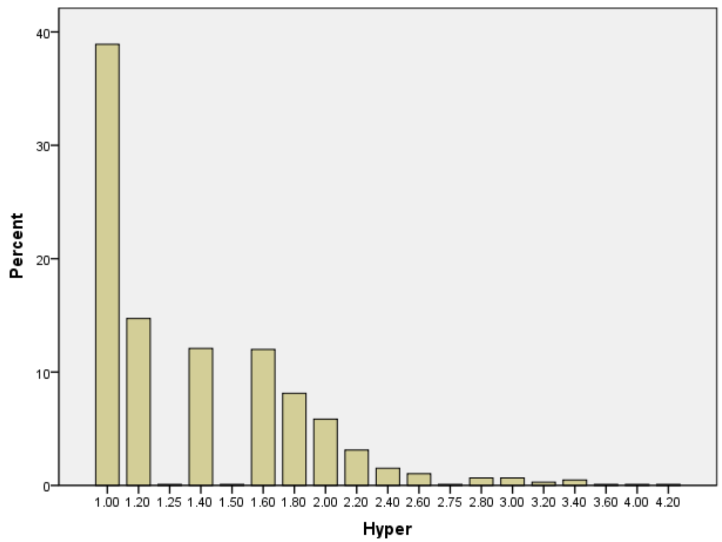
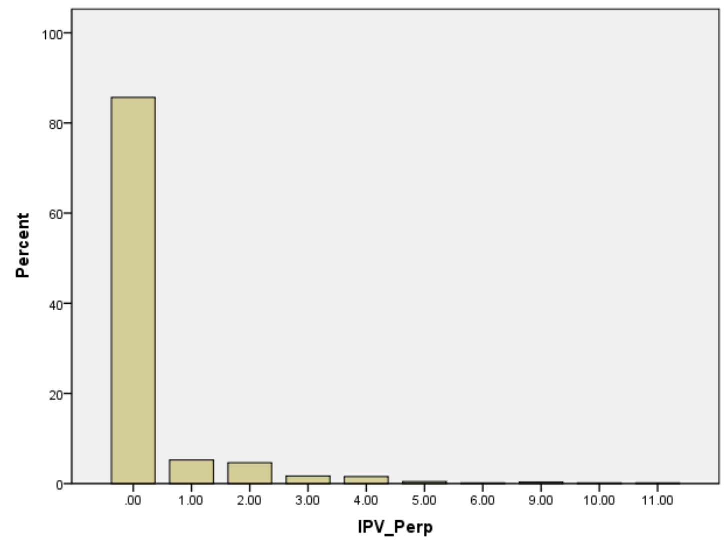
Example 5: Multivariate Multilevel Models for Non-Normal Outcomes in Mplus v. 8
(complete syntax and output for Mplus available electronically)

These (real) data come from a daily diary study that followed 41 male and female college students over a six-week period to examine within-person relationships among hyperarousal symptoms, alcohol use, and perpetration of intimate partner violence (IPV). To be eligible, potential participants had to be currently involved in a romantic relationship and have face-to-face contact with their partner at least once a week with no intentions of breaking up with their partner in the preceding six weeks. In addition, participants had to report using alcohol in the previous six weeks with no intention of abstaining from future alcohol use, and perpetrating or experiencing at least one instance of physical (e.g., pushing, shoving, slapping/punching, or choking), sexual (e.g., using threats or physical force to obtain sex), or psychological abuse (e.g., calling the partner stupid, worthless, or ugly) in the previous six months. Below are the distributions of the hyperarousal predictor (left) and intimate partner violence outcome (right) across all daily observations.

<u>Predictor</u>: Hyperarousal
(mean across items on 1-5 scale)



<u>Outcome</u>: Perpetration of Intimate Partner Violence (IPV = count of not-nice actions)



We will be examining several candidate models for IPV: Normal, Negative Binomial, Negative Binomial/Poisson Hurdle, and Two-Part Log. Although it may be somewhat suspect given its distribution above, for the sake of illustration we will treat hyperarousal as conditionally normal across models. We are, however, using the MLR estimator (i.e., robust maximum likelihood) that corrects the parameter standard errors (via the "sandwich" method) for non-normality.

