Appendix A

The following SAS code is an example for fitting the Global Odds model with 3 levels for each outcome, Y and Z. The words in bold should be replaced to represent the data of interest.

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*****************************************
* Sample SAS code to run the Global Odds model   *
*****************************************;

proc nlmixed data = DataNam tech = trureg optcheck cov;
*If you have a 3 level in each outcome, you will have 4 intercepts. Use initial values obtained by fitting separate logistic regressions. The term "YTrend InitialValue" and "ZTrend InitialValue" is included when the trend odds holds respectively for Y and Z.;
  parms
     YIntercept1 InitialValue YIntercept2 InitialValue
     ZIntercept1 InitialValue ZIntercept2 InitialValue GlobalOddsIntercept InitialValue
     YBeta InitialValue ZBeta InitialValue YZBeta InitialValue
     YTrend InitialValue ZTrend InitialValue;
  array Y_intercept{2}       YIntercept1 - YIntercept2;
  array Z_intercept{2}        ZIntercept1 - ZIntercept2;
  array eta{2}                eta1 - eta2;
  array ksi{2}                ksi1 - ksi2;
  array Ypr{3}   Yp1 - Yp3;
  array Zpr{3}    Zp1 - Zp3;
  array YZpr{3,3}     YZp1 - YZp9;
  array YZcpr{3,3}    F1  - F9;
  array S_terms{3,3}      S1  - S9;
  array psi{3,3}              psi1 - psi9;
  array log_psi{3,3}        log_psi1 - log_psi9;
  do i = 1 to 2;
*The term "+ i*YTrend*RiskFactorforY" is included when the trend odds holds for Y.
      eta[i] = Y_intercept[i] + YBeta*RiskFactorforY + i*YTrend*RiskFactorforY;
     Ypr[i] = exp(eta[i]) / (1+ exp(eta[i]));
 end;
  do j = 1 to 2;
*The term "+ j*YTrend*RiskFactorforY" is included when the trend odds holds for Z.
      ksi[j] = Z_intercept[j] + ZBeta*RiskFactorforZ+ j*ZTrend*RiskFactorforY;
      Zpr[j] = exp(ksi[j]) / (1+ exp(ksi[j]));
  end;
  do i = 1 to 3;
      do j = 1 to 3;
```

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        log_psi[i,j] = GlobalOddsIntercept + YZBeta*RiskFactorforGlobalOdds;
      end;
 end;
Ypr[3] = 1;   Zpr[3]  = 1;   YZcpr[3,3] = 1;   psi[1,1] = exp(log_psi[1,1]);
YZcpr[1,1] = ( 1 + (Yp1+ Zp1)*(psi[1,1]-1) - (sqrt(  (1+( Yp1+Zp1)*(psi[1,1]-1))**2 +
                  4*psi[1,1]*(1-psi[1,1])* Yp1* Zp1)) ) / (2*(psi[1,1]-1));
YZpr[1,1]  = YZcpr[1,1];
 if Y = 1 and Z = 1 then z = YZpr[1,1];
 do i = 2 to 3;
      psi[i,1] = exp(log_psi[i,1]);
      YZcpr[i,1] = ( 1 + (Ypr[i]+Zpr[1])*(psi[i,1]-1) - (sqrt(  (1+(Ypr[i]+Zpr[1])*(psi[i,1]-1))**2
                          + 4*psi[i,1]*(1-psi[i,1])*Ypr[i]*Zpr[1])) ) / (2*(psi[i,1]-1));
      YZpr[i,1] = YZcpr[i,1] - YZcpr[i-1,1];
       if Y = i and Z = 1 then z = YZpr[i,1];
 end;
 do j = 2 to 3;
      psi[1,j] = exp(log_psi[1,j]);
      YZcpr[1,j] = (1+(Ypr[1]+Zpr[j])*(psi[1,j]-1) - (sqrt( (1+(Ypr[1]+Zpr[j])*(psi[1,j]-1))**2
                          + 4*psi[1,j]*(1-psi[1,j])*Ypr[1]*Zpr[j]))) / (2*(psi[1,j]-1));
      YZpr[1,j] = YZcpr[1,j] - YZcpr[1,j-1];
      if Y = 1 and Z = j then z = YZpr[1,j];
 end;
 do i = 2 to 3;
    do j = 2 to 3;
       psi[i,j] = exp(log_psi[i,j]);
       YZcpr[i,j] = (1+(Ypr[i]+Zpr[j])*(psi[i,j]-1) - (sqrt( (1+(Ypr[i]+Zpr[j])*(psi[i,j]-1))**2
                         + 4*psi[i,j]*(1-psi[i,j])*Ypr[i]*Zpr[j]))) / (2*(psi[i,j]-1));
       YZpr[i,j] = YZcpr[i,j]-YZcpr[i-1,j]-YZcpr[i,j-1]+ YZcpr[i-1,j-1];
       if Y = i and Z = j then z = YZpr[i,j];
    end;
end;
      if (z > 1e-8) then ll =  log(z);
              else ll = -1e100;
       model ll ~ general(ll);
run;quit;
```

Appendix B. Bivariate distribution of differences in probability. Top graph is the PDF(Y*,Z*|ψ=10)- PDF(Y*,Z*|ψ=0), and bottom graph is the PDF(Y*,W*|ψ=10)- PDF(Y*,W*|ψ=0), for Y*~Logistic(15,2), Z*~Logistic(10,2) and W*~Logistic(10,1).