Interaction effects on linear in log odds slopes Uncertainty Difference in slope Uncertainty in model estimates of with Means Added Visualizations Average Slope in each condition* Quantile Dotplots -0.033 [-0.055, -0.013] Low Variance HOPs -0.043 [-0.075, -0.013] Intervals -0.023 [-0.043, -0.003] Densities -0.025 [-0.048, -0.002] Average over Vis -0.031 [-0.044, -0.020] Quantile Dotplots -0.006 [-0.029, 0.018] High Variance HOPs -0.038 [-0.071, -0.004] Intervals 0.045 [0.024, 0.064] Densities 0.038 [0.014, 0.063] Average over Vis 0.010 [-0.003, 0.023] Average over Variance Quantile Dotplots -0.020 [-0.038, -0.001] HOPs -0.041 [-0.067, -0.015] Intervals 0.011 [-0.005, 0.027] Densities 0.007 [-0.013, 0.026] 0.2 0.3 0.4 0.5 0.6 0.7 Bias toward underestimation Interaction effects on points of subjective equality (PSEs) Difference in PSEs Uncertainty Uncertainty in model estimates of Average PSE in each condition* Visualizations with Means Added Quantile Dotplots 0.252 [0.082, 0.435] Low Variance HOPs 0.091 [-0.160, 0.353] 0.125 [-0.144, 0.433] Densities 0.133 [-0.030, 0.314] Average over Vis 0.150 [0.027, 0.281] Quantile Dotplots -0.043 [-0.156, 0.073] HOPs -0.098 [-0.267, 0.060] High Variance Intervals -0.160 [-0.277, -0.040] Densities -0.116 [-0.238, 0.002] Average over Vis -0.105 [-0.175, -0.036] -0.5 1.0 -1.0 0.5 n Bias toward intervention Bias against intervention Interaction effects on just-noticeable differences (JNDs) Difference in JNDs Uncertainty in model estimates of Uncertainty Average JND in each condition* Visualizations with Means Added Quantile Dotplots -0.019 [-0.108, 0.073] Low Variance HOPs -0.014 [-0.158, 0.139] Intervals -0.055 [-0.216, 0.116] Densities 0.013 [-0.085, 0.125] High Variance Quantile Dotplots -0.032 [-0.083, 0.021] HOPs 0.018 [-0.068, 0.110] Intervals -0.105 [-0.169, -0.049] Densities -0.041 [-0.103, 0.020] over Variance Quantile Dotplots -0.025 [-0.083, 0.034] HOPs 0.002 [-0.092, 0.104] Intervals -0.080 [-0.177, 0.014] Densities -0.014 [-0.080, 0.059] 0.6 0.8 0.4

4 RESULTS

4.1 Probability of Superiority Judgments

For each uncertainty visualization, adding means at low variance decreases LLO slopes. Recall that a slope of one corresponds to no bias, and a slope less than one indicates underestimation. When we average over uncertainty visualizations, adding means at low variance reduces LLO slopes for the average user, indicating a very small 0.8 percentage points increase in probability estimation error.

At high variance, the effect of adding means changes directions for different uncertainty visualizations. Adding means decreases LLO slopes for HOPs, whereas adding means increases LLO slopes for intervals and densities. Because differences in LLO slopes represent changes in the exponent of a power law relationship, these slope differences of similar magnitude indicate a very small increase in probability of superiority estimation error of 0.3 percentage points for HOPs and small reductions in error of about 1.5 and 1.0 percentage points for intervals and densities, respectively.

Users of all uncertainty visualizations underestimate effect size. When we **average over variance**, users show an average estimation error of 8.6, 14.0, 14.8, and 12.4 percentage points in probability of superiority units for quantile dotplots, HOPs, intervals, and densities, respectively, each **without means**. In this marginalization, **adding** means only has a reliable impact on LLO slopes for **HOPs**, but the difference is practically negligible.

4.2 Intervention Decisions

4.2.1 Points of Subjective Equality

For each uncertainty visualization, adding means at low variance increases PSEs. This results in different effects depending on whether the visualization with no means has a PSE below or above utility-optimal. Recall that a PSE of zero is utility-optimal, a negative PSE indicates intervening too often, and a positive PSE indicates not intervening often enough. Users of quantile dotplots with no means have negative PSEs which become unbiased when we add means. Users of HOPs and intervals with no means have positive PSEs, biases which increase when we add means. Users of densities with no means have PSEs near zero and become more biased when we add means. Only the effect for quantile dotplots is reliable. When we average over uncertainty visualizations, at low variance the average user may have a PSE 0.6 percentage points above utility-optimal with no means, and adding means increases this mild bias by about 1.7 percentage points in terms of the probability of winning.

At high variance, adding means decreases PSEs. Since PSEs for all uncertainty visualizations with no means are below optimal, adding means increases biases in all conditions, however, the effect is only reliable for intervals. When we average over uncertainty visualizations, at high variance the average user has a negative PSE 9.5 percentage points below utility-optimal with no means, and adding means increases this bias by about 2.1 percentage points.

4.2.2 Just-Noticeable Differences

Greater sensitivity to evidence

At **low and high variance**, the effects of **adding means** on JNDs are mostly unreliable. Recall that smaller JNDs indicate that a user is sensitive to smaller differences in effect size for the purpose of decision-making. **Adding means** only has a reliable effect on JNDs-for **intervals** at **high variance**, where it reduces JNDs by 1.2 percentage points in terms of the probability of winning.

When we average over variance, quantile dotplots with means—lead to the smallest JNDs, and users of HOPs with or without means—have the largest JNDs, a difference of about 1 percentage point in terms of the probability of winning. Quantile dotplots with or without means have reliably smaller JNDs than other conditions, with the exception of unreliable differences between quantile dotplots—with no means and densities with or without means.

*Probability densities of model estimates show posterior distributions of means conditional on the average participant.