Attractors: Incidental Values That Influence Forecasts of Change

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Abstract

This article examines whether forecasts of change are influenced by *attractors*, salient values in the direction of the considered change. When an attractor is relatively distal from (vs. proximal to) the base value from which change originates, it encourages forecasts of greater change. Participants showed this pattern when predicting: which of two airfare changes was imminent (Study 1) and by how much a stock’s price would change (Study 2). Attractors have this influence because they alter the way people translate subjective interpretations of change into objective amounts of it. Each unit of change feels subjectively smaller (and thus insufficient) in the context of a distal (vs. a proximal) attractor (Studies 3-4). Having participants pre-commit to a subjective interpretation of an objective amount of change reduced a subsequently-introduced attractor’s influence on forecasting (Study 5). Following more than four decades of research showing many ways arbitrary values anchor judgments, we discuss how attractors reflect the first evidence that such values can also influence adjustment.

KEYWORDS: forecasting; trends; pricing; adjustment; anchoring
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A potential traveler searches on-line for airfare between New York and Los Angeles. The website shows the history of fares that has been inching upward as the travel date approaches. The traveler examines this data as she considers how much prices are likely to change in the near future. A dietitian weighs a client each week and keeps records on his progress. She looks at the trajectory and considers how likely he is to lose 3 pounds again this week as she formulates a recommended regimen. With oil refineries shut down by a hurricane in the Gulf of Mexico, a driver accesses AAA’s Daily Fuel Gauge to see how gas prices have been trending upward. Contemplating a quick run to the service station, he considers whether tomorrow morning will bring another spike or the beginning of a plateau.

In each of these examples, people are forecasting change. When doing so, some information is obviously relevant (e.g., the observed variability in fares over time, the general trend of a client’s weight loss, previous gas spikes following hurricanes). But in this paper, we examine a more arbitrary influence on forecasts of change: salient values in the direction of change, which we call attractors. We hypothesize that attractors may influence forecasts of change because they influence one’s interpretation of whether a potential amount of change feels subjectively substantial or insubstantial. This should make the same prospective changes feel like overestimates or underestimates, respectively. Before articulating our account in greater detail, we highlight some previously identified factors that influence how people forecast and evaluate change and then describe how attractors relate to other known influences on judgment.

Regardless of the specific occurrence of change under consideration, there are several common constituents of actual or forecasted change. A real or forecasted change involves the transformation of some property from its base or starting value to its actual (or forecasted)
ending value. Change can be quantified in absolute terms (e.g., “Consumer sentiment grew by 1 point after the Democratic primary, and another 2 points after the presidential election”). But change can also be observed and considered in completely relative terms without reference to absolute numeric values (e.g., “Consumer sentiment grew twice as much after the presidential election than the Democratic primary.”

Previous research has identified influences on people’s forecasts or interpretations of change. In some cases, this research has looked at how information about historical patterns of change influences forecasts of future change (Lawrence, Goodwin, O’Connor, and Onkal 2006; Lawrence and Makridakis 1989; Reimers and Harvey 2011). For example, when people observe a time-series graph that shows a very slow rate of growth, they tend to assume growth will accelerate, but when they observe a very fast rate of growth, they assume growth will decelerate (Harvey and Reimers 2013). In other cases, researchers have looked not at what influences forecasts of change, but at what properties govern evaluations or interpretations of a given change. A classic example is the jacket-calculator problem, which exhibits differential sensitivity to change: More than twice as many people reported being willing to travel for 20 minutes to save $5 on a $15 item than on a $125 one (Tversky & Kahneman, 1981; see Thaler 1980). In other words, the subjective magnitude of the same (five-dollar) change depends on the base value of the item it was attached to. Also, research from the numerosity literature shows that even when the percentage change is held constant, the equivalent amount of change feels bigger when expressed in a metric that describes the change as more units in that metric (Brannon & Terrace, 1998; Pandelaere et al., 2011). For example, Wertenbroch et al. (2007) showed the same monetary difference seemed bigger when expressed in a weak currency (473.9 vs. 4,739 Chilean pesos) compared to a strong currency (1 vs. 10 U.S. dollars).
Although the specific lessons from these programs of research vary, they all highlight how properties of the change itself (e.g., the historical rate of change, the percentage change, the units in which change is expressed) influence how people evaluate or forecast it. In contrast, we propose that an incidental feature—a salient value in the direction of the forecasted change—shapes forecasts of change because it alters perceptions of a given, considered amount of change. In this sense, we combine these two research foci (forecasts and evaluations of change) and examine an influence that is incidental to the change itself.

**Attractors: The Complement of Anchors**

There is a large literature on how arbitrary or incidental values influence judgments. Anchoring research has identified numerous ways in which numerical values or non-numerical expressions of magnitude (Oppenheimer, LeBouef, & Brewer, 2008) exert an assimilative pull on numeric judgments. Anchors have been shown to influence a variety of judgments: willingness to pay (Adaval & Wyer, 2011; Critcher & Gilovich, 2008; Nunes & Boatwright, 2004; Simonson & Drolet, 2004), size estimates (Wong & Kwong, 2000), or even judicial sentencing (English & Mussweiler, 2001).

Forecasting change is one example of an anchoring and adjustment problem (Eggleton, 1982). People begin from an anchor (a base value), and then decide on an appropriate amount of adjustment (change). In the context of forecasting change, Harvey and Rimers (2013) note that the anchoring-and-adjustment heuristic predicts the underestimation of change. Such a result, when present, may emerge because people adjust only far enough to reach a value that seems plausible, but little further (Epley & Gilovich, 2006).

But in this paper, we do not seek to identify a new reason why anchors restrain forecasts of change. To the contrary, we seek to understand a complementary phenomenon: how incidental
values in the direction of a change—what we call *attractors*—influence forecasts of change from an anchor. In considering the novelty of this approach, it is worth appreciating that the many anchoring literatures have devoted considerable attention to different reasons why anchors restrain judgments. That is, anchoring phenomena have been tested using multiple operationalizations that invoke different psychological processes—numeric priming (e.g., Critcher & Gilovich, 2008), response scale distortion (Frederick & Mochon, 2012), the selective accessibility of anchor-consistent information (Adaval & Wyer, 2011; Strack & Mussweiler, 1997), or an actual process of adjusting along a number line (e.g., Epley & Gilovich, 2001). Despite this diversity, anchoring phenomena are unified by a common theme: for various reasons, anchors restrain people’s judgments, making them unlikely to move far from their grip. We are aware of no attempts to examine a phenomenon in which an arbitrary value (here, an attractor) influences how much adjustment from an anchor seems warranted. Although our empirical focus is on how and why attractors influence forecasts of change, we return in the General Discussion to the question of (and offer some preliminary data to speak to) whether attractors’ influence generalizes to other anchoring-and-adjustment paradigms.

Just as Epley and Gilovich (2006) emphasized that the process of adjustment is marked by uncertainty about whether one has adjusted “far enough,” people considering a specific change (in formulating their own forecast or considering someone else’s proposal) should possess similar uncertainty as to whether any specific change feels too small or too large. In such contexts, there are reasonable cues that people can, and no doubt do, consult (e.g., “Is this change plausible given natural constraints within the domain?”, “Is this change a big percentage shift?”, “Is this change larger or smaller than the ones in previous periods?”). We argue that attractors—and specifically, these incidental values’ distance from the base value from which the change
originates—shape subjective characterizations of the magnitude of change. By our account, attractors serve as a psychological benchmark that influences one’s subjective sense of whether a given amount of change has been substantial, and thus sufficient.

Our proposal is based on a relatively straightforward observation: The same objective amount of change or adjustment toward an attractor that is far away (a distal attractor) compared to one that is close by (a proximal attractor) covers proportionally less ground toward that attractor. We argue that because the same objective change will feel less substantial (and thus potentially too insubstantial) when considering movement toward a distal than a proximal attractor, that change will be forecast to be larger when moving toward a distal (compared to a proximal) attractor. We illustrate the implications of this logic in the context of one of our opening examples—the question of how much gas will spike following a hurricane.

