

# Qualitative and Quantitative Effects of Surprise: (Mis)estimates, Rationales, and Feedback-Induced Preference Changes While Considering Abortion

Jennifer Garcia de Osuna (jmgdo@berkeley.edu)<sup>1</sup>

Michael Ranney (ranney@cogsci.berkeley.edu)

Janek Nelson (jamin@socrates.berkeley.edu)

University of California, \*Graduate School of Education, 4533 Tolman Hall, Berkeley, CA 94720

## Abstract

The Numerically Driven Inferencing (NDI) paradigm, and one of its methods, EPIC (Estimate, Prefer, Incorporate, and Change), are used to study both one's estimates and the effects of numeric feedback on one's personal policies (herein, about abortion). Both quantitatively and qualitatively, 92 undergraduates offered estimates and preferences for the legal U.S. abortion rate, explaining and justifying them. After receiving the (usually, quite surprising) true rate as feedback, they provided another (typically changed) preference-and-rationale. Results show that people vastly underestimated the abortion rate, and largely advocated decreases in it—both pre- and post-feedback. Feedback caused most of those who initially wanted no change in the abortion rate both to abandon the status quo and change preference-justifications; after feedback, two thirds of these students preferred a rate decrease, while the rest preferred an *increase*. Although many researchers hold that belief revision and conceptual change are quite difficult to elicit, these and other results show dramatic effects of simple base rate feedback on policy evaluation. Our findings highlight the importance of having and using data when reasoning about society-engaging topics such as abortion rates. This experiment represents a new way to study numerically-based reasoning that includes the subjective natures of our personal beliefs and social lives.

Please answer this question: “As a percentage of the current U.S. population, what is its *legal* immigration rate?” Does a typical response of 10% (Ranney, Cheng, Garcia de Osuna & Nelson, 2001) sound right? The true value is about *thirty-fold* less—only 0.3%. Does (or ought) this datum alter your immigration preference—your personal policy—some? Common sense may suggest that beliefs, decisions, and rationales will (or should) change with new information, but literatures from science learning to attitude change (e.g., from evolution or inertia to executions or diversity; Ranney et al., 2001), suggest that people are often unmoved by new data. Classical economics even suggests that preferences are exogenous (e.g., from estimates; Lurie & Ranney, 2003).

The Theory of Explanatory Coherence and its models (e.g., ECHO) describe a set of principles that guide belief evaluation and revision. Two such principles are that we (a) weigh evidence more strongly than conjecture, and (b) accept propositions explained more parsimoniously (Ranney & Thagard, 1988; Read & Marcus-Newhall, 1993; Schank & Ranney, 1991; Thagard, 1989). True base rates, then, would seem to represent parsimonious evidence (relative to a host of instances or anecdotes) and thus be (1) weighted heavily in one's reasoning about an issue and (2) evaluated as quite acceptable. The present paper explores aspects of

this general hypothesis about (especially surprising) minimalist interventions—for instance, that a single, germane, critical number may foster conceptual change.

Some studies have noted that learning related base rate values (seeds) affects one's estimates (e.g., about spatial judgments or populations; Brown & Siegler, 1996; Brown, 2002, etc.). While intuitions about real world quantities are often incorrect (Brown, 2002), exposure to base rates increases the accuracy of one's estimates on closely related topics, and the benefits of such exposure can have lasting effects even months later (Brown & Siegler, 1996). Little is known, though, about the effects of base rate queries and feedback on preference/policy formation and change, so we suggest three “ifs.” 1) If intuitions about real world numbers are often flawed, then they are likely being used to create anomalous or skewed personal policies among people. 2) If feedback can correct these intuitions, such feedback might affect individuals' policies. 3) If people are generally biased toward evidence (and they are; e.g., Schank & Ranney, 1991), then giving them factual, numeric feedback—say, the U.S. abortion rate, our main example—should affect conceptions and interpretations about the abortion rate, and thus affect both personal policies on abortion and the explanations supplied when justifying their policies. Among other questions, we seek to answer the following: Can supplying factual, numeric information about abortion markedly change one's abortion policy? Does receiving the actual rate as feedback affect the *Points of View* (POVs) by which people reason about abortion? Most such POVs (see below), involve moral or ideological reasoning aspects; religion plays a role, as well. (Space constraints prohibit reviewing the vast abortion literature here, e.g., Bernas & Stein, 2001, and we seek to focus on more paradigm-relevant aspects, in any case.)

