**Introduction**

Moderation analysis is well-developed and widely-used in between-subjects, correlational or experimental designs, and primarily relies on including an interaction term in a multiple regression equation. This provides estimates of the conditional effect of the focal predictor (X) on the outcome (Y) conditional on the moderator (M).

![Diagram](image)

**Two-condition within subjects designs**, where each participant is measured in two conditions or at two time points, are very common in psychology. Moderation analysis in these designs examines if the effect of condition (manipulated within participants, e.g. happy story, sad story) on some outcome (measured in each condition; e.g., helping) depends on a moderator (measured once for each person and assumed constant over condition; e.g. empathy).

**Probing Methods for Probing**

Probing is a method for estimating and conducting inference on conditional effects. It allows the researcher to understand the pattern of conditional effects across the range of the moderator.

**Simple slopes (AKA Pick-a-point).** In this method researchers select a value of the moderator for which they would like to estimate the conditional effect of X on Y. An estimate of this effect and its standard error is calculated and compared to a t-distribution with proper degrees of freedom.

\[
\hat{b}_1 + \hat{b}_2 M
\]

![Diagram](image)

Johnson-Neyman Procedure. This method derives the values of the moderator for which there is a statistically significant effect of X on Y at a specific level of significance (α). These regions are defined by the boundaries of significance.

\[
M = \frac{-2(2b_0 - 2b_1 M + 2b_2 M^2) \pm \sqrt{(2b_0 - 2b_1 M + 2b_2 M^2)^2 - 4(2b_0 - 2b_1 M + 2b_2 M^2)(b_0^2 - b_1^2 M + b_2^2 M^2)}}{2(b_0^2 - b_1^2 M + b_2^2 M^2)}
\]

*Note: t* is critical t-value for a test with df degrees of freedom at level α

**Moderation in Two-Condition Within-Subjects Designs**

Judd et al. (1996, 2001) showed how to test for an interaction in two-condition within-subjects designs by first setting up models for the outcome in each condition, then taking the difference between them.

\[
\begin{align*}
Y_{i1} &= b_0 + b_1 M_i + \epsilon_i \\
Y_{i2} &= b_0 + b_2 M_i + \epsilon_i \\
Y_{i2} - Y_{i1} &= b_2 - b_1 (M_i - M) + \epsilon_i
\end{align*}
\]

The coefficient \(b_2\) indicates whether the relationship between M and Y depends on condition, and whether the relationship between condition and Y depends on M.

![Diagram](image)

**Probing in Two-Condition Within Subjects Designs**

Conditional Effects. The conditional effect of condition on Y at specific values of M is the difference in expected outcomes from each condition at a pre-specified value of the moderator.

\[
\theta_{C \rightarrow Y}(M) = b_0 + b_1 M
\]

The conditional effect of M on Y in a specific condition is the relationship between M and Y estimated in the condition of interest.

\[
\theta_{M \rightarrow Y}(C) = b_{1C}
\]

**Simple slopes (AKA Pick-a-point)**. The conditional effects can be estimated and tested by taking the ratio of the estimate to its standard error and comparing to a critical t-value.

\[
\frac{\hat{b}_0 + \hat{b}_1 M}{\text{SE} \left( \hat{b}_0 + \hat{b}_1 M \right)} \sim t_{df}
\]

**Johnson-Neyman Procedure**. This method can only be used to probe the effect of condition on the outcome along a continuous moderator. The effect of the moderator cannot be analyzed with this method because condition is dichotomous.

\[
M = \frac{-2b_0 + 2b_1 \text{var}(b_0, b_1) \pm \sqrt{(2b_0 + 2b_1 \text{var}(b_0, b_1))^2 - 4(2b_0 + 2b_1 \text{var}(b_0, b_1) - b_1^2 \text{var}(b_0, b_1))}}{2(b_1^2 \text{var}(b_0, b_1))}
\]

*Note: t* is critical t-value for a test with df degrees of freedom at level α

**Discussion**

This research expands methods of inference for within-subjects moderation to include probing, which is very popular in between-subjects designs. Probing allows the researcher to understand the pattern of effects along the range of the moderator. Specifically, for what values of the moderator are there significant effects of X on Y?

MEMORE makes the analysis easy for any researcher to conduct. This work, in combination with previous work will allow for estimation of moderated mediation models in two condition within-subjects designs.