Imagine that gas prices have been trending up 5 or 10 cents per day. But because the gas prices were lower to begin with in South Carolina than in New York, the price in each state is now $3.55 and $3.85, respectively. Drivers in both states may ask themselves how much prices are likely to rise the next day. If $4 is a psychologically salient value toward which prices are moving, then note that each additional cent increase does less to “close the gap” with the salient attractor when it is distal (for South Carolinians) than when it is proximal (for New Yorkers). As a result, this may lead the same objective increase to feel less substantial in the context of the distal attractor. In Figure 1, this is illustrated by a 5-cent increase feeling “small” for South Carolinians but “medium-sized” for New Yorkers (Figure 1). As a result, people may forecast greater change when moving toward proximal than distal attractors.

Although our thesis and the contexts to which it applies may be novel foci of research, our hypotheses are made psychologically plausible by a wide range of work that examines the
imperfect and inconsistent mapping between objective stimuli and a person’s subjective interpretations of those stimuli (e.g., Ostrom, 1970; Parducci, 1965). That said, we examine a new way in which the surrounding context (a salient value) changes the way that an objective value (a certain amount of adjustment) is subjectively construed and thereby alters forecasts of change.

Overview of the Present Studies

Studies 1-2 test our hypothesis that attractors influence forecasts of change. We tested whether participants thought airfare between two cities was about to experience a small or large change (Study 1) and how much participants believed gas prices were likely to shift (Study 2). In both cases, we tested how distal vs. proximal attractors—incidental values in the direction of adjustment that are relatively far from or close to the base value, respectively—influenced these forecasts. The basic prediction is that the addition of a distal attractor (vs. a proximal attractor) should make larger objective changes seem more likely.

Studies 3-5 test our proposed mechanism for this effect—that attractors influence forecasts of change by altering how people translate a subjective evaluation of change or adjustment into an objective amount of change or adjustment. We begin by testing each direction of this influence. Study 3 tested whether the same subjective amount of change (e.g., “The stock experienced a [small, medium] increase in price”) was translated into more objective change in the context of a distal (vs. a proximal) attractor. Study 4 reversed this by testing whether the same objective amount of change (i.e., a 3 lb. weight loss) seemed less daunting in the context of a distal (vs. a proximal) attractor. Providing the strongest test of our mechanism, Study 5 had participants pre-commit to a certain subjective interpretation of a specific objective amount of
change before even being exposed to the attractor. By our account, this manipulation should interfere with attractors’ influence on forecasts of change.

**Study 1**

When people search for flights on kayak.com, they are shown a time-series graph that illustrates how the airfare between two cities has fluctuated over the last several weeks. Although Kayak predicts whether fares are likely to rise or fall, it is up to the user to intuit how large such shifts will be. But critically, these graphs include one or more attractors as well: prominent y-axis numerical labels that have accompanying lines that cross the entire horizontal span of the graph. Inspired by this format, we showed participants trajectories of how airfare between a pair of cities had fluctuated over 9 weeks. We positioned these trajectories on graphs such that the ninth week’s price was relatively proximal to or distal from an attractor. We then had participants estimate which of two possible price changes—one relatively small, one relatively large—was more likely. Our primary prediction was that when airfare was moving toward a distal (instead of a proximal) attractor, people would be more likely to think the large change in airfare was accurate.

**Method**

**Participants.** Three hundred eighteen undergraduates from universities in the southern and western United States participated in exchange for course credit.

**Procedure.** Participants were told that their task would be to predict fluctuations in airfare. As part of the instructions, participants saw a time-series graph that was an actual graph shown to shoppers on Kayak.com. It traced the cheapest airfare found each week between a pair of cities. Participants were told that we were testing whether their intuitions about price changes might be as good as the algorithms used by sites like Kayak.com and Bing Travel.
Participants completed sixteen trials. On each trial, participants saw four time-series graphs (whose generation is described below). Two graphs were for one flight route; two, for another. We paired flight routes such that for the final price change—the price change that participants were forecasting—both routes experienced a price increase, or both routes experienced a price decrease. Furthermore, participants always saw one flight route (e.g., Miami to Atlanta) paired with a distal attractor, and the other flight route (e.g., New York to Chicago), with a proximal attractor. We counterbalanced between participants which flight route had which type of attractor (see Figure 2).

Participants’ task was to select which flight route (the one with the distal or the proximal attractor) was the one that experienced the large price change, and which flight route experienced the small price change. The two possible pairings (between price change and route) were shown on the left and right halves of the screen. This means that one half of the screen depicted price changes that matched our hypotheses (a large price change moving toward a distal attractor, a small price change moving toward a proximal attractor), while the other half depicted price changes that did not match our hypotheses (a small price change moving toward a distal attractor, a large price change moving toward a proximal attractor). Participants indicated which they thought reflected the real price changes from 1 (*pretty sure Left Half is REAL*) to 6 (*pretty sure Right Half is REAL*). Of the 16 trials that participants considered, only the 8 experimental trials—those that involved price changes toward the attractor—are analyzed further.

**Materials.** We constructed 32 time-series line graphs. Displaying data using this format is ideal when one wants to depict period-over-period changes (Hutchinson, Alba, and Eisenstein 2010), our construct of interest. Each graph supposedly reflected fluctuations in the cheapest airfare for an identified U.S. domestic route. The graphs included 10 data points, reflecting the
price from “10 weeks ago” to “1 week ago.” Each graph also included an attractor, operationalized as a prominent y-axis label and accompanying horizontal line that spanned the width of the graph. For each graph, the specific attractor value was always the multiple of $100 that was closest to the actual cheapest airfare between the two cities (as found on Kayak.com on February 27, 2014). The y-axis plotted a total range of $70, which meant only one prominent y-axis label (and thus potential attractor) was on each graph. The full randomization procedure used to generate the graphs is detailed in the Supplemental Materials.

We created four versions of each of these 32 time-series graphs. The versions of each graph were identical except for two features. First, we varied whether the last depicted change in price (from “2 weeks ago” to “1 week ago”) was relatively small ($3-$5) or relatively large ($9-$11). Second, we shifted the entire trajectory on the graph so that the base price for this final price change (i.e., the “2 weeks ago” price) was relatively proximal to the attractor ($12 - $16 away) or relatively distal from the attractor ($24 - $28 away, but always $12 more than the matching proximal version). The graphs were constructed such that the base price (“2 weeks ago”) was always in the very middle of the numerical space delimited by the y-axis. In this way, the dollar amount by which airfare could adjust or change (and still remain in the area of the plot) was identical on all trials. For half of the flight routes, we constructed graphs such that the final price change moved toward the attractor. For the remaining half, the final price change moved away from the attractor. These latter trials were filler trials that did not factor into analyses. After all, if attractors are not in the direction of change, then our account does not anticipate that they should shape people’s subjective interpretation of change. Given across the stimuli prices were just as likely to move toward as away from an attractor, this helped to demonstrate that the attractor did not provide information about the price shift, such as the
airfare’s long-term average or the value most prices converged toward. Furthermore, so participants would know why that value in particular was labeled on the graph, we explicitly stated that only multiples of $100 would be labeled on the graph.

**Results and Discussion**

In order to test whether hypothesis-matching price changes (i.e., large—distal, small—proximal) are forecast to be relatively more likely than hypothesis-mismatching ones, we used a hierarchical linear model. We created a variable *match*, which differentiated whether on a particular trial, the hypothesis-matching price changes were on the left (-1) or right (+1) half of the screen. We nested match within flight route pair (thereby differentiating participants who saw hypothesis-consistent changes on the left vs. right side of the screen) in a random-slope, random-intercept model. This permitted the effect of attractor to vary across the eight flight route pairs (random-slope), but also permitted a tendency for participants to see a large or small price change as more likely to accompany specific routes (random-intercept). Finally, to account for variability in participants’ tendencies to believe the graphs on the left or right half of the screen were the real ones, as well as the non-independence of within-subject trials, we included a random effect of participant.