We explore and measure phenomena of these sorts using a novel paradigm, Numerically Driven Inferencing (NDI; Ranney et al, 2001), and one of NDI's central empirical methods: EPIC (Estimate, Preference, Incorporate, and Change; cf. Lurie & Ranney, 2003, who introduced PEIC and IC as complementary methods). Such analytic frames allow us to study both estimates of, and dynamically changing preferences about, base rates (e.g., Munnich, Ranney, Nelson, Garcia de Osuna & Brazil, 2003). NDI also represents an emerging coherentist framework in which numbers are the “tips of the iceberg” of a person's thinking about a network of (magnitude-relevant) evidential and hypothetical propositions. A prime aspect of NDI's paradigmatic novelty is in its elicitation of what people *prefer* a quantity to be; it is further unique in its analysis of

<sup>1</sup> The order of the first two authors is alphabetical. \*For J. Nelson's address, substitute in “Department of Psychology, 3510 Tolman Hall.”

how such individuals' *policies* (as base-rate relative preferences) evolve in the face of numeric information. Using EPIC to study abortion numeracy, we asked each individual to *Estimate* the current legal abortion rate—per one million live births—and then offer a *Preference* (and thus a *policy*, relative to one's estimate) for what each would want the current rate to be (had one the power to change the rate), and give reasons for both numbers. They then received feedback (the actual abortion rate), which they *Incorporated* into their knowledge of the abortion issue. Students then provided a second preference and explanation; by contrasting their former and new preferences, estimates, and reasons, we can note *Changes* in preferences and policies that resulted from the feedback. Essentially, then, EPIC has four queries, about a rate X that has a value Y: (1) What is X's value? (2) What *should* X's value be? (3) X's value is actually Y, so (4) *Now*, what should X's value be?

## Method

### Participants, Design, Materials, and Procedure

Psychology pool undergraduates (N = 92) participated, as part of their course requirement. (The "N" will often be somewhat fewer in our Results, due to occasional missing data points.) The experiment used a pre- and post-feedback repeated measure, within a 2X2 factorial between-group design, although the two independent variables (Ranney et al., 2001) are tangential to the present issues and so omitted here, due to space constraints. Responses included numeric (continuous) estimates and preferences, written explanations of the estimates and preferences, and Likert ratings about: (a) general preference about a rate change, (b) familiarity with the topic, and (c) how much one cared about the topic.

This paper examines only one topic from a set of 16 (usually less emotion-laden) randomized topics: the U.S. legal abortion rate (which we defined for students—and represents the vast majority of abortions). Each person was first asked to estimate the current rate—per one million live births—and to explain the bases of that estimate. Next, each was asked how low and high the true abortion rate would have to be to be surprising, and to rate the confidence that the rate would fall in one's "non-surprise interval." Students were then each asked to give a numeric preference for the abortion rate, had one the power to change it, and to explain the preference. Then, they rated, on a 5-point Likert scale, how familiar they were with the topic of abortion rates, and how much they cared about the topic (with both ratings in contrast to the average American). As another measure of rate preference, on a 1-5 scale, students were also asked whether they generally preferred (1) a big decrease, (2) a decrease, (3) neither an increase nor a decrease, (4) an increase, or (5) a big increase. After this, feedback was provided—the then-current abortion rate—an often-shocking 335,000 per million live births (gleaned from independent federal agencies, e.g., the CDC & NIH; nb. the rate has since dropped some). Each was then asked to consider the feedback and again give a numeric preference, and to explain that final preference. Finally, the students were again asked both to rate how much they cared about the topic and to offer a 5-point general preference rating.

(Our lab has since replicated this abortion item's results, and has noted the effects both of varying how the rate is framed—e.g., with respect to a million *fertile women*, Munnich et al., 2003—and of omitting a numeric referent.)

