Supplement

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Video game stimuli

Here are hyperlinks to demo footage of the four modified games on YouTube:

Violent, difficult

Less-violent, difficult

Violent, easy

Less-violent, easy

Manipulation checks

Here we provide the full model output for the effects of condition on the manipulation checks.

Participants' responses to "The game involved a great deal of violence" were influenced by game violence but not difficulty.

```
##
## Call:
## lm(formula = violence ~ Difficulty * Violence, data = dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.4355 -1.1613 -0.1613  0.9063  3.8387
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)          3.73820    0.09188  40.685   <2e-16 ***
## Difficulty1         -0.06018    0.09188  -0.655    0.513
## Violence1            1.52641    0.09188  16.613   <2e-16 ***
## Difficulty1:Violence1 -0.11068   0.09188  -1.205    0.230
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.45 on 245 degrees of freedom
##   (26 observations deleted due to missingness)
## Multiple R-squared:  0.5311, Adjusted R-squared:  0.5254
## F-statistic:  92.5 on 3 and 245 DF,  p-value: < 2.2e-16

## Warning: Removed 26 rows containing non-finite values (stat_count).
```

Violent Content Manipulation Check
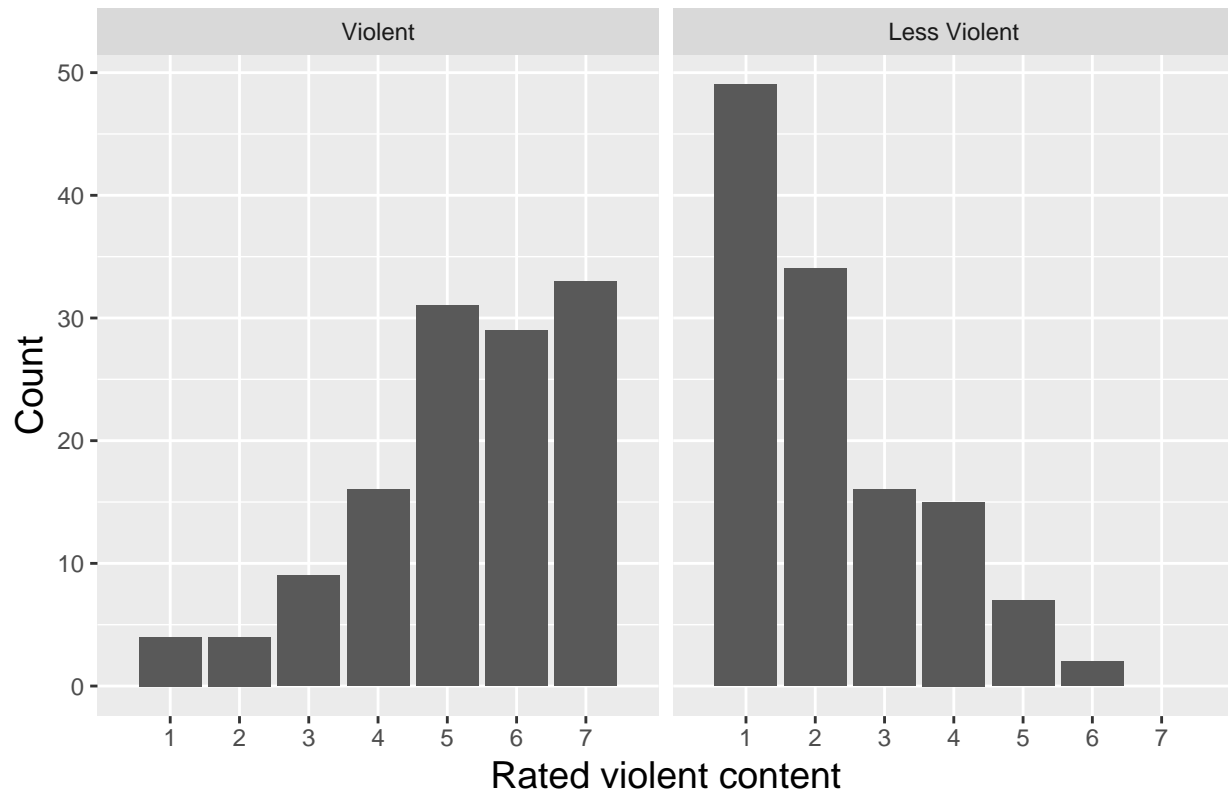
Participants' responses to "I felt I behaved aggressively during the game" were mostly influenced by game violence, but there was a hint of an interaction with difficulty.

```
##
## Call:
## lm(formula = aggressed ~ Violence * Difficulty, data = dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.8710 -1.5968  0.0656  1.4032  4.0656
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)           3.1826     0.1054  30.190   <2e-16 ***