Model 1: Normal Conditional Distribution

Later versions of the model generated this error:

```
*** ERROR in MODEL command
  Unrestricted x-variables for analysis with TYPE=TWOLEVEL and
  ALGORITHM=INTEGRATION must be specified as either a WITHIN or
  BETWEEN variable.  The following variable cannot exist on both
  levels:  HYPER
```

So we will use a latent variable work-around to trick Mplus:
This is only necessary for non-normal distributions

```
TITLE:      Model 1: Normal Conditional Distribution
DATA:       FILE = Example5.csv;  ! Syntax in same folder as data
VARIABLE:
NAMES = PersonID hyper alc IPV;  ! List ALL variables in data file
USEVARIABLES = hyper IPV;        ! Variables included in this model
MISSING ARE ALL (-99);           ! Missing data identifier
CLUSTER = PersonID;              ! Level-2 ID
! No extra code here means each outcome is conditionally normal

ANALYSIS: TYPE = TWOLEVEL RANDOM;   ! In case of random slopes
          ESTIMATOR = MLR;          ! For non-normal hyper
MODEL:
%WITHIN%
 hyper IPV;       ! L1 R: residual variances
 IPV ON hyper;    ! L1 WP fixed effect

%BETWEEN%
! Move hyper random intercept to new latent variable
  Fhyper BY hyper@1;
! Shut off hyper random intercept variance
  hyper@0;
! IPV and hyper fixed intercepts (hyper=grand-mean-centered)
  [hyper IPV];
! Shut off new latent variable intercept
  [Fhyper@0];
! L2 G: random intercept variances
  Fhyper IPV;
! L2 BP fixed effect using new latent variable
  IPV ON Fhyper;
```

```
                Intraclass                 Intraclass → Only given
     Variable   Correlation    Variable   Correlation    for normal
    HYPER          0.464         IPV         0.521

Number of Free Parameters                        8
Loglikelihood
          H0 Value                       -1385.261
          H0 Scaling Correction Factor       7.021 → 1 means normal
            for MLR
          H1 Value                       -1385.261
          H1 Scaling Correction Factor       7.021
```

```
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
Within Level

FOR EVERY UNIT INCREASE IN L1 WP HYPER, L1 WP IPV INCREASES BY .396:
MORE HYPER THAN USUAL PREDICTS MORE IPV THAT DAY
IPV      ON
    HYPER              0.396      0.112      3.547      0.000

L1 RESIDUAL VARIANCE (NOTHING PREDICTING HYPER)
Variances
    HYPER              0.132      0.024      5.577      0.000

L1 RESIDUAL LEFT OVER VARIANCE (IPV IS PREDICTED BY HYPER)
Residual Variances
    IPV                0.783      0.242      3.230      0.001

Between Level

INTERCEPT VARIANCE IN HYPER HAS BEEN MOVED TO FHYPER TO TRICK MPLUS
FHYPER   BY
    HYPER              1.000      0.000    999.000    999.000

FOR EVERY UNIT INCREASE IN L2 BP HYPER, L2 BP IPV INCREASES BY .850:
MORE L2 MEAN HYPER THAN OTHERS ALMOST PREDICTS MORE L2 MEAN IPV THAN
OTHERS
IPV      ON
    FHYPER             0.850      0.465      1.828      0.067

FIXED INTERCEPT FOR HYPER IS FIXED TO 0 TO CREATE GRAND-MC VERSION
Means
    FHYPER             0.000      0.000    999.000    999.000

FIXED INTERCEPT FOR HYPER
(HYPER IS UNCONDITIONAL SINCE IT IS NOT BEING PREDICTED BY ANYTHING)
Intercepts
    HYPER              1.436      0.056     25.716      0.000

FIXED INTERCEPT FOR IPV (FOR SOMEONE WITH AVERAGE HYPER ACROSS DAYS)
Intercepts
    IPV                0.561      0.146      3.848      0.000

L2 RANDOM INTERCEPT VARIANCE (NOTHING PREDICTING HYPER)
Variances
    FHYPER             0.115      0.025      4.663      0.000

L2 RANDOM INTERCEPT VARIANCE LEFTOVER (IPV IS PREDICTED BY FHYPER)
Residual Variances
    HYPER              0.000      0.000    999.000    999.000
    IPV                0.793      0.460      1.725      0.084
```