Providing support for our central hypothesis, the main effect of match was significant, $B = 0.072$, $SE = 0.031$, $t(2,199.24) = 2.31, p = .02$. As expected, participants were more likely to believe that the price changes depicted on the right side of the screen were the real ones when they depicted large price changes paired with distal attractors and small price changes paired with proximal attractors ($M = 3.33$) compared to when these were reversed to be hypothesis-inconsistent pairings ($M = 3.19$).
One question is whether these findings differ from diminishing sensitivity to change, as illustrated by the jacket-calculator problem (Tversky & Kahneman, 1981). That research shows that the same absolute change feels smaller when it is made from a larger base value. Note that in the context of price decreases, the attractor effect and diminished sensitivity to change make the same prediction. That is, when the price was more distal from (vs. more proximal to) a smaller attractor, then the same downward price change may have felt subjectively smaller because it reflected a smaller percentage change. If so, this offers an alternative explanation for why downward adjustment was greater in the context of a distal (vs. proximal) attractor. But this alternative explanation predicts a reversal when price changes were positive: Participants should forecast less change when adjusting upward toward distal attractors (vs. proximal attractors). But we did not find that our results were driven by the price-decrease trials. In fact, the effect of attractors did not differ when participants were forecasting positive as opposed to negative price changes, $B = -0.030, SE = 0.033, t < 1$. This demonstrates both the robustness of and the distinctiveness of the attractor effect from past research.

The present results show that people believe that in the context of an uninformative distal (vs. proximal) attractor, a relatively large (vs. small) price change is more likely. Beyond testing our theoretical account, these findings have an intriguing applied implication. Because Kayak and similar travel websites are incentivized by referral fees to encourage people to purchase their airfare on the spot, Kayak could position attractors on their price graphs strategically. When Kayak predicts airfare increases, it could use graphs with distal attractors, so large price hikes seem imminent. But when Kayak predicts airfare decreases, it could use graphs with proximal attractors, which encourage the impression that the decline will be minimal.

**Study 2**
Whereas the first study shows how attractors changed the likelihood of a proposed change, Study 2 moved one step further by having participants forecast these changes themselves. We moved to a new context in which forecasting change is relevant: predictions of the price of gas. Drivers receive frequent information about how gas prices are shifting, and their decisions about when to “fill up” are influenced both by the quantity of gas remaining in their vehicles and their estimates of how gas prices are likely to shift in the coming days.

Participants saw time-series graphs that supposedly depicted how the average price of gas, in a randomly selected U.S. state, fluctuated over a randomly selected 9-day period. Participants learned whether the average price increased or decreased on Day 10. They had to adjust a “prediction bar” up or down from the Day 9 price to reach their final forecasted value for Day 10. We predicted that participants would adjust further (thereby forecasting a larger change) when moving toward a distal compared to a proximal attractor.

Method

Participants. Two hundred eight undergraduates at a university in the southern United States participated for extra course credit.

Materials. We generated 24 time-series trajectories, each with nine points of data that represented a gas price’s value over nine days. The visible portion of the y-axis was approximately 72 cents in length. Each time-series trajectory was centered such that its value on Day 9 (the base price from which adjustment would occur) was located at the middle of the range delimited by the y-axis. In this way, the space for adjustment on each side of the base price was identical (36 cents) for all materials.

Each gas-price trajectory also included an attractor: a single value marked with a horizontal line through the y-axis. The attractor was randomly selected to be $2 or $3, plausible
values given the depicted gas prices were said to have come from the last 10 years. To offer an explanation of why the attractor was present, the instructions explained that only the whole-dollar prices would be prominently displayed. Given the y-axis range was less than a dollar, only one attractor appeared on each graph. Short tickmarks identified five-cent increments. We created two versions for eight of the 24 graphs. For the proximal attractor versions, the attractor was relatively close to the Day 9 value (8 to 12 cents away). For the distal attractor versions, the attractor was relatively far from the Day 9 value (20 to 24 cents away, but always exactly 12 cents more than in the corresponding proximal attractor version).

For the 16 critical trials (i.e., the distal and proximal attractor versions of the eight distinct trajectories), the stated direction of adjustment was always toward the attractor (see Figure 3, for an example of one of these eight key pairs). For the 16 filler trials, the direction of adjustment was always away from the attractor. Thus, as in Study 1, the direction of the attractor was not correlated with the direction of adjustment. This served to reinforce that the attractor was not meant to communicate what the Day 10 price was.

**Procedure.** Participants were told that commodity traders are paid hefty salaries to anticipate changes in the price of oil, and thus the price of gas. We stated we were interested in whether ordinary people might be able to intuit price changes as well as professional traders can. Immediately to the right of the Day 9 value was a short red bar. Participants were asked to use the up or down arrow keys to adjust this prediction bar to their final forecasted value. Before beginning the task, participants were quizzed on their understanding of the instructions: “How many cents does each tick mark on the y-axis represent?”, “How many days’ worth of prices will you receive?,” and “How many graphs will you make predictions about?”. To correct any misunderstandings, participants were shown the answers before beginning the forecasting task.
The 32 trials (16 experimental graphs and 16 filler graphs, as described above) appeared in one of two semi-randomized orders. We placed one constraint on the randomization: The two versions of each trajectory could not appear in the same half of trials (to minimize the likelihood of detection). Each semi-randomized order differed in whether the proximal or distal version of a particular trajectory appeared in the first or second half. On each trial, participants used the up and down arrow keys to adjust the red cursor to where they thought the average gas price would be on Day 10. Each click moved this prediction bar up or down one cent; through iterative clicks participants adjusted to their final forecast. We excluded trials on which participants failed to adjust (1.3%) or adjusted in the opposite direction of what was instructed (5.9%).

Results and Discussion

To test whether participants adjusted more toward distal than proximal attractors, we leaned on a similar data analytic strategy to what was used in Study 1. We created the variable attractor distance, which differentiated those trials for which the attractor was proximal to (-1) or distal from (+1) the base price (i.e., the Day 9 value). Distance was nested within the specific gas-price trajectory in a random-slope, random-intercept model. In this way, the effect of attractor distance could vary between the eight distinct gas-price trajectories (random-slope), but the distinct gas-price trajectories could also differ in whether the trend they reflected seemed to call for more or less adjustment on Day 10 (random-intercept). Finally, to account for differences between participants in how much they tended to adjust from the Day 9 price (as well as the non-independence of the repeated measures), we included a random effect of participant.

Confirming our central hypothesis, participants adjusted further in the direction of a distal attractor than a proximal attractor, $B = 0.33, SE = 0.06, t(4,339.50) = 5.60, p < .001$. Extrapolating from the model, participants adjusted an average of 6.44 cents toward distal
attractors, but only 5.74 cents toward proximal attractors. In other words, participants estimated that the price change from Day 9 to Day 10 would be 12% greater in the context of a distal (vs. proximal) attractor. As in Study 1, the influence of the attractor did not differ when participants were instructed that the gas price had increased as when told that it had declined, \( B = -0.07, SE = 0.06, t(4,713.33) = 1.11, p > .26. \)

Although the first two studies have established that attractors influence estimates of change, they have yet to demonstrate why attractors have this effect. By our account, attractors change the way people map an objective amount of change onto a subjective impression of it (e.g., small vs. medium), and vice versa. This is because the same objective change closes a smaller proportion of the gap (and thus is more likely to feel implausibly small) in the context of a distal vs. a proximal attractor. The final three studies test our mechanistic account.