## Violence1             0.4170     0.1054   3.955   0.0001 ***
## Difficulty1          -0.0513     0.1054  -0.487   0.6270
## Violence1:Difficulty1 -0.2201    0.1054  -2.088   0.0378 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.663 on 245 degrees of freedom
##   (26 observations deleted due to missingness)
## Multiple R-squared:  0.07603,    Adjusted R-squared:  0.06472
## F-statistic:  6.72 on 3 and 245 DF,  p-value: 0.0002246

## Warning: Removed 26 rows containing non-finite values (stat_count).
```
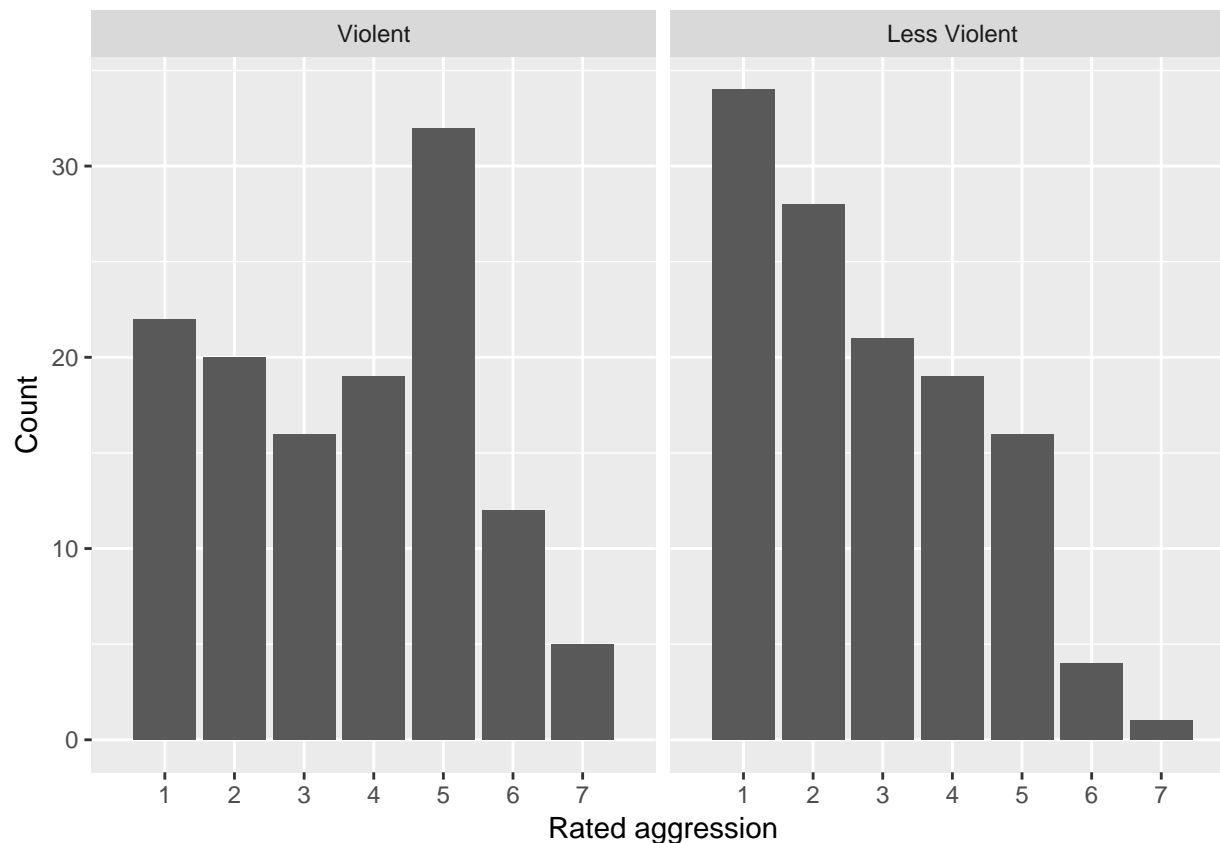
The latent factor representing challenge (see "Exploratory analyses" for details on factor structure) was affected by difficulty but not by violence.

```
##
## Call:
## lm(formula = challenge ~ Violence * Difficulty, data = dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.2762 -0.5953 -0.1238  0.5225  3.1676
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)         -0.004798   0.053625  -0.089    0.929
## Violence1            0.035034   0.053625   0.653    0.514
## Difficulty1          0.330015   0.053625   6.154 3.09e-09 ***
## Violence1:Difficulty1 0.019825  0.053625   0.370    0.712
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8426 on 243 degrees of freedom
##   (28 observations deleted due to missingness)
## Multiple R-squared:  0.137,  Adjusted R-squared:  0.1264
## F-statistic: 12.86 on 3 and 243 DF,  p-value: 7.937e-08

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.

## Warning: Removed 28 rows containing non-finite values (stat_bin).
```

