

# vICC: Varying Intraclass Correlation Coefficients in R

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## Software

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## Summary

In mixed-effects (a.k.a, hierarchical or multilevel) models, intraclass correlation coefficients (ICC) are commonly computed, with applications spanning from characterizing group-level homogeneity (Shieh, 2016) to measurement reliability (Williams et al., 2020). While there are a wide spectrum of applications, an underlying assumption of each is that the variance components used in their computation are fixed and non-varying. Consider the case of ICC(1), that is,

$$\text{ICC}(1) = \frac{\sigma_b^2}{\sigma_b^2 + \sigma_w^2} \quad (1)$$

where  $\sigma_b^2$  is the between-group variance and  $\sigma_w^2$  the within-group variance. In a one-way random effects model,  $\sigma_w^2$  is essentially the *average* within-group variance. However, if there are group-level differences in  $\sigma_w^2$ , this implies that there is group-level variation in the ICC.

The methodology in the R package **vICC** was specifically designed to quantify variation in ICC(1) by allowing  $\sigma_w^2$  to vary. This can be used to identify groups that are more (or less) homogeneous, as well as which groups are adequately described by Equation (1). There is currently no software for this purpose.

## Statement of Need

The **vICC** package can be used to:

- Obtain posterior probabilities that each group shares a common within-group variance (i.e.,  $\sigma_w^2$  in Equation 1). This is accomplished with the spike and slab approach for Bayesian hypothesis testing (a review is provided in O'Hara & Sillanpää, 2009).
- Test for between-group differences in  $\sigma_w^2$ . This is also accomplished with a spike and slab formulation.
- Compute group-specific ICCs, that is the correlation for any two observations from the same group, and ICC(2), that is average score reliability. Both ICC(1) and ICC(2) are reliability indices.

Additionally, there are plotting capabilities using the R package **ggplot2** (Wickham, 2016).

## Methodology

The following models are in **viCC**:

1. `pick_group`:

This model has a spike and slab on the random intercepts for the within-group variance. This provides posterior inclusion probabilities (PIP) that each group (e.g., person) does not belong to the common within-group variance model.

2. `pick_tau`:

This model has a spike and slab on the random effects standard deviation in the scale model which captures between-group variability in the within-group variances. This provides a PIP that there is variation in the within-group variances.

3. `pick_none`:

This model also provides group-specific reliability, but there is no spike and slab formulation. This is perhaps ideal for those not familiar with Bayesian testing, but would still like to compute varying ICCs.

4. `customary`:

This is the standard random intercepts model that assumes a common within-group variance.

Note that options 1 and 2 provide Bayesian model averaged estimates for the ICCs. The model formulations are provided in Williams et al. (2019).

## Implementation

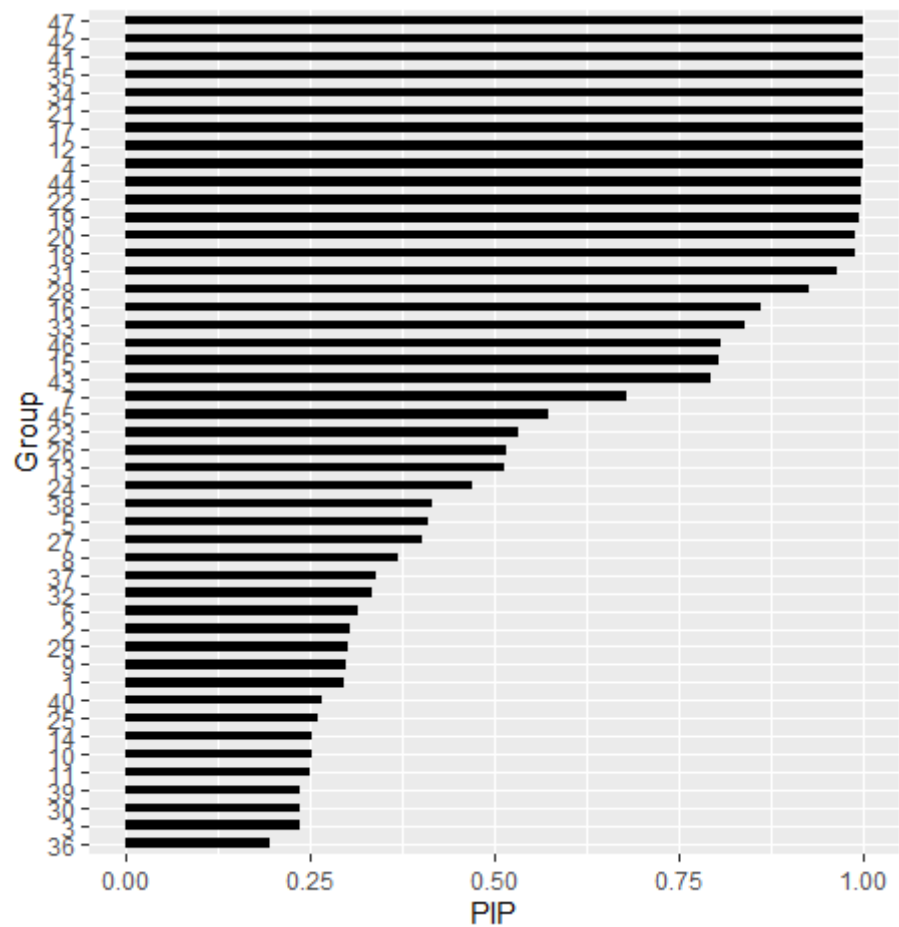
The following estimates the `pick_group` model for reaction times from a cognitive task (Hedge et al., 2018).

```
# congruent trials
congruent <- subset(flanker, cond == 0)

# subset 25 from each group
dat <- congruent[unlist(tapply(1:nrow(congruent),
                             congruent$id,
                             head, 25)), ]

# fit model
fit <- vicc(
  y = dat$rt,
  group = dat$id,
  chains = 2,
  iter = 500,
  burnin = 10,
  type = "pick_group"
)
```