### Coding Scheme for Written Justifications

As part of NDI's methodology, the written justifications for abortion preferences (before and after feedback) were coded qualitatively using verbal analysis methods. We developed a 14-category coding scheme by extracting major patterns from elicited explanations, and then coded *all* justifications with the scheme. A student's explanation could fit up to three of the 14 coding categories, with many requiring more than one code. Inter-rater reliability for coding the reasons was 90% among three coders. For ease of discussion, the 14 categories were grouped into six broader categories called *Points of View* (POVs) by which people justified their personal abortion rate preferences. These POVs are: (1) preferring a utopian world in which abortions are essentially unnecessary or moot; (2) that the abortion rate should reflect the greater good for society; (3) that abortions should always be allowed/legal, regardless of circumstance; (4) that abortions should only be allowed in some circumstances; (5) that abortions should never be allowed (e.g., illegal) under any circumstances; and (6) other/no explanation.<sup>2</sup>

## Results

Findings are reported following the EPIC procedure: Estimates and Preference (EP), then Incorporation (feedback) and Change (IC). We also focus analysis on (a) written, post-preference, justifications, (b) correlations between preferences and some Likert ratings, and (c), two especially interesting subsets of participants: those who wanted a rate of zero abortions, and those who notably changed the direction of their preferences after feedback. (Space limits do not permit us to report all, or even all statistically significant, findings; cf. Ranney et al., 2001.)

<sup>2</sup> POVs (1-6) map onto the *original* 14 (a-n) code categories as follows. POV-1: (a) "perfect world" in which *all* pregnancies are desired or yield loving adoptions, (b) "birth control," with perfect contraception preventing *all* unwanted pregnancies, and (c) "responsibility" by *full* abstinence or pregnancy-completion. (I.e., a-c respondents wish abortions need never be considered.) POV-2: (d) abortions needed to optimize social benefit (e.g., economics, improved life-quality for all, and crime reduction). (POVs 3-5 concern availability or legality.) POV-3: (e) "better for mother or unborn child," as some wish to reserve abortion as perhaps better for the mother (e.g., her health) and/or fetus's predicted life, (f) "basic 'pro-choice' position," as some didn't expand on being pro-choice, (g) "women's right," with which they may choose abortion, and (h) "status quo," such that the abortion rate ought not change. (In categories e-h above, rationales include notions that abortions ought *always* be available.) POV-4: (i) "not for contraception," by which some decried abortions-as-birth-control, and (j) "emergency only," with abortions only allowed in extreme cases (e.g., after rape or to save a mother's life). POV-5: (k) "murder/loss of life," in which the fetus's loss of life is deplored, and/or abortion is seen as murder, and (l) the "basic con position," as some didn't expand on being anti-abortion. (Codes k-l reflect being *fully* anti-abortion.) POV-6: (m) a comment/rationale that was not captured by prior codes (e.g., "Why are you asking me this?") or (n) no explanation.

## Estimates and Initial Preference/Policy

Participants greatly underestimated the abortion rate. The median *estimate* was 5,000 abortions per million live births ( $M=50,479$ ;  $S.D. = 148,469$ ), much less than the true—and often evocative—rate of 335,000. (Due to high variance, we focus more on median estimates, as they usually inform more than do means.) In general, students' initial numeric preferences differed from what they thought the true rate to be (i.e., there was, overall, a significant difference between one's estimate and initial preference;  $t(88)=-2.62$ ,  $p=.01$ ). The median initial preference was only 100 abortions per million live births ( $M = 19,381$ ;  $S.D. = 110,372$ ), or 4,900 less than the median *estimate*—that is, a policy advocating a 98% (or fifty-fold) decrease. Thus, most people (62.2%) preferred rate decreases, relative to their estimates. Counter-intuitively, ratings of familiarity and caring about the topic did *not* significantly correlate with estimate accuracies, indicative of rather modest metacognition.

Recall that we also elicited initial *general* preference ratings (from 1-5) for the abortion rate. These ratings tended to favor decreasing the abortion rate ( $M= 2.07$ ), and were negatively correlated with initial caring ratings ( $r(90)=-.32$ ,  $p=.002$ ). The initial numeric preferences of those who wanted a *general* decrease (a “1” or a “2” rating) differed significantly ( $F(1,86) = 4.33$ ;  $p = .04$ ) from preferences of those who did not. The median initial preference was zero for those initially wanting a (Likert scale) decrease in abortions ( $n=56$ ,  $M= 1,337.32$ ;  $S.D.= 3,577$ ). The median initial preference was 2,000 abortions per million live births for those who initially preferred either (a) an increase, or (b) neither an increase or a decrease on the Likert scale ( $n=34$ ,  $M= 50,001$ ;  $S.D.=178,723$ ). Before feedback, the majority (62%) chose either “prefer big decrease” or “prefer decrease” for the abortion rate, prior to feedback, mirroring the numeric preferences. Only two participants wanted an “increase,” and none preferred a “big increase.” The rest (35.6%) preferred “neither an increase nor a decrease.” As expected, given the great tendency to underestimate, initial preferences were negatively correlated with later being surprised by the feedback ( $r(89)=-.25$ ,  $p=.02$ ).