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Difficulty Manipulation Check
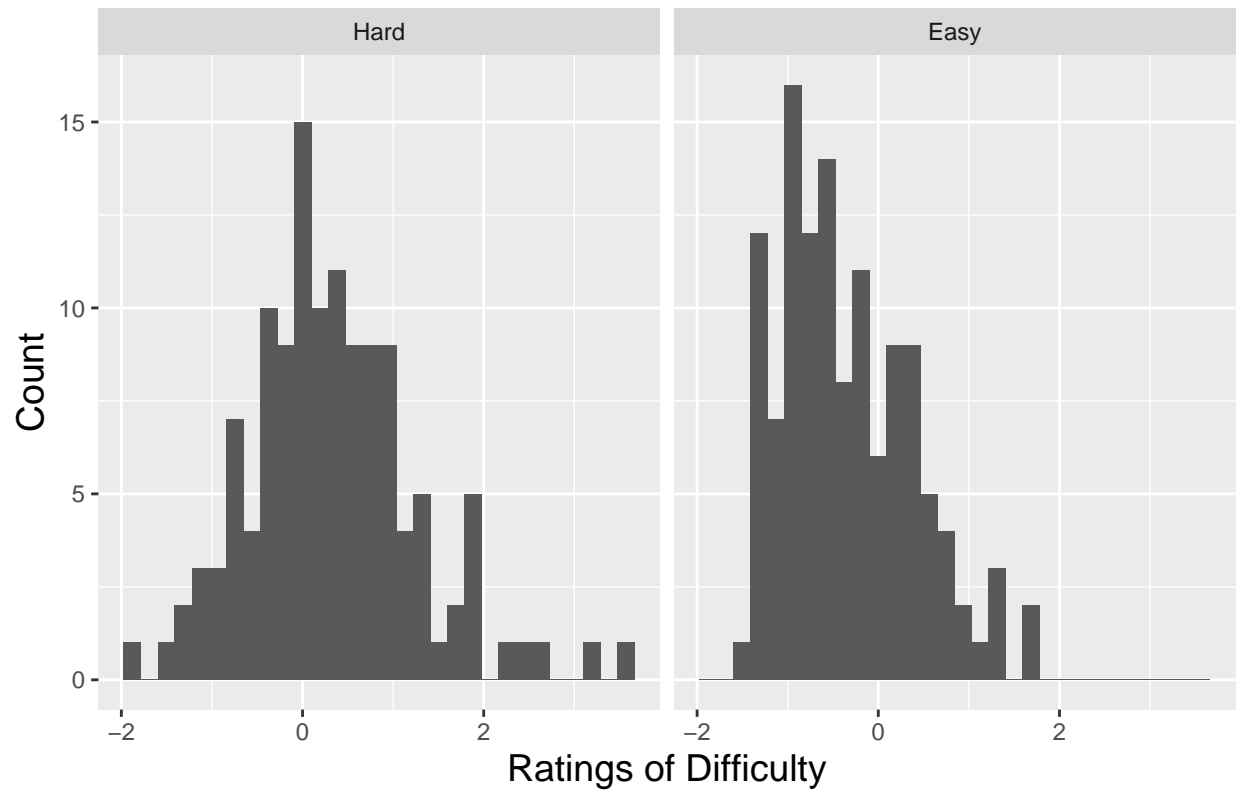
