An Illustration of Bayesian Hypothesis Testing in the Social and Behavioral Sciences

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Introduction: Bayesian hypothesis testing

As an alternative to traditional hypothesis testing, *Bayesian methods* have many benefits. Instead of a p-value, we interpret a *Bayes factor*, which is the relative likelihood of our observed data occurring under one hypothesis compared to another. Recently, free software packages such as JASP have made Bayesian methods accessible to a wide range of users.
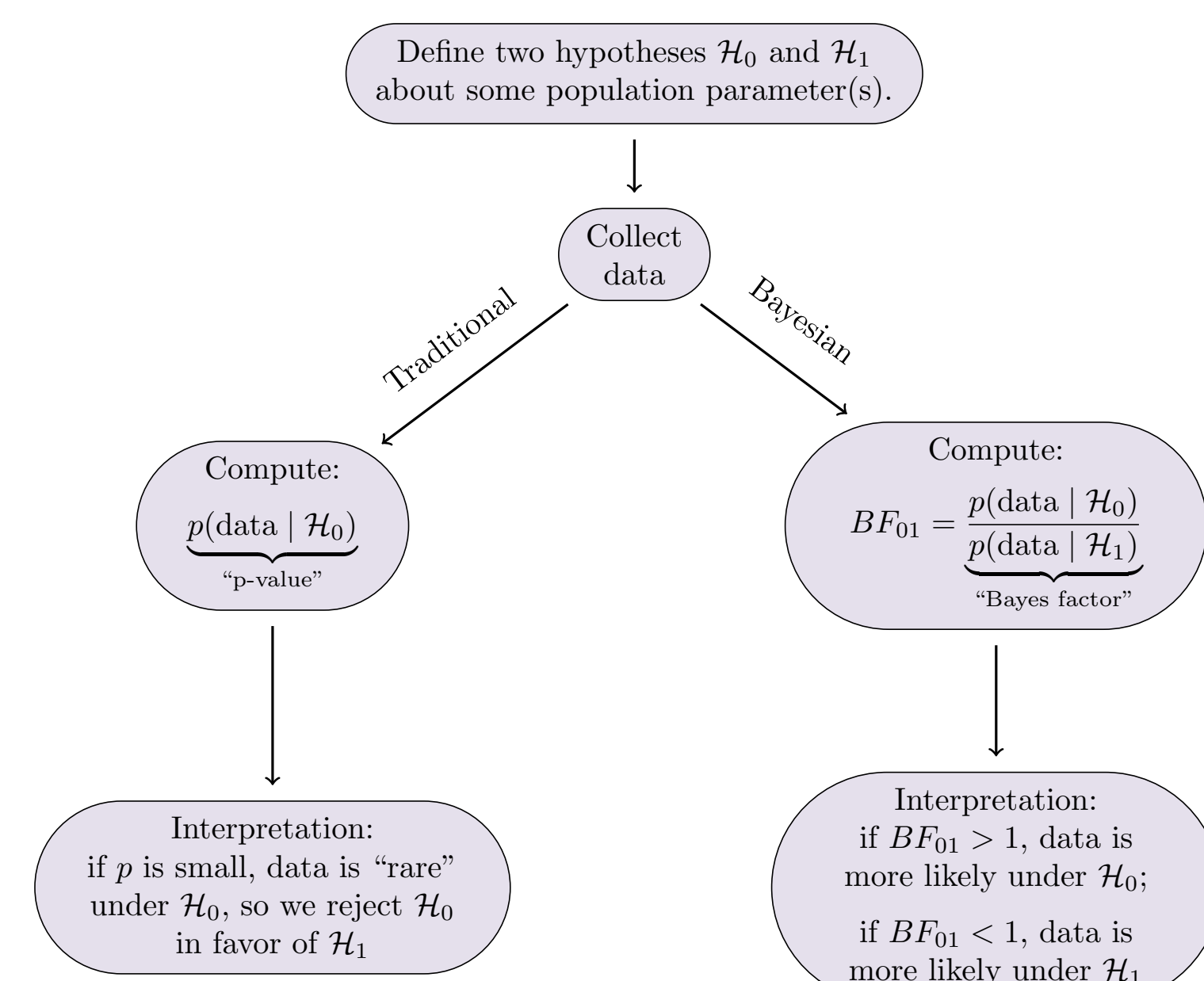
Bayes factors need priors