Of the 67 explanations by those who initially preferred a decrease in abortion (relative to their estimate), the bulk of them fell into three POVs: 26 explanations held that abortions should never be allowed, 24 referred to a utopian world in which abortions are unnecessary or moot, and 10 asserted that abortions should only be allowed in some circumstances. For example, one decrease-preferring participant (with Estimate: 100,000; Initial Preference: 0) wrote, “It would be great if every baby was cherished enough to be allowed to live.” Another person preferring a decrease (Est: 1,000; Init. Pref: 10) stated, “Because I don't believe women should end a child's life unless it affected their own physical health.” People preferring a rate equal to their estimates most often indicated that abortions should always be allowed (17 of 29 explanations); the remaining justifications were from all other POVs except that for the “Other/no explanation” (see Table 1). For example, one of these status-quo students (Est: 800; Init. Pref: 800) stated, “[I prefer] as many as necessary to not have unwanted children. I believe people have the right to have an abortion

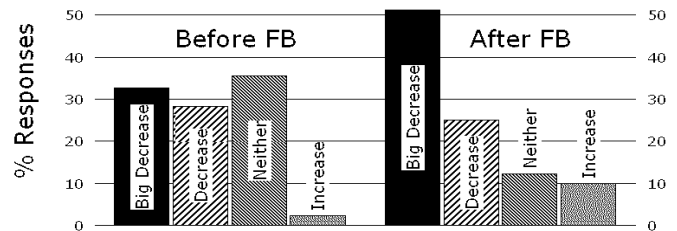


Figure 1: Distributions of general preference ratings (Likert; 1-4 out of 1-5), before and after feedback.

if they cannot have the child for personal reasons.” All three people whose preferences exceeded their estimates indicated that abortions ought always be allowed. For example, one (Est: 20,000; Init. Pref: 1,000,000) stated, “People should choose whether or not they can bring a kid to the world.”

## Incorporation (of Feedback) & Preference Change

After feedback, the median numeric preference *increased* to 1,000 abortions per one million live births ( $M = 108,178$ ;  $S.D.= 174,688$ ). However, that median is a larger 99.7% decrease-policy from the true abortion rate of 335,000. (Recall that the median initial preference called for a 98% decrease-policy in the rate, relative to their estimates.) Final numeric preferences still significantly differed from the feedback value ( $t(88)=-12.25$ ,  $p<.001$ ), and represented a non-proportionate shift in policy ( $p < .001$  via a Wilcoxon Signed Rank test). Mirroring this policy shift toward a greater decrease (percentage-wise) in abortions, the mean Likert rating for general preference dropped from 2.1 (out of 5) to 1.8 after feedback ( $t(89)=3.39$ ,  $p=.001$ ). After feedback, 51.1% preferred a “big decrease,” dramatically up from 32.6% (and 25.0% preferred a “decrease,” down slightly from 28.3%). This movement is evident in Figure 1, which contrasts the distribution of initial Likert ratings for general preferences before and after feedback. Those who initially chose “neither an increase nor a decrease” most notably changed Likert ratings for general preferences; after feedback, 66% of them (21 of 32) “moved off the status-quo fence,” with five coming to prefer a “big decrease,” nine a “decrease,” and the other seven dramatically diverging to prefer an “increase.” In Figure 1, this scattering is seen in the shrinking of the “Neither” bar and the growth of both the “Big Decrease” bar and—more surprisingly—the “Increase” bar. (Note that no one in this study ever preferred a “Big Increase.”) This striking bifurcation of most of the (initially) status-quo group is qualitatively analyzed below.