Distribution of outcome
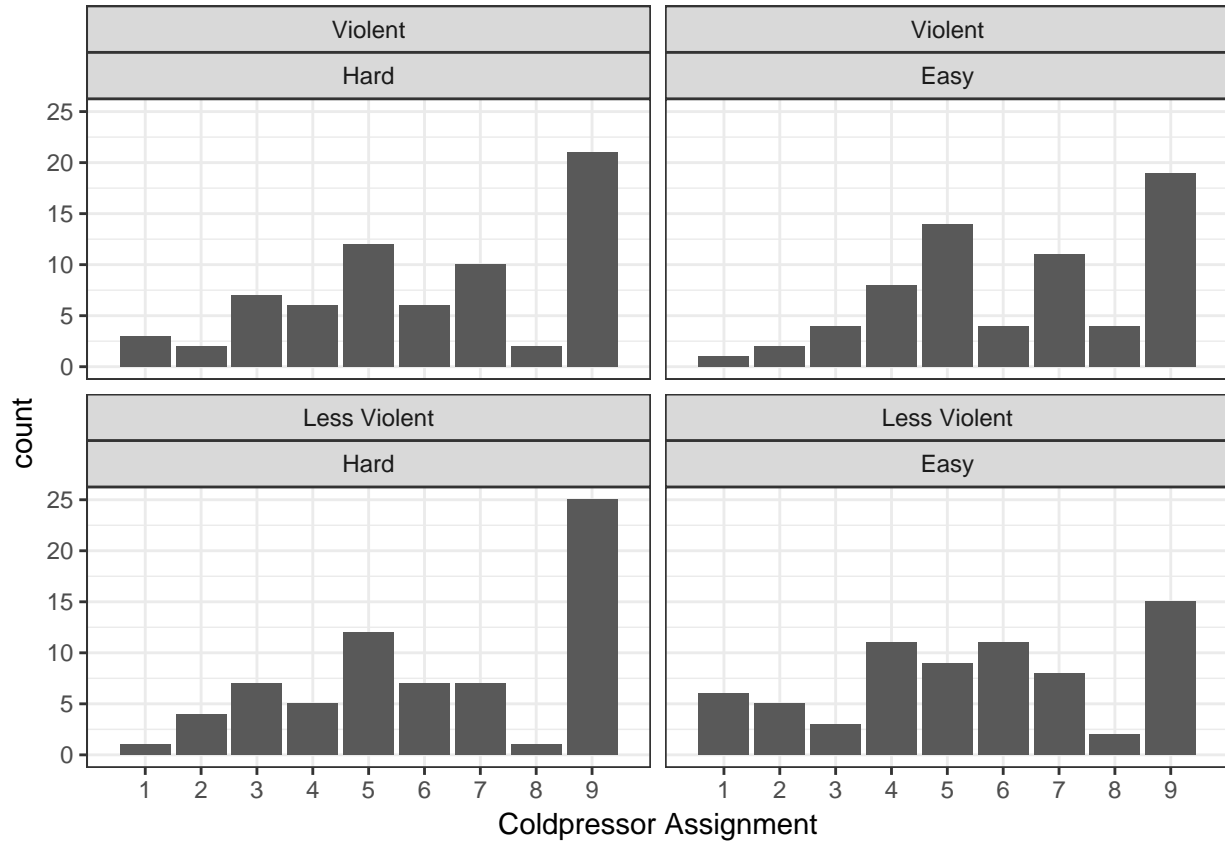
This histogram provides greater detail into the non-normality of the outcome.