**Study 3**

If attractors alter people’s forecasts of change by shaping what they think would constitute a subjectively large or small amount of change, then people should translate the same subjective description (“A small change in price was experienced on the last day”) into different objective amounts of change in the presence of distal vs. proximal attractors. In Study 3, participants again saw graphed trendlines and had to adjust a prediction bar toward a distal or proximal attractor to indicate their forecasts. But this time, we told participants—in subjective terms (“small” or “medium”)—how much change had actually occurred. We have two predictions for how the same subjective description of change would translate into objectively different forecasts in the context of distal and proximal attractors.

First, we expected that what constitutes a “small” or “medium” change would be greater in the context of a distal vs. a proximal attractor. Second, and reflecting a more nuanced
prediction, we expected that the difference between what constituted a “small” and “medium” change would be objectively greater in the context of a distal (vs. proximal) attractor. Both predictions follow directly from the idea that each unit of adjustment in the context of a distal attractor feels subjectively smaller than each unit of adjustment in the context of a proximal attractor. Thus, in the context of a distal attractor, more adjustment would be necessary to achieve both “medium” and “small” change (the first prediction), just as more units of adjustment would be necessary to differentiate “medium” and “small” change (the second prediction).

In addition, participants in Study 3 were told they were forecasting how a stock’s price changed over time. On-line investment companies like E*Trade, Scottrade, and Ameritrade have brought investment opportunities to the masses. The brokers themselves, as well as free resources like Yahoo Money, provide information about stock price fluctuations over time. In addition, these graphs often have prominent attractors. For example, intra-day stock graphs on Yahoo Money highlight the stock’s opening price with a horizontal line that covers the full length of the graph. Even though we did not want to choose an informative attractor (like an opening value), this speaks to the external validity of the experimental context.

Method

Participants. One hundred thirty-eight undergraduates at a university in the western United States participated for course credit or as part of a larger session for which they received $15.

Materials. We leaned on the same set of 32 graphs (16 experimental, 16 filler) used in Study 2, but made three modifications. First, because the trajectories were said to reflect stock-price movement, the attractors were randomly sampled from a uniform distribution of integers
from $1 to $99. Second, instead of merely telling participants that a stock experienced an increase or decline in price from Day 9 to Day 10, we also described this change as “small” or “medium.” For half of the trials, we said the stock experienced a “small” change. For the other half, we indicated there was a “medium” change. Thus, across all 32 graphs (half of which were fillers), there were 8 small increases, 8 small decreases, 8 medium increases, and 8 medium decreases.

Third, in an effort to test the robustness of our effects and in keeping with previous research on forecasting trends (e.g., Harvey & Reimers, 2013), we eliminated the minor tickmarks from the y-axis. Note that the decision to exclude or include the tickmarks is superfluous to the internal validity of the study (i.e., it matters not whether one unit of adjustment is thought to be 1 cent, 5 cents, or some other value). The benefit of their inclusion is it enhances the external validity of the materials. The benefit of their exclusion is that by providing the precise value for the attractor but not the base price, we could vary attractor distance without having to vary between the two conditions either the stated base price or the attractor value. Given this change, we describe adjustment in units of adjustment (1 up or down click = 1 unit) instead of the objective value of change.

Procedure. The instructions were similar to those used in Study 2, except the graphs were described as tracking changes in the closing prices of stocks traded on the NYSE over a random 9-day period. Participants were asked to adjust a prediction bar from Day 9’s value to estimate the value of the stock on Day 10. After a sample trial, participants completed all 32 trials. As in Study 2, we excluded the trials (0.4%) in which participants did not adjust the bar.

Results and Discussion
We aimed to test two predictions for how attractors influence adjustment. First, to test whether the same subjective amount of change is translated into larger objective change in the context of a distal vs. proximal attractor, we expected to find a main effect of attractor distance while controlling for subjective change label. That is, even given the same subjective description of an upcoming change, people should expect that change to be objectively larger in the context of a distal (compared to a proximal) attractor. Second, to test whether the objective gap between what constitutes a “medium” vs. “small” change is greater in the context of a distal vs. proximal attractor, we tested for an interaction between attractor distance and subjective change label.

Our statistical models were analogous to those used in our previous studies. We again created the variable attractor distance, which differentiated the distal (+1) and proximal (-1) attractor version of each graph. We defined the new variable subjective change magnitude, which differentiated the trajectories that we said would experience a small (-1) versus a medium (+1) change. Because both the distal and proximal attractor versions of each particular trajectory were always given the same subjective change label (small or medium), in this study we nested attractor distance and subjective change within participant in a random-slope, random-intercept model. This permitted the influence of attractor distance and subjective label to differ for each participant (random-slope), even as we allowed for differences between participants in how much they tended to adjust (random-intercept). We also included a random effect of trajectory to account for differences between trajectories in how much they seemed to call for more or less adjustment.

Providing a manipulation check of sorts, there was a main effect of subjective change, $B = 1.89$, $SE = 0.15$, $t(11.18) = 12.30$, $p < .001$. This confirmed that participants attended to the subjective change labels: They adjusted further when told the change was “medium” ($M = 7.88$
units) rather than “small” ($M = 4.09$ units). Supporting our first hypothesis, there was also a main effect of attractor distance, $B = 0.20, SE = 0.04, t(2,616.87) = 5.44, p < .001$. This reflects that what constituted a “small” or “medium” change was different in the context of a proximal vs. a distal attractor. On average, the same subjective characterization was represented by an additional 0.41 units of adjustment in the context of a distal than a proximal attractor. Finally, consistent with our second hypothesis, there was also an Attractor Distance $\times$ Subjective Label interaction, $B = 0.09, SE = 0.04, t(1,905.21) = 2.61, p = .01$. Reflecting that in the context of a distal attractor, more adjustment was necessary to differentiate between two subjective benchmarks, the objective gap between “small” and “medium” was wider in the context of a distal attractor (3.97 units of adjustment) than a proximal attractor (3.60 units of adjustment).

Study 3 supports our account of (one reason) why attractors influence estimates of change. Even if people are trying to forecast the same subjective amount of change (e.g., “This stock is only going to experience a small change tomorrow”), they will do so by translating the same subjective intent into more objective change in the context of a distal (vs. proximal) attractor. More specifically, our results showed that distal (vs. proximal) attractors elongate consumers’ translation of subjective perception into objective adjustment.

**Study 4**

Study 4 offered a complementary test of our account of how attractors influence judgments of change. Instead of testing how people translate the same subjective descriptions of change into different objective instantiations of change, we tested whether attractors shift people’s subjective understanding and interpretation of the same objective amount of change. Study 4 moved to a new prediction context, one that had participants consider how a dieter’s weight might change over the course of a week. The base value was the dieter’s current weight,
which was depicted on a stylized number line that had been divided into units of 10 lbs. These salient labels served as potential attractors (i.e., 190 lbs, 200 lbs.) We varied the base value (i.e., the dieter’s initial weight) so that it was relatively close to or far from the nearest attractor in the anticipated (downward) direction of adjustment. We predicted that the same amount of weight loss would appear less difficult to achieve when the attractor was distal (i.e., moving from 209 lbs. to 206 lbs., with 200 lbs. as the attractor, or moving from 199 lbs. to 196 lbs., with 190 lbs. as the attractor) than when it was nearby (i.e., moving from 204 lbs. to 201 lbs., with 200 lbs. as the attractor). We included two distal-attractor conditions that flanked the proximal condition so that the attractor distance manipulation was not confounded with the percentage decline, a methodological strategy used elsewhere in the anchoring literature (Janiszewski & Uy, 2008).