Mean care ratings (from 1 to 5: “not at all” to “much more than average”), increased significantly after feedback, from 3.29 to 3.51 ( $t(90)=-2.89$ ,  $p=.005$ ). Numeric and (Likert) general preference measures concurred, because after feedback, numeric preferences continued to differ between those wanting either a “decrease” or “big decrease” and those who did not ( $M= 1,337$  and 50,001, respectively  $F(1,87) = 445.8$ ;  $p<.001$ ). Interestingly, both before and after feedback, “care” ratings were negatively correlated with general-preference Likert ratings (respectively,  $r(90)= -.32$ ,  $p=.002$ ;  $r(90)= -.21$ ,  $p=.047$ ). That is, those “caring” more about abortion preferred more of a decrease in its rate.

Table 1 shows the effect of feedback (i.e., pre- vs. post-) on the percentage of each POV mentioned, within the four

Table 1: Percent usage of POVs, from pre-feedback to post-feedback, by general/Likert preference rating.

<b>Point of View (POV) Justification</b>	<i>Big Decrease (1)</i>		<i>Decrease (2)</i>		<i>Neither (3)</i>		<i>Increase (4)</i>	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Abortions should never be allowed	48.6	40.4	28.1	21.4	3.5	0	0	0
Utopian world: abortion as non- issue	40	31.6	31.3	50*	6.9	0	0	0
Allow abortions only in some circumstances	2.9	24.6*	28.1	25	3.5	0	0	0
(Other / No Explanation)	0	1.8	0	3.6	17.2	18.2	0	12.5
Abortion rate ought depend on the greater good	2.9	0	3.1	0	10.3	0	0	37.5*
Abortions should always be allowed	5.7	1.8	9.4	0	58.6	81.8*	100	50*
Totals (i.e., each column sums to 100%)	100	100	100	100	100	100	100	100

levels of general preference Likert ratings that people used. Five notable distributional changes are marked by asterisks (\*s). One such change (from 2.9% to 24.6\*%) represents the finding that, before feedback, only *one* of 35 “big decrease” justifications was coded as “Abortions should be allowed only in some circumstances,” but *14* of 57 “big decrease” justifications were so coded after feedback.

As a rather orthogonal analysis from those above, the following set of subsections examine three sets of participants and how they were differentially affected by feedback: those preferring zero abortions (both before and after feedback), those changing their basic position on the abortion rate, and the remaining participants.

**Zero Preference Participants** Of all students, 34.8% initially wanted zero abortions. After feedback, 84.2% of the 34.8% still preferred zero abortions. Initially, such people typically used a utopian world POV (50%), or a POV that abortions should never be allowed (41%). Feedback spurred only a non-significant drop in the use of a utopian world POV (42%), concomitant with a non-significant rise in the view that abortions should never be allowed (44%). Preferring zero abortions before feedback was correlated with initial caring ratings ( $r(88)=-.24, p=.025$ ); there was *no* correlation, though, between preferring zero abortions *after* feedback and *final* caring ratings ( $r(88)=.06, p=.60$ ).

**Participants Who Changed Away from "Status Quo"** Of 89 respondents, 24% changed their policy direction—and *all* of these 21 were those who initially preferred neither an increase nor a decrease in abortions on the Likert scale, yet preferred either an increase or a decrease after feedback. We refer to these as “semi-flips,” as no one *fully* flipped sides (e.g., from “increase” to “decrease” or vice versa). Of the

“semi-flippers,” 14 shifted to preferring a “decrease” (11 of whom were “technically surprised” by the feedback, in that 335,000 fell outside of their non-surprise intervals). Remarkably, given that almost everyone underestimated the rate (mostly by vast amounts), the other seven changed to wanting an *increase* in the abortion rate (e.g., by concluding that numerically unwarranted taboos due to media-skewed rate perceptions may be *inhibiting* abortions); indeed, six of the seven were technically surprised by the high feedback. For all semi-flippers, as per above, the initial (Likert) general preference was “3” (i.e., “neither an increase nor a decrease”). The post-feedback mean general preference for the semi-flippers dropped to 2.43, but this aggregates a drop to 1.64 for “decreasers-come-lately” (DCLs) and a rise to 4.00 for “increasers-come-lately” (ICLs).

