from precise numbers than round numbers in subsequent studies.

Study 3a

The primary goal of Study 3a was to investigate what, if any, inferences individuals make about precise numbers, beyond the possible scale inferences hypothesized by Janiszewski and Uy (2008). In particular, I expected that individuals would infer that precise numbers originate from more believable sources than comparable round numbers.

Method

Fifty-five undergraduate students from a large Midwestern university (52% female, \( M_{\text{age}} = 19.6 \) years, ranging from 18-42) completed Study 3a in exchange for course credit. Participants were randomly assigned to one of two conditions in which they were presented a statistic about the percentage of households that recycle regularly. In one condition, the statistic was presented as a round number (e.g., “60% of American households recycle regularly”); in the other condition the statistic was presented as a precise number (e.g., “60.37% of American households recycle regularly”). Participants indicated the likelihood that they would believe the statistic on a six-point scale anchored at 1 (Very Unlikely) to 6 (Very Likely), with no midpoint; higher responses indicated greater believability. On the following page, participants were presented two pictures of men. One picture was of a casually dressed and unshaven man while the other was a clean cut man in a suit with glasses and a tie (see Appendix A for materials). By selecting
one picture or the other, participants indicated which of the two men they believed to have produced the statistic.

**Results and Discussion**

Participants in the round condition, on average, rated themselves as moderately *unlikely* to believe the statistic, whereas participants in the precise condition on average rated themselves as moderately *likely* to believe the statistic, $M_{\text{round}} = 3.11$, $M_{\text{precise}} = 4.10$, $t(53) = 3.58$, $p < .001$, $\eta^2 = .19$. Consistent with H2, it appears that statistics presented in a precise numerical format are more believable than those presented in a round numerical format. These results are inconsistent with Janiszewski and Uy’s (2008) contention that the precision of the number only influences participants’ subjective response scales.

I contend that individuals infer greater believability from precise numbers than from round numbers. In the current study I expected participants to be more likely to attribute the precise statistic than the round statistic to the picture of the formally dressed man than to the casually dressed man. Note, the formally dressed man with a tie and glasses was considered the more believable source because of the substantial correlation between participants indicating that they believed the statistic and their attribution of the statistic to the formally dressed man, $r = .92$, $p < .0001$. As further evidence in favor of H2 (i.e., that individuals infer greater believability from precise numbers than from round numbers), participants in the precise number condition attributed the precise statistic to the formally dressed man 90% of the time, whereas participants in the round number condition attributed the round statistic to the formally dressed man only 65% of the time, $t(53) = 2.23$, $p = .03$, $\eta^2 = .09$, $\chi^2 = 4.73$, Fisher-exact $p < .05$. Participants were more
likely to infer that the precise statistic originated from the more believable looking source.

**Study 3b**

The results of Study 3a demonstrated that participants were more likely to believe precise statistics than round statistics and were more likely to attribute precise statistics to a more believable source. The goal of Study 3b was to test the same effect within participants and to further investigate participants’ inferences by eliciting free responses.

**Method**

Sixty undergraduate students from a large Midwestern university (47% female, $M_{age} = 20.0$ ranging from 18-36) completed Study 3b in exchange for course credit. Participants in Study 3b were presented both recycling statistics from Study 3a in counterbalanced order (i.e., Imagine that you are presented the following two statistics: “60% of American households recycle regularly” and “60.37% of American household recycle regularly.” Which of these two statistics are you more likely to believe?). Participants were asked to indicate which of the two statistics they were more likely to believe, from -3 (*Much More Likely to Believe 60%*) to 3 (*Much More Likely to Believe 60.37%*). Subsequently, about half of the participants ($n = 32$) were randomly assigned to complete the same source attribution task (with pictures) as in Study 3a. The rest of the participants ($n = 28$) were asked to explain why they believed one statistic over the other in a free response question.
Results and Discussion

Replicating the results of Study 3a, participants’ responses indicated that they were more likely to believe the precise statistic than the round statistic, $M = 1.15$, $t(58) = 3.51$, $p < .001$, Cohen’s $d = .90$. They were also more likely to attribute the precise statistic than the round statistic to the more believable looking source (i.e., the formally dressed man with a tie and glasses), McNemar’s $\chi^2 = 7.00$, $p = .01$. Specifically, 66% of participants attributed the precise statistic to the more believable source and the round statistic to the less believable source. This pattern was reversed for 22% of participants. The remaining 12% of participants attributed both statistics to the same source.