By our account, attractors shape people’s true interpretation of change, not merely the way they express the meaning of change on a Likert-type scale. To probe whether the attractors prompted a substantive shift in people’s understanding of how large a given change would be (i.e., one that actually changes people’s true subjective interpretation of just how large a given amount of change is), we included additional measures that asked what instrumental actions would be necessary to achieve the specified change. We thus examined whether, in the context of a distal attractor, participants would see the same objective change (i.e., losing 3 pounds) as not only subjectively easier, but as requiring less effort to achieve (e.g., fewer hours spent exercising).

In addition, we modified the presentation of the attractor and the representation of the proposed adjustment (i.e., the 3 lbs.) to assess the robustness of attractors’ influence. Although we again relied on a visual presentation to make the base value and attractor salient, we did so using a stylized number line that was not “to scale.” In the image, the on-screen distance between
the base value and the attractor was equivalent across distal and proximal conditions, which permitted us to test whether effects emerge due to the numeric distance, not merely the spatial distance, between the base value and the attractor. Note that this change necessarily makes the considered 3-lb. shift take up a larger proportion of the number line in the proximal attractor condition. For this reason, we did not actually depict the 3-lb. shift. Observing hypothesis-consistent results despite such variations across our studies in our approach to representing change and attractors would promote confidence in the robustness of our effects.

**Participants.** Sixty-five American participants were recruited via Amazon Mechanical Turk and received payment for their participation.

**Procedure.** Participants learned about a dieter named Kristen. The background information was presented as part of a dynamic slideshow. First, participants were informed of Kristen’s initial weight, which was said to be either 199, 204, or 209 pounds. This value was presented on an otherwise blank number line (see Figure 4a). Participants then read that, “Kristen is dissatisfied with her weight and is going to begin a diet and exercise routine immediately.”

On a new page, participants were asked to evaluate a stated amount of change (weight loss) in the context of distal or proximal attractors: “How hard do you think it will be for Kristen to go from [199, 204, 209] lbs. to [196, 201, 206, respectively] lbs. the first week?” At the same time as this subjective difficulty question appeared, tick marks were added to the number line at the 10s (see Figure 4b and 4c). Thus, the next lowest multiple of 10 was the salient attractor (190 or 200 lbs.) Participants responded on a 14-point scale anchored by 1 (extremely easy) and 14 (extremely hard). As part of the presentation, participants learned Kristen did not have a target weight, to ensure they would not confuse the tick marks or the attractor itself as being her weight loss goal. Furthermore, we intentionally identified the first several multiples of 10 on the number line.
line so it would seem natural that the number line would restart at the multiple of 10 below Kristen’s current weight.

After participants registered their response, a new page loaded that asked them to assume that Kristen did lose weight, going from [199, 204, 209] lbs. to [196, 201, 206, respectively] lbs. through a combination of running, skipping meals, and using a stair climber. With the knowledge that she lost the weight, participants estimated Kristen’s behavior for the week: how many hours she ran, how many of her 21 meals she skipped, and how many hours she spent on the stair climber. Participants responded with integers between 1 and 15, inclusive. We standardized and averaged the three items to create a composite measure of objective effort ($\alpha = .72$).

**Results and Discussion**

To test our primary predictions, we conducted planned contrasts that compared the two conditions in which the attractor was distal (-1: starting weights of 209lbs, 199lbs) against the condition in which the attractor was proximal (+2: starting weight of 204lbs). The means by condition are summarized in Table 1. As hypothesized, participants thought that Kristen would have more difficulty losing 3 pounds in the context of a proximal attractor (base, 204 lbs: $M = 7.17$, $SD = 4.04$) than in the context of a distal attractor (base, 199 lbs: $M = 5.05$, $SD = 3.08$; base, 209lbs: $M = 5.57$, $SD = 2.94$), $t(60) = 2.08$, $p = .04$. Suggesting the contrast fit the data well, the orthogonal linear contrast—which orders conditions by how large a percentage decline the proposed change was: 199lbs (-1), 204lbs (0), 209lbs (+1)—was not significant, $t < 1$. These results indicate that the same objective amount of adjustment (3 lbs.) seemed subjectively easier to achieve in the context of a distal (versus proximal) attractor.

Was this effect merely a scaling effect (reflecting differences in how people used our Likert scale), or did attractors actually change how much objective effort participants thought
was required to achieve change? First, and providing some support for our interpretation, the perceived subjective difficulty of losing three pounds was positively correlated with the objective steps thought necessary to achieve that result, \( r(60) = .41, p = .001 \). Second, and offering more central support, attractors influenced the objective effort composite: Participants thought that losing three pounds toward a distal attractor would require less dieting and exercise (199lbs: \( M = -0.07, SD = 0.54 \); 209lbs: \( M = -0.31, SD = 0.59 \)) than would losing three pounds toward a distal attractor (\( M = 0.33, SD = 1.01 \)), \( t(61) = 2.64, p = .01 \). Here too, the orthogonal linear contrast was not significant, \( t(61) = 1.01, p > .31 \).

Moving to a new context and a modified instantiation of attractors, Study 4 found that the same objective amount of change seems less daunting in the context of a distal vs. a proximal attractor. Combined with Study 3, this yields insight into why attractors affect forecasts of change. By changing how people map subjective perceptions of the magnitude of change onto objective change amounts (Study 3) and vice versa (Study 4), attractors encourage larger forecasts of change in the context of distal (vs. proximal) attractors. Whereas Studies 3 and 4 provide evidence consistent with this account, Study 5 provides a more definitive test.

**Study 5**

By our reasoning, attractors affect forecasts of change because they shape people’s objective representation of what constitutes different subjectively conceptualized amounts of change (e.g., small or medium). Studies 3 and 4 support this account by showing that attractors influence the translation between objective change and subjective interpretation, but we have yet to directly test whether it is this modified translation that is responsible for attractors’ influence on forecasts of change. Study 5 provided this test by having some participants pre-commit—
before being exposed to the attractor—to the subjective meaning of an objectively-depicted change.

Participants were exposed to the materials used in Study 2, time-series graphs said to depict changes in the average price of gas across days. But before being exposed to the attractor or forecasting the change in gas price, participants saw the Day 1 to Day 9 gas-price trajectory. All participants’ attention was directed to the change in price from Day 4 to Day 5. In the pre-commitment condition, participants were asked to characterize their (subjective) sense of the magnitude of that objective price adjustment. In this way, participants were forced to pre-commit to a particular translation of objective change into subjective interpretation before the attractor had the opportunity to influence this assessment. In the control condition, participants estimated the number of eighths-of-an-inch that separated the graphical depictions of the Day 4 and Day 5 prices. In this way, all participants were focused on the same change in price, but only those in the pre-committed condition took a position on what we expected the attractor to influence— their subjective assessment of a specific, objectively depicted amount of change. If attractors influence forecasts of change by altering people’s subjective interpretations of the magnitude of a given amount of adjustment, then the pre-commitment manipulation should interfere with this mechanistic pathway and thereby reduce the effect of attractors on forecasts of change.

A precedent for our general empirical strategy can be found in past research that has likewise examined the latitude people have in moving between subjective labels and objective representations. For example, de Lange et al. (2011) found that the influence of the labels provided on subjective rating scales (more specifically, whether they were written in one’s native tongue or a second language) was reduced when objective information (pictorial representations of emotion) was added that more precisely defined the emotional intensity meant to be
communicated by each point on the scale. In this way, the experimenters clarified the objective meaning of each scale point. By analogy, we examine whether having participants pre-commit to their own objective-subjective mapping will reduce the influence of attractors on their change forecasts.

Method

Participants and design. One hundred sixty-three undergraduates at a university in the western United States took part in the study. They participated as part of a longer session for which they received $15 or course credit. Participants were randomly assigned to one of two estimation conditions: pre-committed or control.

Procedure. The initial instructions described a task similar to that encountered by participants in Study 2. But participants in the present study learned that they would make two judgments for each graph. The first varied by condition. The second was the forecast that served as our dependent measure of interest.