The posterior inclusion probabilities are then plotted with `plot(pip(fit))`.



**Figure 1:** Posterior Inclusion Probabilities

Figure 1: Posterior inclusion probabilities for each group that provide the evidence for differing from the average within-group variance.

The group-level ICCs are plotted with

```
plts <- plot(fit)

plts$plot_icc1 +
  theme(axis.text.x=element_text(angle=90, hjust=1),
        legend.title = element_blank()) +
  xlab("Group")
```

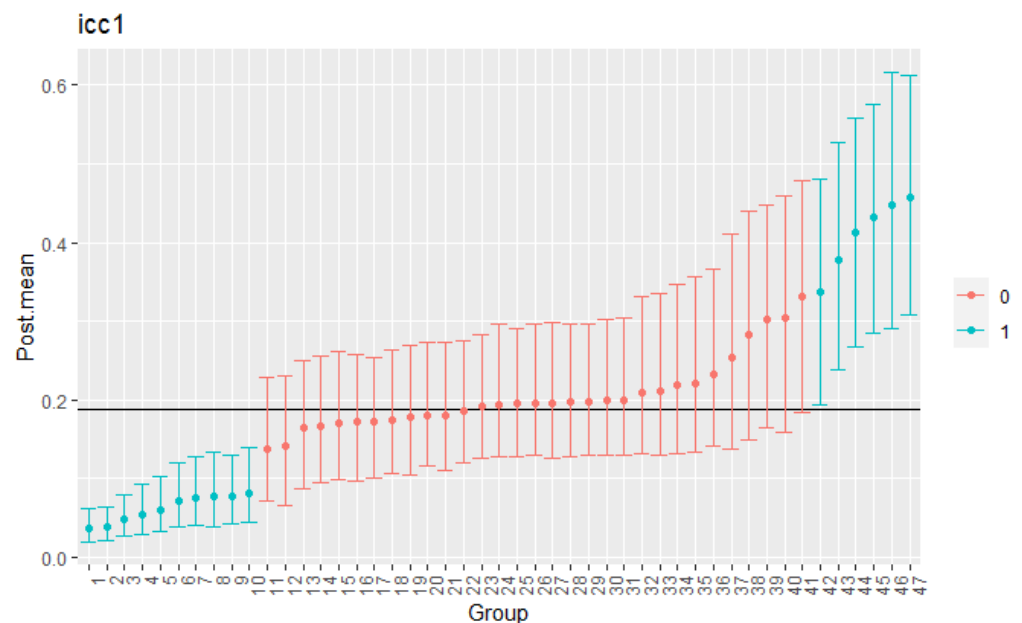


Figure 2: Group-level intraclass correlation coefficients. The black line is the customary ICC computed with Equation (1).

Notice that the object `plts` can be further modified with **ggplot2**. Further, it also includes plots for the means (`plot_mean`), standard deviations (`plot_sd`), ICC(2) (`plot_icc2`).

## Conclusion

The **vICC** package allows researchers to investigate variability in the intraclass correlation coefficient. In the future, the suite of models will be expanded to allow for partitioning the variance among several grouping variables.

## Acknowledgements

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