In analyzing participants’ answers to the free response question (i.e., “In a brief statement, please explain why you believed one of these statistics more than the other.”), responses were coded for explicit mention of authenticity (e.g., “it seems more authentic because its more detailed”), accuracy (e.g., “because it looks more accurate”), validity (e.g., “the number is so exact that it makes it much more believable that it is a valid statistic”), or anything that may indicate that the participant inferred greater believability
(e.g., “60.37% implies a bigger sample of people”). Three independent coders investigated free responses for either explicit or implicit mention of one of the previously mentioned aspects of believability (mean inter-rater reliability of 79.1%). Discrepancies were handled with majority rule. Of the participants who indicated that they were more likely to believe the precise statistic, 91.3% (21/23 participants) appeared to infer more believability from the precise number than the round number. Particular inferences are broken up as follows: 13% (3/23) inferred authenticity, 78% (18/23) inferred accuracy, 9% (2/23) inferred validity, and 39% (9/23) inferred believability (participants’ responses could be categorized with more than one inference). In contrast, of those participants who indicated that they were more likely to believe the round statistic, only one of the six participants attributed the round statistic to authenticity, accuracy, validity, or believability. Most responses indicated a liking of the “roundness” of the number (e.g., 60% is an easier number to comprehend), or that they did not perceive any particular differences between the numbers (e.g., “I really don’t think I would believe one more than the other, you just gave me choices that made me choose one”). Taken together, Studies 3a and 3b provide evidence in favor of H2, that individuals infer greater believability from precise numbers than from round numbers.

Study 4

In Study 1, I demonstrated that the effect of numerical precision was one of assimilation, rather than a magnitude shift. Study 2 demonstrated that the effect of precise numbers went beyond inferences about the appropriate response scale. Study 3 demonstrated that individuals inferred greater credibility from precise numbers than from round numbers.
The primary goal of Study 4 was to investigate the relationship between source believability and the amount of assimilation in judgments (i.e., the size of the anchoring effect). For example, if a formally dressed man or a casually dressed man provide an anchor about the percentage of Americans who recycle regularly, while the explicit information is the same, the implicit inference is quite different (i.e., the formally dressed man may be a more believable source, therefore their information should be more heavily weighted in judgments than the information originating from the casually dressed man). The greater inferences of believability from precise numbers are incidental information. In Study 4, I test H3, whether this incidental information source is used when an integral (and normatively more useful) source is available. When an explicit source of information is available (e.g., the statistic is provided by a representative of the National Recycling Coalition), I would not expect precise numbers to provide additional inferential information, as the information already appears believable. Thus, I expect precise numbers to influence individuals’ judgments when the believability of the information is ambiguous, but the effect should disappear when the source of the information is explicitly provided and is believable or non-believable.

**Method**

Two hundred adult participants (49% female, $M_{\text{age}} = 35.2$ ranging from 18-73) were recruited from an online subject pool and paid $0.50 for completing the study. Participants were presented four anchoring questions in the following scenarios:

1. Imagine that your acquaintance tells you that the percentage of humans with blood type O+ is (80% / 80.17%). What percentage of humans do you believe have the blood type O+? ____%
2. Imagine that your acquaintance tells you that Gandhi was (40 / 41.33) years old when he died. How old do you believe Gandhi was when he died? ____

3. Imagine that your acquaintance tells you that (60% / 60.91%) of Americans owed money when filing their 2011 federal taxes. What percentage of Americans do you believe owed money when filing their 2011 federal taxes? ____%

4. Imagine that your acquaintance tells you that (30% / 30.69%) of Americans will contract the flu this year. What percentage of Americans do you believe will contract the flu this year? ____%

Half of the participants were randomly assigned to the round anchor condition and the other half to the precise anchor condition. In addition, participants were randomly assigned to one of three information source conditions. The first condition was the control condition, in which the acquaintance is an ambiguous source of credibility. Participants in the second condition read the same scenarios, but were told that the acquaintance happened to be a doctor. In the last condition, participants were told that the acquaintance happened to be intoxicated at the time. Thus, Study 4 employed a 2 between-participant (round vs. precise anchor) x 3 between-participant (ambiguous vs. credible source vs. non-credible source) x 4 within-participant (question type) mixed factorial design.