All participants first saw a graph showing how gas prices fluctuated over the first nine days. (These were the same graphs used in Study 2, except as in Study 3, we did not include the minor tick marks). On this graph, neither the attractor nor any indication that the gas price increased or decreased on the tenth day was included. Everyone’s attention was drawn to the change in price from Day 4 to Day 5 (see Figure 5a).

For participants in the pre-committed estimation condition, they were asked to indicate their subjective characterization of how much the gas price had changed in that interval. More specifically, they were asked, “What is your subjective sense of how the price of gas moved from Day 4 to Day 5?” Participants responded on a 9-point scale anchored at 1 (a small amount), 5 (a medium amount), and 9 (a large amount). This led participants to pre-commit to an objective (a
certain amount of change)—subjective (a subjective interpretation of that amount of change) before being exposed to the attractor.

Participants in the control estimation condition were asked to quantify the objective distance between the dots representing the Day 4 and Day 5 values: “What is your best estimate of how many eighths of an inch the dots representing Day 4 and Day 5 are apart?” For reference, a small line representing one eighth of an inch was provided. Control participants thus considered the magnitude of adjustment over the same interval, but in a way that did not prompt them to pre-commit to a subjective interpretation of this objective amount of adjustment.

After participants had made the initial judgment, the attractor as well as a statement of whether the gas price increased or declined on Day 10 appeared. Participants then used the up and down arrows to adjust the prediction bar from the Day 9 base to their Day 10 forecast (see Figure 5b). As before, we excluded trials from further consideration if participants failed to adjust (1.6%) or adjusted in the wrong direction (2.1%).

**Results and Discussion**

We used a similar data analytic strategy to that from Study 2. We nested not only attractor distance (*distal*: +1, *proximal*: -1), but also our pre-commitment manipulation (*pre-committed*: +1, *control*: -1), within gas-price trajectory in a random-slope, random-intercept model. This permitted the effects of attractor distance and the pre-commitment manipulation to vary for the different gas-price trajectories (random-slope), while also adjusting for the tendencies of some trajectories to invite more adjustment than did others (random-intercept). The crucial interaction term (Attractor Distance X Pre-Commitment Manipulation) was entered as well. We also included a random effect of participant, which accounted not only for the non-independence of observations from the same participant.
Consistent with our main hypothesis, the effect of attractor type depended on—i.e., interacted with—participants’ pre-commitment condition, $B = -0.12, SE = 0.05, t(2,839.35) = 2.27, p = .02$. To interpret this interaction, we examined the effect of attractor distance separately for the pre-commitment and control condition. In the control condition—when attractors had full ability to influence subjective interpretations of change magnitude—participants adjusted 0.87 units more toward a distal ($M = 6.44$ units) compared to a proximal ($M = 5.57$ units) attractor, $t(1,236.38) = 5.64, p < .001$. But when participants had pre-committed to a subjective interpretation of a given amount of change prior to encountering the attractor, the effect of attractor was reduced: Participants adjusted only 0.40 units more toward a distal attractor ($M = 5.39$ units) than a proximal attractor ($M = 4.99$ units), $t(1,097.19) = 3.08, p = .002$. Stated differently, whereas a distal attractor (compared to a proximal attractor) prolonged control participants’ adjustment by 15.6%, it only prolonged pre-committed participants’ adjustment by 8.0%. In short, the pre-commitment manipulation cut the influence of attractors about in half.

These results directly connect the findings from the previous studies—that attractors influence both the amount and interpretation of adjustment. When participants had already mapped an objective amount of adjustment onto a subjective interpretation, the attractor exerted a diminished effect on adjustment. This supports our account that attractors influence adjustment at least in part because they change one’s sense of how far one has adjusted. By interfering with the attractor’s ability to influence this mapping, the attractor’s influence was reduced.

One strength of these results is they more conclusively put to rest concerns that attractors influenced adjustment because they were mistakenly identified as providing meaningful information. In earlier studies, we described steps we took to demonstrate that attractors were not meaningful—both by explicitly stating this and by including filler trials that showed that
attractors did not even meaningfully predict the direction of change. But still, readers may worry that participants had lay theories that the round-number values associated with the attractors served as actual restraints, reference points that stock prices or airfare naturally converge toward. However such alternative interpretations cannot account for the influence of the pre-commitment manipulation.

Three aspects of the data warrant further comment. First, it is notable that the results from the control condition are almost identical to those from Study 2. In Study 2, the graphs included minor tickmarks (which defined for participants in monetary terms the value of each unit of adjustment), whereas in Study 5, the graphs did not. The near equivalence of the results supports our assumption that this methodological difference has little bearing on the psychology underlying our effect. Second, the pre-commitment manipulation significantly reduced, but did not eliminate, the attractor’s influence. This too is hardly surprising. Having indicated that the price change from Day 4 to Day 5 was, say, a 6 on a 9-point scale of subjective magnitude serves to fix somewhat a participant’s understanding of what constitutes a small, moderate, or large price change. But it need not fix it entirely, which would give the attractor some latitude in defining what would constitute small, medium, or large change. Alternatively, it is also possible that the attractor’s effect is multiply determined, and our manipulation only targeted one of the ways that attractors influence adjustment. Future research may find additional psychological mechanisms that explain attractors’ influence on forecasts of change.

Third, the pre-commitment manipulation not only diminished the effect of the attractor on adjustment, it also diminished the amount of adjustment overall. That is, there was a main effect of pre-commitment, $B = -.41$, $SE = .13$, $t(210.28) = 3.11$, $p = .002$. Although a priori our hypotheses focused on the interaction, not this main effect, the main effect may (admittedly post
h) be incorporated into our account. Relatively few participants adjusted beyond the attractors, whether distal or proximal. As a result, both attractors may have been serving to reduce participants’ subjective sense of the magnitude of any amount of adjustment unless the pre-commitment manipulation had already “fixed” the meaning of a particular amount of change. Distal attractors could simply diminish the subjective perception of change more strongly than do proximal attractors. If this characterization is accurate, this would explain why attractors—both distal and proximal—ordinarily elongate adjustment, but to different degrees. Of course, this is merely speculative. Crucially, the validity of our theoretical account does not hinge on whether this main effect is or is not replicable.

**General Discussion**

We examined how attractors—salient values in the direction of change—influence evaluations and forecasts of change. In so doing, we complement previous literatures in two ways. First, we examined how an incidental feature merely present in the context of change—instead of a feature inherent to the change itself (e.g., the percentage shift)—influences forecasts of change. Second, whereas the anchoring literature has demonstrated how (often arbitrary) values restrain people as they consider adjusting away from or escaping the anchor’s influence, we instead tested whether an arbitrary value in the direction of a change or adjustment would influence just how much adjustment from an anchor would seem warranted.

Our first two studies showed that attractors influence forecasts of change in predictable ways. We tested our hypotheses using complementary paradigms in two contexts: forecasting which of two price changes would be implemented on airline routes (Study 1) and forecasting by how much the average price of gas would change on a given day (Study 2). Although variations between the specific paradigms called for slightly different statistical tests, both supported the
hypothesis that the introduction of a distal (vs. proximal) attractor makes more (vs. less) change seem likely.

Our final three studies supported our account of why attractors influence forecasts of change. In particular, when people forecast change in the presence of a distal (vs. proximal) attractor, they translate the same subjective sense of how much change seems warranted (e.g., “The stock experienced a small loss”) into a larger objective amount of forecasted adjustment (Study 3). Complementing this finding, the same objective amount of change (i.e., a weight loss of 3 pounds) seemed subjectively less substantial (and actually seemed to require less work to achieve) in the context of a distal (vs. proximal) attractor (Study 4). Of course, these findings could have merely reflected two new effects, not the mechanism underlying the basic attractor effect. Crucially, Study 5 most strongly linked the two parts of our paper by showing that when participants pre-committed to a certain mapping between a given objective amount of change and a subjective interpretation of that change, the influence of attractors on forecasts was significantly reduced. Notably, this manipulation eliminated about half of the attractor effect, suggesting that future research may uncover additional mechanisms underlying the effect of attractors on forecasts of change.