Model 2: Negative Binomial Conditional Distribution

So we will use a latent variable work-around to trick Mplus:

```
TITLE:      Model 2: Negative Binomial (predict log of level-1 count)
DATA:       FILE = Example5.csv;  ! Syntax in same folder as data
VARIABLE:
NAMES = PersonID hyper alc IPV;  ! List ALL variables in data file
USEVARIABLES = hyper IPV;        ! Variables included in this model
MISSING ARE ALL (-99);           ! Missing data identifier
CLUSTER = PersonID;              ! Level-2 ID
COUNT = IPV (nb);  ! Now IPV is negative binomial (stretchy poisson)

! Do not need DEFINE for grand-mean-centering anymore (see below)

ANALYSIS: TYPE = TWOLEVEL RANDOM;    ! In case of random slopes
          ESTIMATOR = MLR;           ! For non-normal hyper
          ALGORITHM = INTEGRATION;   ! Because of COUNT option
MODEL:
%WITHIN%
 hyper;           ! L1 R: residual variance for hyper
 IPV;             ! L1 dispersion for IPV
 IPV ON hyper;    ! L1 WP fixed effect

%BETWEEN%
! Move hyper random intercept to new latent variable
  Fhyper BY hyper@1;
! Shut off hyper random intercept variance
  hyper@0;
! IPV and hyper fixed intercepts (hyper=grand-mean-centered)
  [hyper IPV];
! Shut off new latent variable intercept
  [Fhyper@0];
! L2 G: random intercept variances
  Fhyper IPV;
! L2 BP fixed effect using new latent variable
  IPV ON Fhyper;
```

Mplus is still confused, but lets us fit the model anyway…

```
*** WARNING in MODEL command
  In the MODEL command, the following variable is a y-variable on the
  BETWEEN level and an x-variable on the WITHIN level.  This variable
  will be treated as a y-variable on both levels:  HYPER
```

```
                                                        Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
Within Level

FOR EVERY UNIT HIGHER L1 WP HYPER, LOG OF L1 WP IPV IS HIGHER BY 1.348:
MORE HYPER THAN USUAL PREDICTS MORE IPV THAT DAY (AS BEFORE)
 IPV        ON
    HYPER              1.348      0.359      3.751      0.000

L1 RESIDUAL VARIANCE (NOTHING PREDICTING HYPER)
 Variances
    HYPER              0.132      0.024      5.577      0.000

"STRETCHINESS FACTOR" - NB FITS BETTER THAN POISSON, WHICH IS INDICATED
BY SIG. P-VALUE OR -2ΔLL. IF POISSON FITS OK DISPERSION SHOULD EQUAL 0)
 Dispersion
    IPV                2.441      0.679      3.594      0.000

Between Level (TERMS FIXED TO 1 OR 0 OMITTED FOR BREVITY)

FOR EVERY UNIT HIGHER L2 BP HYPER, LOG OF L2 BP IPV IS HIGHER BY .850:
MORE L2 MEAN HYPER THAN OTHERS DOES NOT PREDICT MORE L2 MEAN IPV THAN
OTHERS
 IPV        ON
    FHYPER             0.530      0.786      0.674      0.500

FIXED INTERCEPT FOR HYPER
(HYPER IS UNCONDITIONAL SINCE IT IS NOT BEING PREDICTED BY ANYTHING)
 Intercepts
    HYPER              1.436      0.056     25.716      0.000

FIXED INTERCEPT FOR IPV (FOR SOMEONE WITH AVERAGE FHYPER ACROSS DAYS)
    IPV               -3.494      0.653     -5.347      0.000

L2 RANDOM INTERCEPT VARIANCE (NOTHING PREDICTING FHYPER)
 Variances
    FHYPER             0.114      0.024      4.665      0.000

L2 RANDOM INTERCEPT VARIANCE LEFTOVER (IPV IS PREDICTED BY FHYPER)
 Residual Variances
    IPV                1.869      0.666      2.809      0.005
```