After providing estimates to all four questions, participants were asked to indicate how knowledgeable they would consider their acquaintance to be about each topic. I will use this measure as a proxy for source credibility. Responses were made using an 11-point scale anchored at 1 (Completely Unknowledgeable) to 11 (Completely Knowledgeable).
Results and Discussion

Manipulation Check

For simplicity, I will discuss results across the average of the questions. Averages for individual questions are presented in Table 2. Participants’ average believability ratings were highest in the believable source condition $M_{\text{believable}} = 6.94$, lower in the ambiguous source condition $M_{\text{ambiguous}} = 5.66$, and lowest in the non-believable source condition $M_{\text{non-believable}} = 4.41$. Results of a repeated measures fixed-effects regression indicated a main effect of source, $F(2, 197) = 67.09$, $p < .0001$. All individual pairwise contrasts between conditions were significant at $\alpha = 0.001$. These results confirm that our manipulation was successful in moderating source believability.

Estimates

For each question, I calculated an anchor-estimate gap (i.e., the absolute difference between the anchor and a participant’s estimate). As these gaps were positively skewed, I applied a log transformation to improve the normality of the data. Results of a repeated measures fixed-effects regression indicated no main effect of numeric precision; the average gap in the precise conditions was not significantly different from the average gap in the round conditions, $p > .40$. As expected, participants’ average gaps were smallest in the believable source condition $M_{\text{believable}} = 14.0$, larger in the ambiguous source condition $M_{\text{ambiguous}} = 17.0$, and largest in the non-believable source condition $M_{\text{non-believable}} = 26.1$, $F(2, 194) = 52.00$, $p < .0001$. Furthermore, there was a significant source believability x numeric precision interaction, $F(2, 194) = 3.89$, $p = .02$. Separate repeated measures fixed-effects regressions by source condition indicate no
influence of precise vs. round numbers when the source was believable, $M_{\text{precise}} = 12.9$ vs. $M_{\text{round}} = 15.1, p > .15$, nor when the source was non-believable, $M_{\text{precise}} = 27.5$ vs. $M_{\text{round}} = 24.4, p > .5$). The influence of precise numbers only manifested when the source was ambiguous, $M_{\text{precise}} = 13.6$ vs. $M_{\text{round}} = 20.3, t(67) = 3.80, p < .001$). When the source was ambiguous, participants appeared to use the precision of the anchor as a cue for the believability of the anchor, resulting in greater assimilation toward the anchor value. These results support H3, in that individuals appear to use the numeric precision of the anchor as a cue only when they do not have integral source believability information available.

Also consistent with H3, numeric precision influenced participants’ believability ratings only in the ambiguous condition, $M_{\text{precise}} = 6.11$ vs. $M_{\text{round}} = 5.22, t(67) = 3.61, p < .001$. There were no differences in believable condition, $M_{\text{precise}} = 7.00$ vs. $M_{\text{round}} = 6.86, p > .60$, nor in the non-believable condition, $M_{\text{precise}} = 4.40$ vs. $M_{\text{round}} = 4.41, t(67) = 3.80, p > .90$).

Mediated Moderation Analysis

To add further evidence of believability as the underlying mechanism behind the observed interaction, I conducted a mediated moderation analysis (Muller, Judd, Yzerbyt, 2005). As I have a three level class variable, I created a contrast code of -1/3, 2/3, -1/3 for the non-believable, ambiguous, and believable source conditions to investigate the hypothesized quadratic effect (i.e., null influences of numeric precision when the source is provided and is believable or non-believable). I began by regressing source believability, numeric precision, and their interaction on the anchor-estimate gaps.
Consistent with our previous analysis I found a significant effect of the Source x Numeric Precision interaction on the anchor-estimate gaps, $\beta = .50$, $t(196) = 2.38$, $p < .02$.

Furthermore, the Source x Numeric Precision interaction predicted participants’ believability ratings, $\beta = -.88$, $t(196) = 2.20$, $p < .03$. When I include participants’ believability ratings in the model, predicting anchor-estimate gaps, I found that believability ratings were a significant predictor, $\beta = -.25$, $t(196) = 14.81$, $p < .0001$, but the Source x Numeric Precision interaction was non-significant, $\beta = .29$, $t(196) = 1.52$, $p > .10$. I generated 5,000 samples and tested the indirect effect of believability on the anchor-estimate gaps, employing bootstrap 95% confidence intervals (CI). Results indicated that the indirect effect of the Source x Numeric Precision interaction was mediated by perceived believability, CI [.04, .40].