Table 2 shows the POV distributions for the 21 semi-flippers, pre- and post-feedback, which significantly differed ( $\chi^2(5, N=105)=11.88, p=.036$ ). Pre-feedback, most of their rationales indicated that abortions should *always* be allowed (12 out of the 21 people, with the other nine being grounded in all other POVs). Post-feedback, the POVs these students used depended *entirely* on whether one had semi-flipped to prefer an abortion-rate increase or a decrease. (Note: there were 22 instances, post-feedback, as one person used two POVs.) This feedback-driven bifurcation was total, as shown in Table 2’s last two columns; note the complete lack of overlap, post-feedback, between the first two POVs (rows) and the next three (i.e., excluding “other/no explanation”). After feedback, four of the seven ICLs justified their preferences with “abortions should always be allowed,” while the other three justified with “abortions should reflect the greater societal good.” (One used both.) However, DCLs didn’t use either of these two POVs to justify preferences: Instead, the greatest number of

Table 2: POV changes for semi-flip participants/POV-instances (pre- vs. post-feedback; 21 people vs. 22 POV instances), by general preference/Likert ratings (ICL = “increaser-come-lately;” DCL = “decreaser-come-lately”).

<b>Point of View (POV) Justification</b> (Note: the order has changed from Table 1)	Pre-Feedback (out of 21 semi-flippers)	Post-Feedback (of 22 POVs)	
	<u>Neither an Increase nor Decrease</u>	<u>Increase</u>	<u>Decrease or Big Decrease</u>
Abortions should always be allowed	12 ( <i>8 became DCLs; 4 became ICLs</i> )	<b>5</b>	0
Abortion rate ought depend on the greater good	2 ( <i>both became ICLs</i> )	<b>3</b>	0
Utopian world where aborting a non-issue	2 ( <i>both became DCLs</i> )	0	<b>8</b>
Abortions should never be allowed	1 ( <i>who became a DCL</i> )	0	<b>3</b>
Allow abortions only in some circumstances	1 ( <i>who became a DCL</i> )	0	<b>3</b>
(Other / No Explanation)	3 ( <i>2 became DCLs; 1 became ICL</i> )	0	0

their post-feedback instances involved the utopian POV (eight of 14 instances); the remainder of these participants' explanations included the POVs that either abortions should never be allowed (three of 12 instances) or should be allowed only in some circumstances (three of 12 instances).

Thus, most semi-flippers initially wrote that abortions ought always be allowed, yet not one DCL wrote that belief after feedback. Further, semi-flippers were so polarized after feedback that there was no overlap at all between the POVs of the ICLS and the DCLs. For example, one initially-status-quo participant who first both estimated and preferred a rate of 20,000 (per million live births) wrote, "I think it is a good number." After feedback, the same person changed views, preferring an increase in the abortion rate to 500,000, stating: "I think there are too many kids being [born] into this country, especially since a lot...are being raised by teen/bad/druggie parents." In contrast, a semi-flipper who changed to prefer a *decrease* in the abortion rate post-feedback, at first both estimated and preferred a rate of 800, stating, "[I prefer] as many as necessary to not have unwanted children. I believe people have the right to have an abortion if they cannot have the child for personal reasons." Post-datum, this person wanted a rate of 200,000 (again, a decrease from the feedback's 335,000), stating, "A lot of these probably happen because women/men aren't taking the right precautions and with education or birth control. I think this number could start to decrease. But I do believe women have the right to abortions, but not the right to use abortions as a birth control method."

### Remaining ("Non-Zero, Non-Semi-Flip") Participants

The distributional shift in POVs was also significant for the rest of the people ( $\chi^2(5, N=80)=139.24, p<.001$ )—those who preferred abortion rates above zero, but did not change the direction of their general preference (Likert) rating after feedback. Such people were neither semi-flippers nor those wanting zero abortions, and so represent a less extreme subgroup than those discussed above. It is instructive to note how the relative POV use changed for these intermediate "non-semi-flip/non-zero-preference" participants: Before feedback, the top three abortion POVs for these non-zero, non-semi-flip students were equally split (with 23.5% of instances apiece) among "allowed in some circumstances," "never allowed," and "always allowed." After feedback, though, the POV that abortions should be allowed in some circumstances represented 33.9% and the two absolute POVs that abortions should either *always* or *never* be allowed—made up 16.9% and 18.6% of the responses, respectively. The other POVs' percentages changed rather less (utopian world: 13.8→18.6; other/no explanation: 9.8→10.3; should depend on greater good: 5.9→1.7).

## Discussion

Respondents largely estimated the legal U.S. abortion rate to be far lower than the true rate—seven times lower in mean, and 67 times lower in median. In fact, 79% of students were "technically surprised" by the feedback, such that the true abortion rate was not contained in their elicited non-surprise intervals. Thus, only 21% of our students captured the true value (335,000 legal abortions per million live births) in

their non-surprise intervals—even though their mean confidence of doing so, just after offering their intervals, was 74%. Thus, participants were roughly 3.5 times less likely to capture the true rate than they anticipated.