Model 3/4: Negative Binomial/Poisson Hurdle Conditional Distribution

We will use the same latent variable work-around to trick Mplus:

```
TITLE:    Model 3: Negative Binomial Hurdle
          (predict logit of 0, or log of level-1 count if not 0)

DATA:      FILE = Example5.csv;  ! Syntax in same folder as data
VARIABLE:
NAMES = PersonID hyper alc IPV;  ! List ALL variables in data file
USEVARIABLES = hyper IPV;        ! Variables included in this model
MISSING ARE ALL (-99);           ! Missing data identifier
CLUSTER = PersonID;              ! Level-2 ID
COUNT = IPV (nbh);  ! IPV is negative binomial hurdle (if, how much)

ANALYSIS: TYPE = TWOLEVEL RANDOM;   ! In case of random slopes
          ESTIMATOR = MLR;          ! For non-normal hyper
          ALGORITHM = INTEGRATION;  ! Because of COUNT option
MODEL:
%WITHIN%
 hyper;              ! L1 R: residual variance for hyper
 IPV;                ! L1 dispersion for IPV
 IPV   ON hyper;     ! L1 WP fixed effect for LOG HOW MUCH IF NOT 0
 IPV#1 ON hyper;     ! L1 WP fixed effect for LOGIT of 0 (not 1)

%BETWEEN%
! Move hyper random intercept to new latent variable
  Fhyper BY hyper@1;
! Shut off hyper random intercept variance
  hyper@0;
! Hyper fixed intercept (hyper=grand-mean-centered)
! IPV: fixed intercepts for amount and for logit of 0
  [hyper IPV IPV#1];
! Shut off new latent variable intercept
  [Fhyper@0];
! L2 G: random intercept variances
  Fhyper IPV IPV#1;
! L2 BP fixed effects using new latent variable
  IPV   ON Fhyper;  ! L2 BP fixed effect for LOG HOW MUCH IF NOT 0
  IPV#1 ON Fhyper;  ! L2 BP fixed effect for LOGIT of 0 (not 1)
  IPV WITH IPV#1;   ! L2 G: random intercept covariance
```

