brms: An R Interface for Flexible Bayesian Multilevel Modeling using Stan

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Why use Bayesian Statistics?
Advantages and Disadvantages of Bayesian Statistics

Advantages:

- Natural approach to expressing uncertainty
- Ability to incorporate prior information
- Increased modeling flexibility
- Full posterior distribution of parameters
- Natural propagation of uncertainty

Disadvantages:

- Slow Speed of model estimation
A probabilistic programming language
A unified framework for Bayesian regression models
Purpose of brms

Make Stan usable for a wider range of audience

- Use R formula syntax
- Internally write Stan code that is readable yet fast
- Provide an easy interface for defining priors
- Facilitate post-processing

brms is officially supported by the Stan Development Team
Example: Censored Recurrance Times of Kidney Infections

```r
fitk <- brm(time | censor(censored) ~ age * sex + (1|patient),
            data = kidney, family = weibull())

conditional_effects(fitk, "age:sex")
```
Example: Complex Non-Linear Relationships

Latent mean function

Realized data

- Latent mean function
- Realized data
```
fitgp <- brm(y ~ gp(x), bdata)

conditional_effects(fitgp, nsamples = 100, spaghetti = TRUE)
```
fits <- \texttt{brm(y ~ s(x), bdata)}

\texttt{conditional_effects(fits, nsamples = 100, spaghetti = TRUE)}
Example: Number of Fish Caught at a Camping Place
Modeling Zero-Inflation

```r
form <- bf(nfish ~ persons + child + camper, zi ~ child)
fit_zinb <- brm(form, zinb, zero_inflated_poisson())
conditional_effects(fit_zinb, effects = "child")
```
Learn more about Stan

- Website: http://mc-stan.org/
- Forums: http://discourse.mc-stan.org/

Selected Publications:

Learn more about `brms`

- Help within R: `help("brms")`
- Vignettes: `vignette(package = "brms")`
- List of all methods: `methods(class = "brmsfit")`
- GitHub: [https://github.com/paul-buerkner/brms](https://github.com/paul-buerkner/brms)
- Contact me: paul.buerkner@gmail.com
- Twitter: @paulbuerkner

Publications

Appendix
Why using Multilevel Models?
Example: Effects of Sleep Deprivation on Reaction Times
fit <- lmer(Reaction ~ 1 + Days + (1 + Days | Subject),
            data = sleepstudy)
Bayesian Multilevel Models with brms

```r
fit <- brm(Reaction ~ 1 + Days + (1 + Days|Subject),
           data = sleepstudy)
```
Linear Regression vs. Multilevel Regression
Regression Lines for Specific Subjects
Stan Overview

- Probabilistic programming language...
- ... to fit open-ended Bayesian models
- Powerful sampling algorithms: HMC and NUTS
- Automatic differentiation library
- Runs on all major platforms (Windows, OS X, Linux)
- Has interfaces to R, Python, and many other languages
## Post-Processing Methods in brms

```r
define methods for class "brmsfit"
## [1] add_criterion add_ic as.array as.data.frame
## [5] as.matrix as.mcmc autocor bayes_factor
## [9] bayes_R2 bridge_sampler coef conditional_effects
## [13] control_params cv_varsel fixef formula
## [17] fitted hypothesis kfold
## [21] get_refmodel getCall log_lik log_posterior
## [25] launch_shinystan LOO loo_compare
## [29] loo loo_compare loo_predict
## [33] loo_model_weights loo_moment_match marginal_effects
## [37] loo_R2 loo_subsample marginal_smoots
## [41] mcmc_plot model.frame model_weights
## [45] ngrps nobs neff_ratio
## [49] parnames posterior_average posterior_epred
## [53] posterior_predict posterior_samples posterior_interval
## [57] prior_samples prior_summary predictive_error
## [61] pp_average pp_check predict
## [65] predictive_interval prepare_predictions
## [69] prior_samples prior_summary predictive_interval
## [73] residuals rhat reloo
## [77] stanplot summary reloo
## [81] varsel vcov reloo
## see '?methods' for accessing help and source code
```