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skprJMP: A Monte Carlo Power Evaluation Add-in For JMP

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Executive Summary

Design of Experiments (DoE) provides a solid analytical basis for test planning because it includes tools to characterize the design space, maximizes the value of each run or mission, and links the planning of a test to the data analysis that follows the test. Importantly, DoE allows testers to characterize and minimize risk for a test by calculating statistical power for a particular design and analysis method, providing decision makers with a quantitative assessment of the likelihood of an experiment discovering an effect if one exists. Because of all these benefits, the Government favors test designs that use DoE. However, logistic regression—an important and widely used data analysis method—is not supported in the most common power calculation software packages used in the Department of Defense. The attached code aims to address this issue.

skprJMP[1] is a software add-in for the JMP statistical software application that provides organizations using JMP with highly accurate Monte Carlo-based power calculation tools. As part of IDA's efforts to drive innovation by improving the capabilities, methods, and approaches used in our own work and in the test community, IDA released the R package skpr[2] for DoE in 2017. The skpr package provides a unified set of tools for the generation and evaluation of experimental designs. The skpr package's capabilities include performing exact power calculations using Monte Carlo methods, generating optimal designs, and providing a code-based interface to support a reproducible DoE workflow. Since skpr was released, the tool has supported developmental and operational test planning across dozens of programs, and has become a core piece of analytical test infrastructure for many organizations. Most importantly, this tool allows analysts to calculate exact power estimates for test designs with non-linear responses, which in practice are common, such as designs based on logistic regression, a capability which none of the commercial statistical software suites (JMP, Minitab, StatEase) currently provide. However, some organizations have been unable to use skpr due to strict information technology constraints that disallow the installation of the R programming language, and thus have been unable to generate accurate power estimates for designs with non-linear responses. The skprJMP add-in implements a subset of the capabilities provided by skpr entirely within JMP, allowing these organizations to calculate power for these designs within the constraints of their computing environment.

The skprJMP software provides a point-and-click graphical user interface (see Figure 1) written in the JMP scripting language (JSL) to generate and evaluate experimental designs when

1 http://testscience.org/skprjmp/

2 See https://cran.r-project.org/web/packages/skpr/index.html for code and reference manual.

the response is a probability. This software has been provided as a free, open-source JMP add-in, so the underlying JSL code that performs the power calculations can be viewed (and audited) by an organization before using it.

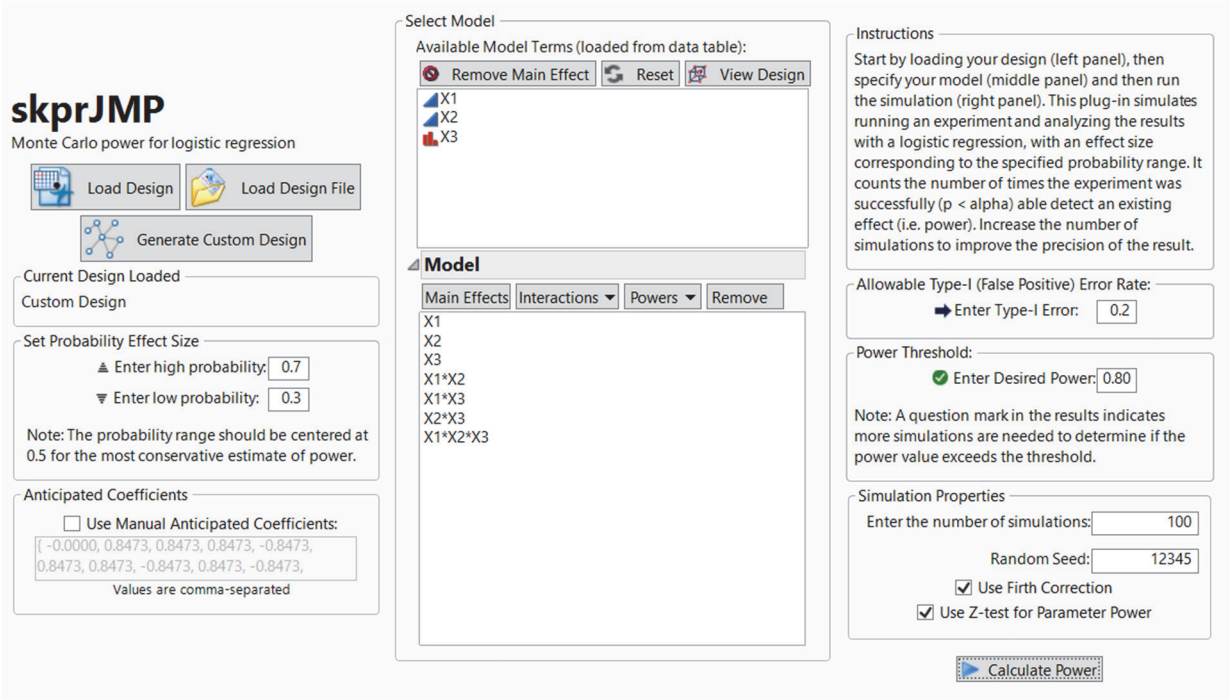

Figure 1. skprJMP's graphical user interface.