The model did not converge, possibly because it could not estimate a IPV dispersion for the "how much" part. So I tricked it into a Poisson-like hurdle model by fixing the dispersion to .001 (now Model 4):

```
%WITHIN%
 hyper;              ! L1 R: residual variance for hyper
 IPV@.001;           ! Fix L1 dispersion for IPV to mimic Poisson
 IPV   ON hyper;     ! L1 WP fixed effect for LOG HOW MUCH IF NOT 0
 IPV#1 ON hyper;     ! L1 WP fixed effect for LOGIT of 0 (not 1)
```

```
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
Within Level

GIVEN L1 IPV>0, MORE HYPER THAN USUAL DOES NOT PREDICT HOW MUCH L1 IPV
(LOG OF NON-0 COUNT HIGHER BY .054 PER UNIT L1 HYPER)
IPV        ON
    HYPER              0.054      0.131      0.412      0.680

MORE HYPER THAN USUAL --> LESS LIKELY TO BE IPV=0 (SO WILL PRY DO IPV)
LOGIT OF L1 IPV=0 LOWER BY 1.557 PER UNIT MORE HYPER THAN USUAL
 IPV#1      ON
    HYPER             -1.557      0.443     -3.516      0.000

L1 RESIDUAL VARIANCE (NOTHING PREDICTING HYPER)
 Variances
    HYPER              0.132      0.024      5.576      0.000
 Dispersion - FIXED TO MIMIC POISSON HURDLE (NO MORE STRETCHY)
    IPV                0.001      0.000    999.000    999.000

Between Level (TERMS FIXED TO 1 OR 0 OMITTED FOR BREVITY)

AMONG HITTERS, MORE MEAN HYPER THAN OTHERS DOES NOT PREDICT MORE MEAN
IPV THAN OTHERS (LOG OF NON-0 COUNT HIGHER BY .603 PER UNIT L2 HYPER)
IPV        ON
    FHYPER             0.603      0.430      1.402      0.161

MORE MEAN HYPER THAN OTHERS DOES NOT PREDICT TENDENCY TO NOT HIT
(LOGIT OF IPV=0 LOWER BY .383 PER UNIT L2 HYPER)
 IPV#1      ON
    FHYPER            -0.383      0.866     -0.442      0.658

THOSE WITH MORE PROBABILITY OF IPV=1 HAVE BIGGER TENDENCY FOR BIG IPV
 IPV       WITH
    IPV#1             -0.784      0.303     -2.585      0.010

 Intercepts
    HYPER              1.435      0.055     25.881      0.000
FIXED INTERCEPT FOR LOGIT OF IPV=0 WHEN FHYPER=0
    IPV#1              4.159      0.718      5.792      0.000
FIXED INTERCEPT FOR LOG IPV (IF NOT 0) WHEN FHYPER=0
    IPV                0.140      0.251      0.558      0.577

L2 RANDOM INTERCEPT VARIANCE (NOTHING PREDICTING HYPER)
 Variances
    FHYPER             0.115      0.024      4.682      0.000

L2 RANDOM INTERCEPT VARIANCE LEFTOVER (IPV IS PREDICTED BY HYPER)
 Residual Variances
    IPV#1              2.116      0.790      2.677      0.007
    IPV                0.291      0.130      2.233      0.026
```