**Provocation and aggression**

Participants generally indicated that they were irritated ($M = 5.0$, $SD = 1.7$), angered ($M = 4.2$, $SD = 1.8$), and annoyed ($M = 4.9$, $SD = 1.8$) by their partner. Furthermore, they were neither happy ($M = 2.4$, $SD = 1.4$) nor pleased ($M = 2.2$, $SD = 1.4$) with their partner and found the feedback unhelpful ($M = 1.7$, $SD = 1.3$).

The 6 items about the interaction with the partner were submitted to parallel analysis. Parallel analysis recommended two factors. Factor 1 had loadings >.65 on irritated, angered, and annoyed, with loadings < .3 otherwise. Factor 2 had loadings .57, .61, and .89 for happy, helpful, and pleased.

```
##
## Loadings:
##            MR1    MR2
## irritated  0.77
## happy     -0.25  0.57
## angered    0.76  0.14
## helpful           0.61
## pleased           0.89
## annoyed    0.67 -0.13
##
##                  MR1    MR2
## SS loadings    1.683  1.534
```

```
## Proportion Var 0.280 0.256
## Cumulative Var 0.280 0.536
```
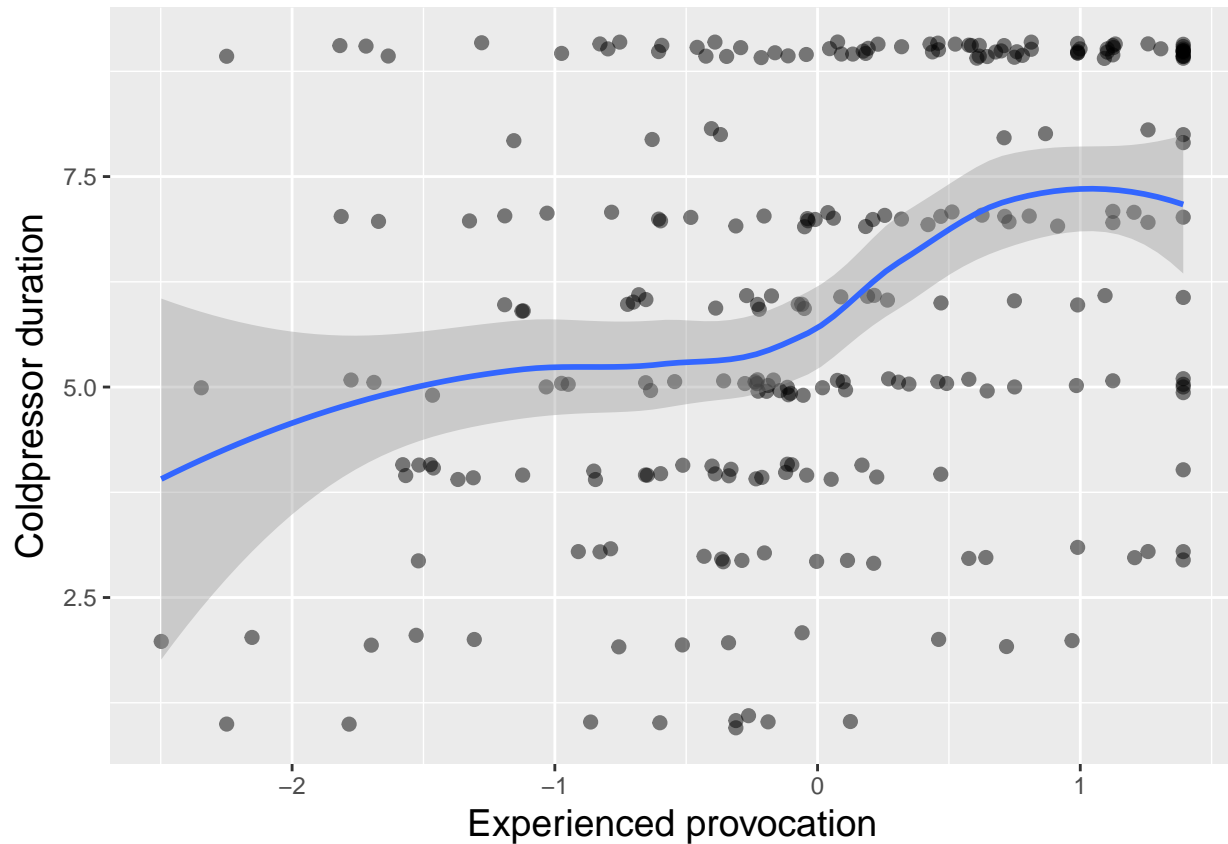

This scatterplot shows the relationship between Factor 1 and cold pressor assignments. A locally-weighted regression curve (LOESS) with shaded standard error region is overlaid. Slight vertical jitter is added to reduce overplotting. Participants who reported being more irritated, angered, and annoyed by their partner assigned greater cold pressor durations.