skprJMP provides the following features:

1. **Design Import and Generation**: skprJMP allows analysts to import an existing design from their filesystem or local JMP session as well as use JMP's custom design interface to generate a design directly within the add-in. This interface supports any kind of tabular data format that the JMP software can import.
2. **Model Specification**: skprJMP provides a JMP-style interface for specifying and building a model, allowing users to specify interactions and add and remove model terms easily.
3. **Monte Carlo Power Calculation**: the software automates the complex process of performing a Monte Carlo power analysis to get accurate, state-of-the-art power estimates, with the precision controlled by the user-controllable number of simulations. The power output also uses the user-specified power threshold to label which terms do and do not have adequate power for a given design, as well as informing the users if they need to increase the number of simulations due to the power falling within the Monte Carlo error (see Figure 2 for an image of the power output pane).

4. **Reproducibility**: the user can specify a random seed to ensure that they (or other organizations) can reproduce the results of any single power analysis at a future date, given the same input design.
5. **Effect Size Calculation**: skprJMP automates the calculation of binomial effect sizes using a user-friendly probability range as the input.
6. **Firth Correction Support**: Logistic regression can be degraded from a type of degeneracy called "separation," where the model fails to converge for certain arrangements of data. skprJMP provides an option to analyze the simulations using a Firth correction, which fixes this issue.
7. **Built-in Tooltips and Help**: skprJMP provides helpful tooltips for all input fields, providing context and suggestions to help analysts follow IDA-developed best practices when evaluating their designs, as well as guidance for interpreting results.

Effect Power

Term	Power	±	>=0.80
X1	1.000	0.018	✓
X2	0.990	0.026	✓
X3	0.990	0.026	✓
X1*X2	1.000	0.018	✓
X1*X3	0.970	0.037	✓
X2*X3	0.910	0.057	✓
X1*X2*X3	0.960	0.041	✓

Parameter Power

Term	Power	±	>=0.80
Intercept	0.220	0.080	X
X1	1.000	0.018	✓
X2	1.000	0.018	✓
X3[L1]	0.690	0.089	X
X3[L2]	1.000	0.018	✓
X1*(X2+0.01563)	1.000	0.018	✓
X1*X3[L1]	0.730	0.086	?
X1*X3[L2]	0.970	0.037	✓
(X2+0.01563)*X3[L1]	0.580	0.095	X
(X2+0.01563)*X3[L2]	0.920	0.054	✓
X1*(X2+0.01563)*X3[L1]	0.580	0.095	X
X1*(X2+0.01563)*X3[L2]	0.940	0.048	✓

⚠ Any terms marked with a "?" require more simulations to determine if they are above the 95% Monte Carlo error threshold (Wilson interval).

Figure 2. Monte Carlo power analysis output of skprJMP.

For a description of the Monte Carlo algorithm skprJMP uses to compute power for logistic regression, see IDA Document NS D-8992, "skpr: R Package for Generation and Evaluation of Experimental Designs" and the associated Journal of Statistical Software paper "Optimal Design Generation and Power Evaluation in R: The skpr Package."

The skprJMP add-in is available for download at https: //testscience.org/skprjmp/.

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14. ABSTRACT

As part of IDA's efforts to drive innovation by improving the capabilities, methods, and approaches used in our own work and in the test community, IDA has developed the "skprJMP" tool to provide state-of-the-art Monte Carlo power calculation methods to organizations using the JMP statistical software application. The "skpr" R package was released by IDA in 2017, and provides an integrated suite of tools for the generation and evaluation of experimental designs, enabling testers to perform highly accurate power calculations using Monte Carlo methods, use reproducible workflows, and automate complex DOE analyses in a way that follows IDA-developed best practices. However, some organizations have been unable to use "skpr" due to strict cybersecurity constraints that disallows installation of the R programming language in their computing environment, and thus have been unable to accurately generate power estimates for designs with non-linear responses, such as logistic regression. The "skprJMP" JMP plug-in implements a subset of the capabilities provided by "skpr" entirely within JMP, providing these organizations with the capability

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