To compute Bayes factors, we need to encode our prior beliefs about the effect sizes δ we expect to observe under $\mathcal{H}_1$. Mathematically, we use *probability distributions* to encode these beliefs. Then $\mathcal{H}_0$ is defined as a single point in the distribution – that is, $\mathcal{H}_0 : \delta = 0$.
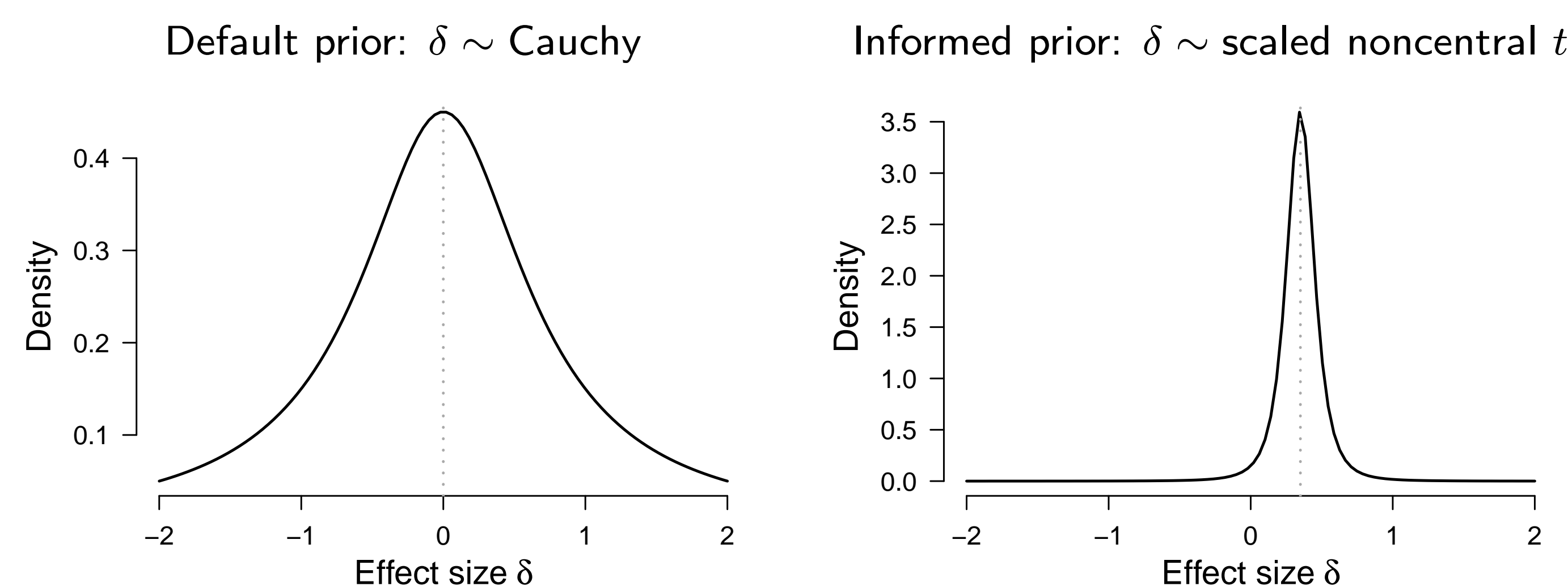
Example: Facial Feedback Hypothesis

Strack et al. (1988) found that forming different facial expressions can induce specific emotions. For example, when participants held a pen in their teeth (facial expression = smile), they rated comics funnier than people who held a pen in their lips (facial expression = pout).
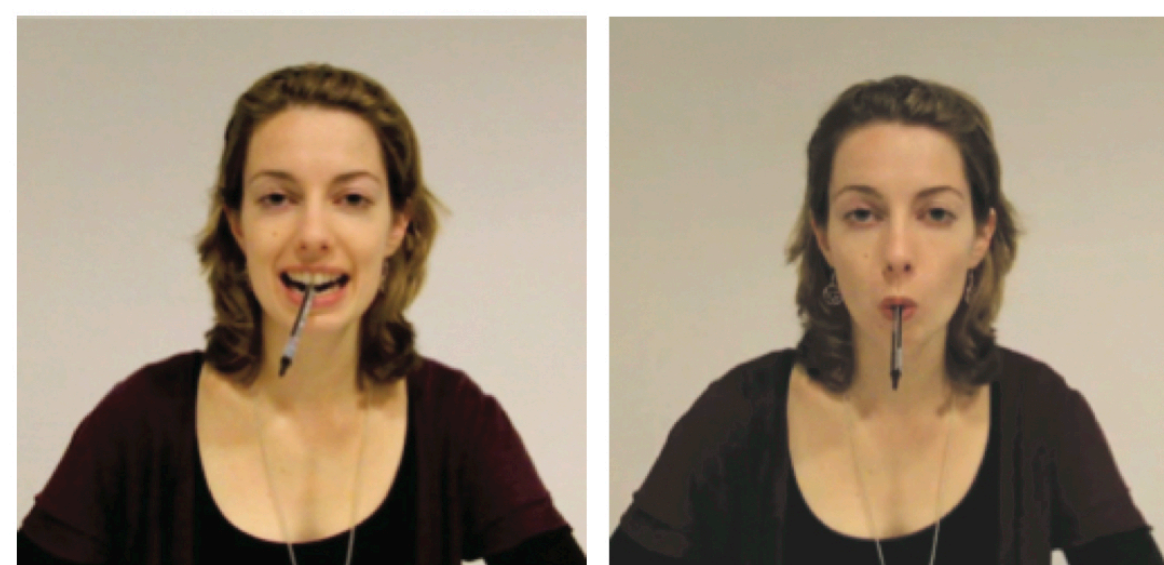