Although we have described attractors as arbitrary values, one worry is participants may have interpreted them to be meaningful—communicating, for example, a long-term average. There are two reasons why we believe this alternative is not viable. First, in several studies we provided explanations as to why certain values were (and by implication, why others were not) made prominent. For example, in Study 1, we explained that only multiples of $100 and integer dollar amounts would be labeled on the y-axis. Second, for most of our studies (Studies 1-3 and 5), change was—across the trials—just as likely to occur toward as away from the potential
attractor. This reinforces that the attractor is not a long-term average toward which prices were converging.

Despite this, perhaps participants still believed that the attractor communicated information about where the value was ultimately heading. For example, maybe people have a lay theory that values tend to converge toward round numbers. To address this worry, we conducted a follow-up study to further explore this alternative explanation. Participants made forecasts on the same 32 graphs used in Study 5, but this time we also recorded how much participants adjusted away from the attractor (on filler trials). If the attractor was naturally interpreted as a long-term average, participants should adjust less when moving away from a distal (wrong-direction) attractor than a proximal one. This is because when the (wrong-direction) attractor is distal, the price has strayed especially far from what the alternative account identifies as the long-term average, meaning further deviations are especially unlikely. Although we replicated our finding of more adjustment toward distal than proximal attractors, \( t(1,743.31) = 3.56, p < .001 \), we found no evidence that wrong-direction attractors influenced adjustment, \( t(1,759.02) = -0.65, p = .51 \).

Another worry is that even if people do not have a belief that values ultimately converge toward round numbers, they may believe that round numbers serve as “resistance levels” past which change is unlikely to go. Our follow-up study might not speak to this more subtle critique given attractors only failed to exert an influence when adjustment was occurring in the opposite direction of the attractors. Fortunately, two other details—one methodological, one empirical—speak against this possibility. Because trajectories paired with proximal attractors were, by definition, closer to those attractors, the history of the price was more likely to have crossed the attractor, thereby demonstrating that the value can move on both sides of the attractor. If
participants thought attractors reflected rigid resistance levels, they would have been more likely to have been disabused of this notion in the proximal than the distal attractor trials. This would have worked against the hypotheses. Second, the resistance level alternative cannot explain why the pre-commitment manipulation in Study 5 significantly reduced the attractor effect. Of course, it is also possible that people do have lay theories about how round numbers can serve as resistance levels, but attractors seem to influence forecasts of change independently of such beliefs.

Finally, readers would also be right to question whether the impacts of the attractors demonstrated here are implausibly large. Given identical information about a value’s past trajectory, we find that distal attractors—in the absence of manipulations meant to constrain or describe subjectively how much adjustment there was—increase change estimates by an average of 14%. Given that stock market fluctuations depend on where investors think the market is going, are we proposing that the United States’ 7.2% average stock market return could have been boosted to 8.2% through some strategically placed y-axis labels, leading 40-year market returns to increase 23 fold instead of 16 fold? Although such speculation is tempting, we would caution against it. Like many laboratory effects, these findings should perhaps best be thought of as a theoretical upper limit on what attractors can do. In a more informationally rich world, attractors are likely to have a diminished effect.

**Comparisons with Other Literatures**

**Stimulus evaluation.** The present work is both consistent with and distinct from research and theory in cognitive psychology that has emphasized that there is not a one-to-one correspondence between objective values (e.g., inches, years, dollars) and how they are subjectively interpreted (e.g., narrow, soon, pricey). Parducci’s (1965) frequency-range theory
posits that people ascribe different subjective labels (e.g., Likert scale values from 1[short] to 9[tall]) to describe a stimulus’s property (e.g., height) depending on the range of stimuli to which they have been exposed (see also Ostrom and Upshaw, 1968). A 5’5” male may be labeled as a 9 in a room of eleven-year-old boys, but a 1 in a room of forty-year-old men. Similarly, subjective ratings are sensitive to the range of permissible objective responses. For example, after participants committed to giving a harsh or a lenient punishment, they gave objectively longer sentences when they learned the maximum permissible sentence was 30 years, as opposed to 5 years (Ostrom, 1970).

Our research departs from these existing findings and frameworks in three ways. First, whereas previous research examined how people evaluate stimuli in the context of different ranges of possible responses, we instead examine how people evaluate stimuli in the context of the same range of possible responses. That is, the attractor values in our studies did not change the possible range into which participants could adjust, or the set of comparison stimuli to which they were exposed. For example, we were careful in Studies 1-3 and 5 to always center the base value on the y-axis, so that the number of units of potential change in each direction was held constant. In this way, we did not simply demonstrate a visual trick well-honed by those who trade in misleading bargraphs: making differences seem larger by expanding or contracting the plotted range. Instead, even as the meaning of each unit of adjustment remained objectively constant, attractors altered the subjective construal of such changes. Furthermore, regardless of whether participants made estimates in the context of a proximal or distal attractor, they were exposed to the same range of previous values (i.e., comparing across conditions, each previous price was the same number of units from the base price from which adjustment proceeded), meaning that the range of observed stimuli was also equivalent.
Second, whereas previous research has examined how people view an individual stimulus (e.g., a square, a prison sentence) in the context of a range of other individual stimuli (e.g., a set of squares, a set of possible prison sentences), the present studies examined how a comparison between stimuli (i.e., an amount of adjustment) was seen differently in the context of different individual stimuli (i.e., different attractors) unrelated to the range of possible responses. Third, the results of Study 5 indicate that the same objective change (3 pounds) not only prompted participants to use a different subjective label (more or less difficult), it also shifted their underlying representations of the change (and therefore, for example, how many hours of jogging it would take to achieve it). This result goes beyond previous demonstrations of how context can change the subjective descriptors people use to characterize objective values (cf. Frederick & Mochon, 2012).

One question is whether the present findings could be seen as an extension of this past work if one merely identified attractors as another observed value—one that was salient in the judgment context, even if it was not one of the points observed in the time-series graph. But even this would not seem to capture the novel attractor effect documented herein. Consider again our follow-up study in which we showed that attractors in the opposite direction of adjustment failed to influence how much change was expected. In other words, even by leaning on more inclusive criteria for what set of values define the frequency or range of observed values, it seems that previous accounts do not easily account for the present effects. Instead, attractors seem to operate by the distinct psychological mechanism illustrated above.

**Anchoring.** When anchoring was first introduced, it was assumed that anchoring phenomena were the result of the psychological process of anchoring and (insufficient) adjustment. By this account, anchors serve as a starting point for judgment, but because attempts
to adjust away from the anchor are insufficient, anchors exert an assimilative pull on responding. Such examples of anchoring and (insufficient) adjustment can influence numeric judgments (e.g., Epley & Gilovich, 2001), trend estimation (e.g., Eggleton 1982), or attempts to adopt another person’s perspective (e.g., Epley, Keysar, Van Boven, & Gilovich 2004). And although there have been numerous paradigms to test, and proposed mechanisms to explain, why arbitrary numbers anchor judgments, the present paper offers the first paradigm (of what may be many more) and accompanying mechanistic account that demonstrates and explains why arbitrary values influence how much adjustment is seen to be warranted.