Taken together, these results suggest that decision makers infer greater believability about the source of the information from the precision of provided numbers when the source is ambiguous, but the effect attenuates when a source is made explicit and is believable or non-believable. For example, whether or not an intoxicated acquaintance offers information in a round or precise format makes little difference to an individual’s inferences. Although precise vs. round numbers appear to have a clear relationship with believability, an individual is not likely to infer additional believability from an intoxicated acquaintance presenting a precise number than an intoxicated acquaintance presenting a round number, as the explicit source of the number is clearly not believable. It is likely that individuals neglect the believability information provided by the precise number because it is incompatible with the more normatively relevant information about the acquaintance’s current state. The same logic applies to believable
sources. If the source is already believable (e.g., a doctor), then the addition of an incidental inference from a precise number should be negligible. However, when ambiguity exists about the believability of the information, precise numbers provide incidental inferential information about the believability of the information provided by the anchor.

I should note that it is still possible for precise numbers to influence judgments when a believable or non-believable source is provided. This can occur if there still exists any ambiguity about the believability of the information provided by the source. For instance, although the source may be a doctor, whether or not the doctor specializes in hematology may influence the amount of ambiguity an individual perceives in the believability of the information provided by the doctor when judging the percentage of people with blood type O+. Thus, a source can be believable, but there can still exist ambiguity in the believability of the information that they provide if the information item does not directly relate to the source. Anecdotal evidence for this contention can be found in Table 2. Notice for the believable source (i.e., the doctor), the anchor-estimate gaps are nearly identical for precise and round anchors when the target judgment concerned medical information. When the target concerned Gandhi’s age and taxes (areas where there would be more ambiguity about the believability of a doctor’s knowledge), there is a directionally consistent influence of precise numbers, \( ps > .4 \).
Chapter 3: General Discussion and Conclusions

In four studies I demonstrated that the presentation of precise numbers results in inferences about the believability of the information. The effect of numerical precision appears to increase the assimilation of judgments toward the initial value, in direct contrast to the magnitude shift theorized by Thomas et al. (2010). In Study 1, participants provided lower WTA responses when the initial price was precise than when the initial price was round, whereas Thomas et al.’s (2010) theory is more consistent with the opposite result.

The following studies primarily concerned the theory laid out by Janiszewski and Uy (2008). The authors contended that individuals infer a more fine-grained subjective response scale when the initial value (e.g., anchor, listing price, etc.) was precise than when the initial value was round. As an extension to the theory laid out by Janiszewski and Uy (2008), I demonstrated that precise numbers provide additional information on top of the granularity of the subjective response scale. In Study 2 I demonstrated that precise numbers have a greater influence on judgments (i.e., larger anchoring effects), even when the response scale is made objective and constant across conditions.

Study 3 demonstrated that individuals infer believability from precise numbers. For example, participants indicated that they were more likely to believe a precise statistic than a round statistic, both between participants and within participants. In addition, participants more often attributed the precise statistic to a more believable
source (i.e., the picture of the formally dressed man with a tie and glasses). Furthermore, free responses from Study 3 indicated a relationship between numeric precision and perceptions of the authenticity, accuracy, validity, and believability of the information.

In Study 4, I again demonstrated the relationship between precise versus round numbers and inferences of greater credibility. Moreover, Study 4 demonstrated that the inferences from numeric precision may be incidental and therefore attenuated when a more integral inference is made available. For example, participants had no need to infer believability from the precise number when the source of the number was an intoxicated acquaintance. Although a participant could infer some believability from a precise number, this incidental inference is of little diagnostic relevance considering the large amount of diagnostically relevant information in the current state of the individual. As discussed in Study 4, the particular influence of numerical precision depends upon the extent of the ambiguity of the source of the information.

As discussed earlier, Janiszewski and Uy (2008) contended that the reliability of an anchor did not influence the size of the anchoring effect. Although reliability and believability are related, the apparent discrepancies between the current results and those found by Janiszewski and Uy (2008) may be due to differences in the constructs being measured. For example, one of the three components of their reliability index was confidence. Recent research has demonstrated that, while confidence can be derived from increased use of the anchor, participants’ ratings of confidence are often related to the amount of prior knowledge they have about the target item (see Schley & Turner, 2012). Although the manipulation used by Janiszewski and Uy (2008) influenced the reliability of the anchor (e.g., telling participants that the product was equal to the anchor value at
three stores in the area and online), it did not necessarily influence the believability of the information itself or the source of the information. Another possibility is that the null results found by Janiszewski and Uy (2008) may be a product of the length and complexity of their materials, as the primary anchoring question involved an elaborate description and the manipulation paragraph added an additional paragraph of text.