Model 5: Two-Part Distribution Model (with log transform for continuous part)

```
TITLE:    Model 5: Two-Part
          (predict logit of 1, log of level-1 continuous amount if 1)

DATA:     FILE = Example5.csv;   ! Syntax in same folder as data

DATA TWOPART:    ! Instructs Mplus to cut up IPV into 0/log of amount
NAMES = IPV; BINARY = BIPV; CONTINUOUS = CIPV;
CUTPOINT = 0; TRANSFORM = LOG;   ! Or NONE for no transformation

VARIABLE:
NAMES = PersonID hyper alc IPV;  ! List ALL variables in data file
USEVARIABLES = hyper BIPV CIPV;  ! Variables included in this model
CATEGORICAL = BIPV;              ! Indicate binary outcome
MISSING ARE ALL (-99);           ! Missing data identifier
CLUSTER = PersonID;              ! Level-2 ID

ANALYSIS: TYPE = TWOLEVEL RANDOM;   ! In case of random slopes
          ESTIMATOR = MLR;          ! For non-normal hyper
MODEL:
%WITHIN%
 hyper;            ! L1 R: residual variance for hyper
 CIPV;             ! L1 R: residual variance for amount IPV
 CIPV ON hyper;    ! L1 WP fixed effect for LOG HOW MUCH IF 1
 BIPV ON hyper;    ! L1 WP fixed effect for LOGIT of 1 (not 0)

%BETWEEN%
! Move hyper random intercept to new latent variable
  Fhyper BY hyper@1;
! Shut off hyper random intercept variance
  hyper@0;
! Hyper fixed intercept (hyper=grand-mean-centered)
! IPV: fixed intercept for amount and fixed threshold for logit of 1
  [hyper CIPV BIPV$1];
! Shut off new latent variable intercept
  [Fhyper@0];
! L2 G: random intercept variances
  Fhyper CIPV BIPV;
! L2 BP fixed effects using new latent variable
  CIPV ON Fhyper;  ! L2 BP fixed effect for LOG HOW MUCH IF 1
  BIPV ON Fhyper;  ! L2 BP fixed effect for LOGIT of 1 (not 0)
  CIPV WITH BIPV;  ! L2 G: random intercept covariance
```

```
                                                       Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
Within Level

GIVEN L1 IPV>0, MORE HYPER THAN USUAL DOES NOT PREDICT HOW MUCH L1 IPV
(LOG OF NON-0 COUNT HIGHER BY .139 PER UNIT L1 HYPER)
CIPV       ON
    HYPER              0.139       0.093      1.494      0.135

MORE HYPER THAN USUAL --> MORE LIKELY TO BE IPV=1 (SO WILL PRY DO IPV)
LOGIT OF L1 IPV=1 HIGHER BY 1.589 PER UNIT MORE HYPER THAN USUAL
 BIPV      ON
    HYPER              1.589       0.447      3.552      0.000

L1 RESIDUAL VARIANCE (NOTHING PREDICTING HYPER)
 Variances
    HYPER              0.132       0.024      5.577      0.000
L1 RESIDUAL VARIANCE LEFTOVER (IPV IS PREDICTED BY HYPER)
 Residual Variances
    CIPV               0.271       0.039      7.037      0.000

Between Level (TERMS FIXED TO 1 OR 0 OMITTED FOR BREVITY)

AMONG HITTERS, MORE MEAN HYPER THAN OTHERS DOES NOT PREDICT MORE MEAN
IPV THAN OTHERS (LOG OF NON-0 COUNT HIGHER BY .242 PER UNIT L2 HYPER)
 CIPV      ON
    FHYPER             0.242       0.271      0.892      0.372

MORE MEAN HYPER THAN OTHERS DOES NOT PREDICT TENDENCY TO NOT HIT
(LOGIT OF IPV=1 HIGHER BY .407 PER UNIT L2 HYPER)
 BIPV      ON
    FHYPER             0.407       0.878      0.463      0.643

THOSE WITH MORE PROBABILITY OF IPV=1 HAVE BIGGER TENDENCY FOR BIG IPV
 CIPV     WITH
    BIPV               0.468       0.212      2.207      0.027

 Intercepts
    HYPER              1.436       0.056     25.778      0.000
FIXED INTERCEPT FOR LOG IPV (IF NOT 0) WHEN FHYPER=0
    CIPV               0.458       0.072      6.315      0.000
THRESHOLD*-1 = FIXED INTERCEPT FOR LOGIT OF IPV=1 WHEN FHYPER=0
 Thresholds
    BIPV$1             4.176       0.730      5.724      0.000

L2 RANDOM INTERCEPT VARIANCE (NOTHING PREDICTING HYPER)
 Variances
    FHYPER             0.114       0.025      4.661      0.000
L2 RANDOM INTERCEPT VARIANCE LEFTOVER (IPV IS PREDICTED BY HYPER)
 Residual Variances
    BIPV               2.092       0.793      2.639      0.008
    CIPV               0.120       0.060      2.017      0.044
```

So which model should we choose to interpret? Unfortunately, relative fit statistics (AIC and BIC) are not comparable across the normal, count-based, and two-part families. What we can do is examine the predicted outcomes for each model and see what seems reasonable. The first plots below (from excel) show the predicted amount of IPV for ±2SD of within-person (WP) and between-person (BP) hyperarousal. The WP effect for amount of IPV is significant in the normal and Negative Binomial models. As we can see, the normal model predicts a significant linear relationship, which will eventually extend below 0, whereas the WP effect from other models for the predicted log of the count instead should "shut off" as it approaches 0 (because of the log link transformation—that is its purpose). In contrast, both "if and how much" type models—the Poisson Hurdle and the Two-Part Log—have expected counts that do not approach 0, because that zero-part aspect of the data is modeled as a separate outcome instead. So after dividing the outcome into"0 vs. something", these two models suggest there is no WP relationship for "something". In contrast, they have small but significant WP relationships for the "if" part of each model (in the second figures).