The effect of the feedback on one's preference was likely due, in part, to its shocking magnitude. Results show that learning the true abortion rate clearly changed reasoning about abortions—with regard both to peoples' preferences and the points of view (POVs) by which they justified their policies. While the median person went from preferring 100 abortions per million live births to preferring 1,000, since the median estimate was 5,000 and the feedback was 335,000, students' new preferences represented a much more stringent relative abortion policy (from -98% to -99.7%). Indeed, the failure to capture the feedback value in one's non-surprise interval was significantly correlated with exhibiting a dramatic (i.e., non-proportionate) change in abortion policy ( $r(54)=-.4; p<.01$ ).

Overall relative policy preferences also became more fervently abortion-reducing (constrictive) on other metrics post-feedback. There was a significant overall drop in general Likert preference ratings for the abortion rate, after feedback. Indeed, almost 20% more of the students preferred a "big decrease" after learning the true rate (see Figure 1). The justifications also changed: Before feedback, 25.2% of the full set of explanations provided that abortions should always be allowed, while only 11.1% stated that abortions should be allowed in only some circumstances. After feedback, these frequencies were essentially reversed (13.5% vs. 20.2%). The only people who showed little shift in either their numeric preference or written justifications were those who preferred zero abortions—before and/or after feedback. Considering that these zero-preferring people (a strange-bedfellows group seeming to include utopian liberals and abolitionist conservatives; see Results) essentially held absolutist policies (for zero abortions), it is not surprising that the true rate did little to change that wish.

In both more quantum and qualitative senses, one of the most dramatic of the above results is that those who initially adopted a "status quo" policy usually changed their positions after seeing the generally surprising base rate feedback. Of the 32 respondents who first preferred neither an increase nor a decrease in the abortion rate, feedback caused 21 of them (66%) to take a directional position, thus becoming "semi-flip" participants. Base rate feedback also changed the POVs by which semi-flip people justified their preferences. While before feedback, most such students claimed that abortions should always be allowed, regardless of circumstances, these justifications shifted dramatically after feedback. The participants who changed to preferring decreasing the abortion rate no longer claimed that abortions should always be allowed, and instead largely justified their new preferences by preferring a utopian world in which abortions need never be considered, because either (a) all pregnancies would be wanted (or all unwanted pregnancies prevented), or (b) all unwanted babies would be readily adopted by loving homes. (This is consistent with "Wow! That's too many!" reactions.) Conversely, those semi-flippers who changed to prefer an *increase* after feedback used none of the justifications eventually used by those who

changed to prefer a decrease, and vice versa. Instead, these increasers-come-lately largely continued to claim that abortions should always be allowed, regardless of circumstances, or that the abortion rate should reflect the greater good for society. So, while semi-flip participants seemed rather homogeneously like-minded before feedback, when it caused them to bifurcate into divergent positions (to prefer an increase or a decrease) there was no overlap in the types of justifications used. This is a dramatic effect, considering that the intervention is a single, albeit highly reliable, piece of information (i.e., 335,000:1,000,000).

### Some Implications and Extensions

Our results show some of the effects of numerical feedback on personal preferences and policies regarding topics such as abortion—that is, topics for which the feedback is often surprising and quite far from individuals' estimates. More recent work from our laboratory observes this phenomenon in many realms, involving dozens of items and their rates—about incomes, inflation, executions, home ownership, etc.—and even SAT percentile use in college admissions. Lurie and Ranney (2003) are extending this work even further, into the arena of health-care research funding, and have proposed a general model that relates numeric estimates, preferences, feedback, and seeds.