Figure reprinted from Wagenmakers et al. (2016), and is available at http://tinyurl.com/zm7p917

In 2016, E.J. Wagenmakers led a massive effort to replicate Strack's (1988) original results. This replication involved 17 labs across the world, each of whom followed the same preregistered protocol.

In this poster, we demonstrate several benefits of Bayesian hypothesis testing using data from Suzanne Oosterwijk's lab, one of the 17 included in the Wagenmakers et al. (2016) replication. These data can be downloaded from https://osf.io/d9xeu, or by scanning the QR code to the right.
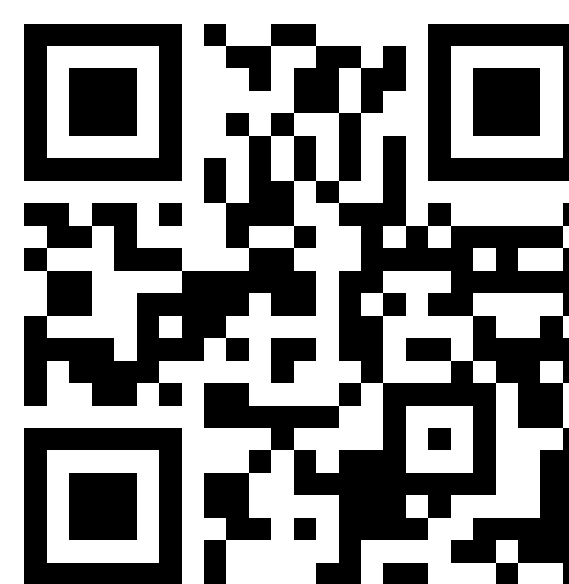
JASP: Free software for Bayesian analyses