In contrast to Janiszewski and Uy (2008), the current research has demonstrated that different information is communicated through precise numbers versus round numbers (i.e., precise versus round anchors differentially influence subsequent judgments based upon individual’s inferences about the believability of the information provided by the anchor), perhaps in addition to the appropriate response scale. Particularly, precise anchors appear to carry greater inferences of believability than comparable round anchors. In the following section, I discuss how inference fits within current theories of anchoring.

The influence of numeric precision can be seen as attribute substitution, in which individuals substitute more veridical cues for more easily accessible heuristic based cues when forming judgments (Kahneman & Frederick, 2002). Zhang & Schwarz (2012) demonstrated that individuals infer smaller plausible ranges (i.e., less uncertainty) from numbers presented in smaller more precise units than numbers presented in less precise units. Although the uncertainty around a number is often related to the accuracy (i.e., believability) of the number, precision does not imply accuracy. Take for instance the statistic that 103.89% of American households recycle regularly. While there is little uncertainty around the range of values that the information is attempting to convey, the magnitude of the number is obviously incorrect.
The role of inference in anchoring

According to the original theory of anchoring and adjustment, when presented an anchor, individuals begin at the anchor value and iteratively adjust away from it, stopping to reconsider whether additional adjustment is necessary (Tversky & Kahneman, 1974). Anchoring and adjustment posits that individuals stop adjusting when they reach the border of a plausible range of values or become cognitively fatigued (Quattrone, et al., 1981; Quattrone, 1982; Gilbert, 2002; Epley & Gilovich, 2001, 2005, 2006). The only discussion of information in anchoring-and-adjustment regards the range of plausible values, where individuals with more knowledge about the target item have smaller ranges. Therefore, there is no room for inference in the anchoring-and-adjustment framework because anchoring-and-adjustment does not allow for the anchor to provide information. The anchor is simply a starting point for adjustment.

In contrast to the anchoring-and-adjustment theory, the selective accessibility model contends that the anchor serves to activate information (Strack & Mussweiler, 1997; Mussweiler & Strack, 1999, 2000, 2001; see also Chapman & Johnson, 1999). In this model, a mental hypothesis test is posited: When presented an anchor, individuals perform a confirmatory search in an attempt to confirm the hypothesis that the target and the anchor are equal. This confirmatory search selectively accesses additional information consistent with the anchor. As a result, the anchor-consistent information is disproportionately salient and influences the subsequent judgment. Unfortunately, inference does not fit within selective accessibility either. According to selective accessibility, the anchor facilitates the selective retrieval of anchor-consistent knowledge; it does not provide information itself. Therefore, an anchor from a doctor should not
selectively access more information from an individual’s memory than an anchor from a layperson.

As previously discussed, Wegener, et al. (2010) contended that anchors can be seen a suggestive “hints” about the true value of the target item (i.e., the anchor operates as a persuasive message). The attitudinal framework proposed by Wegener, et al. (2010) allows for the anchor to provide information above what is activated in memory. Moreover, as the anchor is analogous to a persuasive message, inferences easily fit within this framework.

Conclusions

The current research stems from the impressive finding that precise listing prices result in significantly higher final sale prices than comparable round listing prices (Thomas, et al., 2010; Janiszewski & Uy, 2008). Given the current findings, it appears that buyers may have substantial ambiguity about how fixed the seller is on their listing price. Precise listing prices may result in a buyer inferring that the seller’s price is non-negotiable or that it was set by some computational method. Thus, buyer’s counter offers to precise listing prices would likely assimilate more to a precise listing price than a comparable round listing price.

Precise numbers appear to convey different information than comparable round numbers. Specifically, individuals infer greater believability from precise numbers than from round numbers. A typical inference may be “the number must be precise for a reason.” That is, precise numbers are imbued with additional information about believability of the information.
The current research provides an explanation for the influence of precise versus round numbers on judgments. Although numbers are seemingly objective, their interpretation in judgments appears to be subjective. The current research aids in furthering our understanding of inherent subjectivity of numbers.
References


Appendix A: Tables

<table>
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<tr>
<th>Condition</th>
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<th>Study 2</th>
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<td>Car</td>
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Table 1. Standardized (Study 1) and raw (Study 2) average price increases presented by item

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Table 2. Untransformed estimates and credibility ratings from Study 4
Appendix B: Figures

Figure 1. A diagram representing the corresponding amount of adjustment when individuals are presented round (solid black lines) and precise (dashed grey lines) anchors. Greater distances between the anchor and the lines indicate larger adjustments.