One implication of this work is the need to improve citizens' thinking about critical base rates. For many of the topics our Reasoning With Numbers group employs, many people are clearly quite unaware of crucial numbers related to an issue (Ranney, et al., 2001), and they even have low metacognitive knowledge-awareness (e.g., no significant correlation, for abortion, between familiarity and accuracy). Therefore, our lab has carried out a variety of promising classroom-based experiments, from grades 5-12, to foster such metacognition (e.g., Munnich, Ranney, & Appel, 2004). Among other goals, our curricula are meant to improve students' abilities to (a) estimate (e.g., by disconfirming sub-par, early, estimate-hypotheses and bringing more knowledge and accountability to bear), (b) prefer (or justify what they prefer, e.g., by reflecting on more dimensions influencing one's wishes), (c) utilize feedback (e.g., by "letting go" of one's estimate), and (d) triangulate or "N-angulate" (e.g., by seeking relevant external information sources). Curricular assessments show broad numerical reasoning gains over control students (e.g., in estimation; Munnich, Ranney, & Appel, 2004).

Most people use information other than statistics (e.g., ethics, pragmatics, and conventions) to form their positions, and even use *misconceptions* of true statistics, at times. Still, the actual numbers, especially when surprising, can significantly affect how they think about the issue. Thus, NDI results contrast with views of scholars in diverse fields who suggest that learning, transfer, belief revision, and attitudinal (or conceptual) change are quite difficult to foster (Munnich, Ranney, & Appel, 2004; Munnich et al, 2003; Ranney et al., 2001). Incorporating numeric feedback—even just a single, critical, number—can often dramatically change how one views an issue and reasons about one's positions. Further, such changes clearly transcend the domain of numbers, in that there is much non-numeric

reasoning that lies beneath the iceberg-tips of estimation and quantitative preference. NDI's methods (e.g., EPIC) represent new tools with which science may better probe the submerged prominences and embedded fissures of thought.

### Acknowledgments

We thank Laura Germine, Geoff Saxe, Franz Cheng, Ed Munnich, Nick Lurie, Patti Schank, Christine Diehl, Steve Adams, Michelle Million, Dan Appel, Luke Rinne, Sujata Ganpule, David Levine, Barbara Ditman, Tracy Craig, Tae Kim, Danny Kahneman, and our UC-Berkeley Reasoning Group, among others, for comments.

### References

- Bernas, R., & Stein, N. (2001). Changing stances on abortion during case-based reasoning tasks: Who changes and under what conditions. *Discourse Processes*, 32, 177-190.
- Brown, N.R. (2002). Real-world estimation: Estimation modes and seeding effects. In B.H. Ross (Ed.) *Psychology of Learning and Motivation*, 41, New York: Academic.
- Brown, N.R. & Siegler, R.S. (1996). Long-term benefits of seeding the knowledge-base. *Psychonomic Bulletin & Review*, 3, 385-388.
- Lurie, N., & Ranney, M. (2003, November). *Estimates, Preferences, and Preference Change: Biasing, Debiasing, and Seeding Effects in Thinking About Base Rates*. Paper presented at the annual meeting of the Society for Judgment and Decision Making, Vancouver, Canada.
- Munnich, E.L., Ranney, M.A., Appel, D.M. (2004). Numerically-Driven Inferencing in instruction: The relatively broad transfer of estimation skills. To appear in *Proceedings of the Twenty-sixth Annual Conference of the Cognitive Science Society*. Mahwah, NJ: Erlbaum.
- Munnich, E.L., Ranney, M.A., Nelson, J.M., Garcia de Osuna, J.M., & Brazil, N.B. (2003). Policy shift through Numerically-Driven Inferencing: An EPIC experiment about when base rates matter. *Proceedings of the Twenty-fifth Annual Conference of the Cognitive Science Society* (pp. 834-839). Mahwah, NJ: Erlbaum.
- Ranney, M., Cheng, F., Garcia de Osuna, J., & Nelson, J. (2001, November). *Numerically Driven Inferencing: A new paradigm for examining judgments, decisions, and policies involving base rates*. Paper presented at the annual meeting of the Society for Judgment and Decision Making, Orlando, FL.
- Ranney, M., & Thagard, P. (1988). Explanatory coherence and belief revision in naive physics. *Proceedings of the Tenth Annual Conference of the Cognitive Science Society* (pp. 426-432). Hillsdale, NJ: Erlbaum.
- Read, S.J., & Marcus-Newhall, A. (1993). Explanatory coherence in social explanations: A parallel distributed processing account. *Journal of Personality and Social Psychology*, 65, 429-447.
- Schank, P. & Ranney, M. (1991). The psychological fidelity of ECHO: Modeling an experimental study of explanatory coherence. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp.892-897). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Thagard, P.(1989). Explanatory coherence. *Behavioral & Brain Sciences*, 12(3), 435-502.