JASP provides a simple user interface for performing Bayesian analyses. JASP can be freely downloaded from www.jasp-stats.org
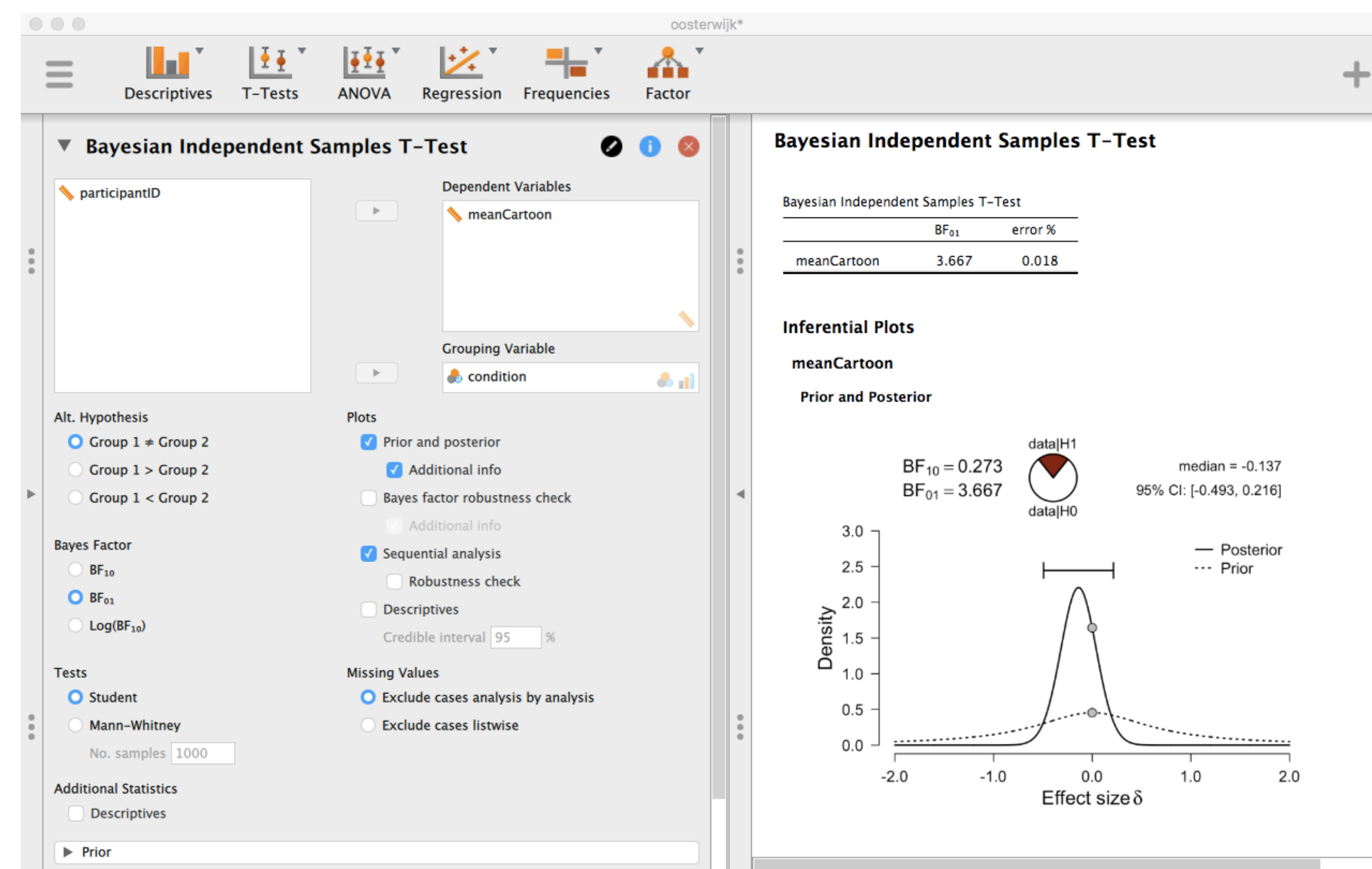

Key outputs:

- BF_{01}: Bayes factor illustrating that the data are 3.7 times more likely under $\mathcal{H}_0$ than $\mathcal{H}_1$.
- Prior and posterior plot: quantifies updating of our beliefs about effect size δ after observing data.
- Probability wheel ("pizza plot"): displays Bayes factor as an odds ratio

Bayesian benefit #1: Evidence for null

As opposed to traditional methods, Bayesian methods can provide evidence *for* the null hypothesis! As can be seen above, the likelihood of the data under $\mathcal{H}_0 : \delta = 0$ increases from prior to posterior.