That said, it is natural to ask whether attractors apply only to the task of forecasting a change, or whether they would apply to other anchoring-and-adjustment problems as well. Arguments could be made either way. Consider what differentiates forecasts of change from other anchoring-and-adjustment phenomena. When one is anchored on Earth’s orbit (365 days) and engages in downward adjustment to reach Venus’s orbit, the end goal is merely to estimate Venus’s orbit. The amount one has adjusted does not itself have significance (i.e., we have no term for Earth minus Venus’s orbit). In contrast, when forecasting change, the amount of adjustment is itself meaningful; it constitutes the forecasted change. In fact, the change may be more important than the end value: A stock investor may care more about the change in a share’s value (her return), not its end valuation (the final share price). Because we showed that attractors change whether a certain amount of adjustment seems subjectively substantial, and thus sufficient, it may be that attractors exert a bigger effect on forecasts of change (for which one is very focused on the amount of adjustment) as opposed to other anchoring-and-adjustment problems (for which adjustment is simply a means to an end value). On the other hand, the
question of “Does it feel like I have adjusted far enough?” may be common to anchoring-andadjustment problems. If so, attractors’ influence should generalize.

We conducted a study to begin to explore this question. The study was similar to Study 2, which examined how attractors influence forecasts of gas prices. We made three modifications. First, we did not show a time-course of 9 periods of pricing, but only one (serving as the anchor). Second, whereas in Study 2 we merely said that the gas prices came from a randomly selected U.S. state, in this study we identified the state. It was randomly chosen, without replacement. Third, and most crucially, we manipulated whether participants were forecasting change from the anchor or forecasting a different numeric value. We told half of the 155 participants that the base value was the average gas price in that state on a randomly selected month, and their task was to forecast the average price the next month. In this way, their task was to forecast a specific change, as in our earlier studies. For the other half of participants, we told them that the base value was the price of a gallon of gas from a randomly selected gas station from that state on a randomly selected day. Their task was to estimate what the price of gas was at the gas station in the same state that was closest to exactly 200 miles away. In this way, participants were still anchored on one value, but adjustment was merely a means to an end of making a judgment about a different, but related target. In other words, the amount of adjustment did not itself have an inherent meaning (like “change in price”).

We found that attractors influenced not only forecasts of change, but also the new anchoring-and-adjustment problem in which the amount of adjustment was not inherently meaningful. That is, there was a main effect of attractor, $t(1,252.30) = 5.52, p < .001$, which was not qualified by our experimental manipulation, $t < 1$. Participants adjusted more toward a distal (vs. proximal) attractor regardless of whether that adjustment represented change ($M_{distal} = 9.23$
cents vs. $M_{\text{proximal}} = 7.63$ cents) or simply the distance between two distinct but related judgments ($M_{\text{distal}} = 9.99$ cents vs. $M_{\text{proximal}} = 8.45$ cents). Although this provides initial evidence that attractors can influence judgments more generally, note that we would not expect attractors to influence responses in anchoring paradigms that do not actually involve adjustment. For example, Tversky and Kahneman’s (1974) classic anchoring paradigm—at least by one prominent account (Mussweiler 2003; Strack and Mussweiler 1997)—involves no adjustment (cf. Simmons, Lebouef, and Nelson 2010).

It is also worth considering how the mechanism we highlighted is compatible with and divergent from mechanisms accounting for why anchors restrain judgments. Frederick and Mochon (2012) presented a scale-distortion theory of anchoring that predicts, for example, that people will give a lower estimate of a giraffe’s weight if they first estimate the weight of a raccoon. Committing to a low weight for a “small animal” appears to distort the meaning of the numeric weight scale in the direction of the anchor. As a result, one then uses a relatively small number to describe the weight of a “big animal.” Despite our shared emphasis on the latitude inherent in mapping subjective representation onto an objective scale, the effects themselves as well as the basic mechanisms differ. Frederick and Mochon might predict that participants in our Study 3 would interpret a “medium gain” as less substantial (i.e., requiring less adjustment) after having considered a “small gain,” but their account does not entail that the subjective interpretation of a medium or small gain would shift in response to an attractor’s location. Also, Frederick and Mochon (2012) found that although their anchors altered participants’ sense of the response scale, the underlying representation of the target object was unchanged. That is, logically related judgments (e.g., the height of a giraffe) were unaffected. In contrast, we found in Study 4 that such representations were affected. For example, in the context of a distal
attractor, it was assumed that less effort would be required (e.g., fewer hours of exercise) to achieve the same weight loss.

In other research, Janiszewski and Uy (2008) found that the precision with which an anchor is stated can influence adjustment. People tend to adjust further from a round anchor value (“10”) than from a more precise anchor (“9.8” or “10.2”). Janiszewski and Uy speculated that more precise anchors encourage adjustment in smaller units, which results in less distance covered after the same number of iterative adjustments. Our account likewise emphasizes how features of the judgment context can influence how numerical space is psychologically partitioned, but our research differs in terms of what features influence that partitioning (the anchor’s precision vs. the attractor’s location) and how this translates into different amounts of adjustment. Furthermore, whereas Janiszewski and Uy emphasized that adjustment may occur in shorter versus longer iterative leaps, we emphasize how attractors influence people’s holistic assessments of a given amount of adjustment—i.e., even when participants are not doing the adjusting themselves (Studies 1 and 4).

**Final Thoughts**

Although our focus has been on how and why attractors influence forecasts of change, we hope future research will explore the behavioral consequences of attractors’ influence. For example, might a retirement advisor create a greater sense of urgency to save more money by depicting a potential fund as trending upward toward a distal (instead of a proximal) attractor? Might health practitioners encourage smoking cessation if they depict one’s drop in cancer risk as moving toward a distal instead of a proximal attractor? If additional mechanisms by which attractors operate are determined, even more such downstream consequences should become apparent.
References


Table 1

*Average Estimates (Standard Deviation) of Effort Needed to Achieve a 3-Pound Weight Loss (Study 4)*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Contrast, t(61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>199lbs (Distal)</td>
<td>(-1, +2, -1)</td>
</tr>
<tr>
<td>204lbs (Proximal)</td>
<td>(-1, 0, +1)</td>
</tr>
<tr>
<td>209lbs (Distal)</td>
<td></td>
</tr>
<tr>
<td>How many hours did she spend on a stairclimber?</td>
<td>4.05 (3.08)</td>
</tr>
<tr>
<td>How many hours did she run?</td>
<td>4.37 (1.86)</td>
</tr>
<tr>
<td>How many meals did she skip?</td>
<td>4.05 (2.59)</td>
</tr>
<tr>
<td><strong>Objective effort composite (Z-score sum)</strong></td>
<td>-0.07 (0.54)</td>
</tr>
</tbody>
</table>

*Note. Asterisked t statistics are significant at the p < .05 level*
Figure 1. By our account, the same price adjustment (5 cents) will be made to feel subjectively smaller when a distal attractor is salient (A) instead of when a proximal attractor is salient (B). Note how in panel A, the same subjective labels are mapped to larger objective changes. As a result, and all else equal, people will tend to forecast more change when adjusting toward a distal attractor compared to a proximal attractor.
Figure 2. Each participant in Study 1 saw one of these two panels. The hypothesis-matching half—pairing a distal [proximal] attractor with larger [smaller] objective change—is on the left half of Panel (A) and the right half of Panel (B).
Figure 3. One of the eight stock price trajectories seen by Study 2 participants. Participants saw both attractor versions—distal (A) and proximal (B)—though always in separate halves of the 32 trials.
Figure 4. Three screenshots from Study 4’s presentation of information. (A) would appear before (B). Note that even though (B) shows a proximal and (C) shows a distal attractor, the physical gap between the anchor and attractor in each panel is equivalent. In this way, we used tick marks that made the round numbers salient as attractors without emphasizing the distal or proximal nature of the attractor perceptually.
Figure 5. Participants in Study 5 were asked to characterize the Day 4 to 5 price change (A) in a way that asked them to pre-commit to a subjective interpretation of an objective amount of change or to judge the distance between the two points. Only following such a judgment did the attractor and announced direction of adjustment appear, at which point participants were to estimate the price changed from Day 9 to Day 10 (B):