## Bayesian benefit #2: Sequential analysis

Researchers can monitor evidence as data is accumulated, stopping the collection of data (or continuing past the predicted N) as needed. This can save time (and money)!
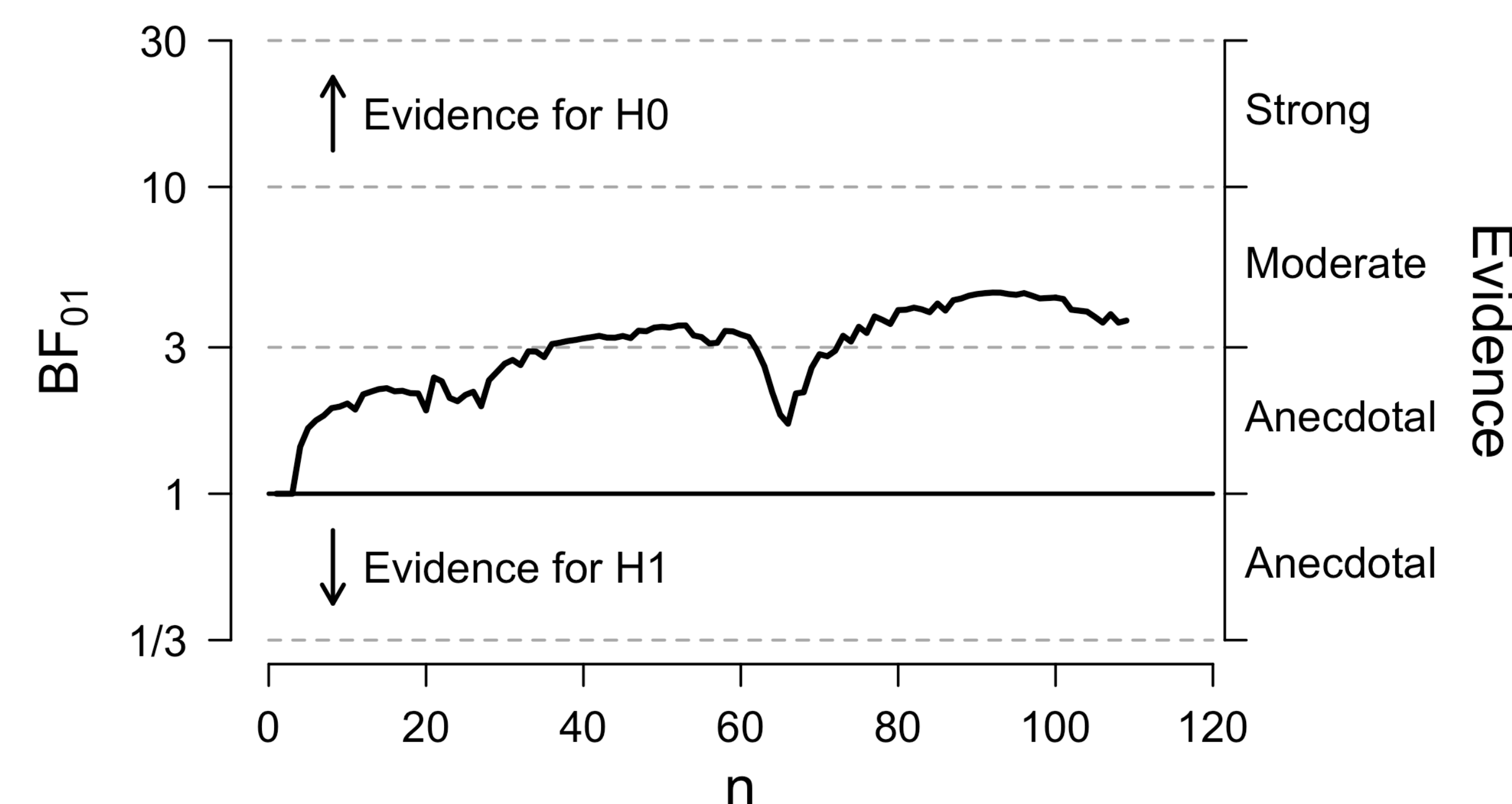
Bayesian benefit #3: Informed priors

JASP includes the ability to use *informed priors*. For example, Gronau et al. (2019) asked an expert in social psychology (Oosterwijk) to predict the direction and median of the expected facial feedback effect. Using an online "uncertainty elicitation" tool, they matched these qualitative predictions to a probability distribution. The result was that Oosterwijk's prior on $\mathcal{H}_1$ was a scaled noncentral t-distribution with center=0.35, scale=0.102, and 3 degrees of freedom.

As can be seen in the JASP output to the right, there is still an increase in the likelihood of the observed data under $\mathcal{H}_0$ from prior to posterior. Thus, even with a highly peaked, informed prior, the data are still evidential for $\mathcal{H}_0$.
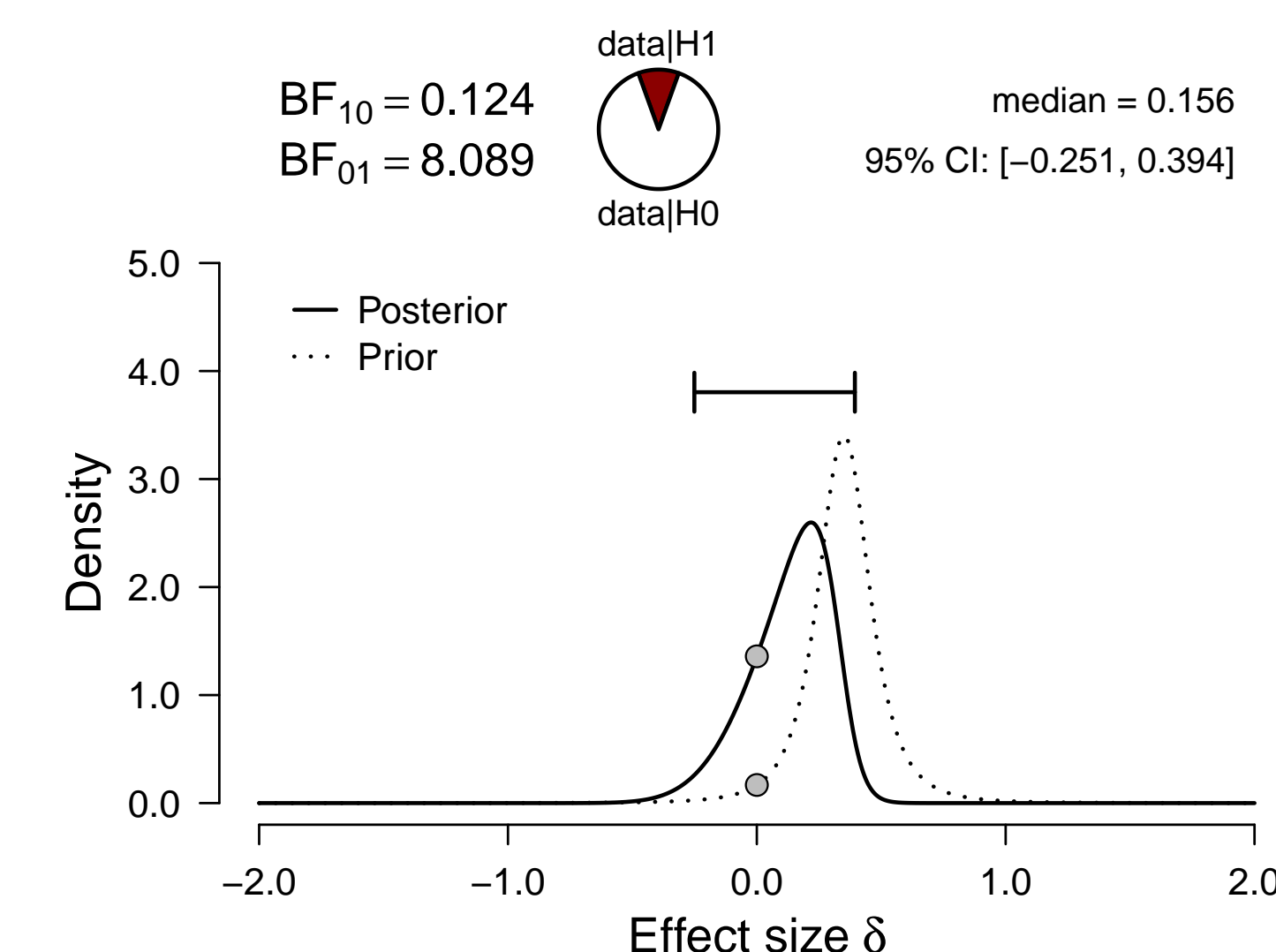
Thus, across multiple priors for $\mathcal{H}_1$, the original facial feedback effect of Strack et al. (1988) does not replicate.

Further reading

For a general introduction to using Bayesian methods in psychology, we recommend:

- Etz, A., & Vandekerckhove, J. (2017). Introduction to Bayesian Inference for Psychology. *Psychonomic Bulletin & Review, 25*(1), 5–34. doi:10.31234/osf.io/q46q3

For specific tutorials with JASP, we recommend:

- Wagenmakers, E.J. et al. (2017). Bayesian inference for psychology. Part II: Example applications with JASP. *Psychonomic Bulletin & Review, 25*(1), 58–76. doi:10.3758/s13423-017-1323-7
- Marsman, M., & Wagenmakers, E.J. (2017). Bayesian benefits with JASP. *European Journal of Developmental Psychology, 14*(5), 545–555. doi: 10.1080/17405629.2016.1259614

If you would like a copy of this poster and the ability to perform these analyses yourself, you can download the poster along with the raw data and a JASP file from https://github.com/tomfaulkenberry/bayesTutorial. Alternatively, you can scan the QR code to the right.

References:

Gronau, Q. F., Ly, A., & Wagenmakers, E. J. (2019). Informed Bayesian t-tests. *The American Statistician.* doi: 10.1080/00031305.2019.1562983

Strack, F., Martin, L. L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology, 54*(5), 768–777. doi:10.1037/0022-3514.54.5.768

Wagenmakers, E.J., Beek, T., Dijkhoffm L., & Gronau, Q. F. (2016). Registered replication report: Strack, Martin, & Stepper (1988). *Perspectives on Psychological Science, 11*(6), 917–928. doi: 10.1177/1745691616674458