Censored regression.

To attempt to ameliorate the potential ceiling effect, a censored regression model was fit with the 'censReg' package for R (Henningsen, 2013). This fits a censored-regression Tobit model and attempts to model values that exceed the maximum of the scale.

Application of this analysis to 2 Violence × 2 Difficulty ANOVA found no significant effects of violence ($t(270) = 0.87$, $p = .386$, $r = .05$ [-.07, .17]), difficulty ($t(270) = 1.23$, $p = .219$, $r = .07$ [-.05, .19]), or their interaction ($t(270) = -1.68$, $p = .092$, $r = -.10$ [-.22, .02]). A significant effect of irritation with the partner's feedback was observed, but applying this as a covariate did not affect the primary results.

Main effects of 2D:4D on aggression were again negligible. Left 2D:4D did not predict aggression, $t(264) = -0.94$, $p = .345$, $b = -.21$ [-.64, .22], nor did right 2D:4D, $t(265) = 0.57$, $p = .57$, $b = .12$ [-.31, .56]. Application of composite irritation as a covariate did not influence the estimated effect. Higher-order interactions of 2D:4D with factors of Violence or Difficulty were not supported by the results (all $|t| < 1$), with the exception of a Difficulty × Violence × Right 2D:4D interaction that was barely significant after adjusting for irritation ($p = .044$).

Logistic regression.

Another possibility is that participants completed the coldpressor assignment in one of two ways: either they followed instructions and randomly assigned the other participant to a value between 1 and 9, or they decided to aggress and assign the other participant the maximum value. To model this possibility, we treated the response variable as a dichotomous outcome. Participants assigning values 1-8 were treated as one category (nonaggressive response) and participants assigning value 9 were treated as the other (aggressive response). Logistic regression was performed to test whether the odds of aggressing were influenced by the experimental assignment.

We conducted a 2 Violence × 2 Difficulty ANOVA with a logistic link function. Violence did not appear to influence aggression, $z = 0.21$, $p = .836$, $OR = 1.03$ [0.79, 1.34]. Difficulty also had a minimal effect on aggression, $z = 1.55$, $p = .121$, $OR = 1.23$ [0.95, 1.61]. Application of composite irritation as a covariate to these models revealed an effect of composite irritation, $z = 4.17$, $p < .001$, $OR = 2.11$ [1.5, 3.03], but did not increase the estimated effects of violence, difficulty, or their interaction.

Main effects of 2D:4D on aggression were again negligible. Left 2D:4D did not predict aggression, $z = -0.38$, $p = .703$, $OR = 0.95$ [0.72, 1.24], nor did right 2D:4D, $z = 0.4$, $p = .689$, $OR = 1.06$ [0.81, 1.39]. Application of composite irritation as a covariate did not influence the estimated effect. Higher-order interactions of 2D:4D with factors of Violence or Difficulty were not supported by the results (all $|t| < 1.53$).

Ordinal regression.

The outcome could also be treated as an ordinal value. We used ordinal logistic regression via the "ordinal" package for R (Christensen, 2018) to fit the 2 Violence × 2 Difficulty ANOVA. No significant effects were observed. Addition of left or right 2d4d ratio to these models revealed no significant effects.

Applying composite irritation as a covariate generally did not affect the results. As with the censored regression approach above, the Violence × Difficulty × Right 2D:4D interaction just reached significance after adjustment for irritation ($p = .019$).

```
## formula: ordered(DV) ~ Violence * Difficulty
## data:    dat
##
##  link  threshold nobs logLik  AIC     niter max.grad cond.H
##  logit flexible  275  -543.29 1108.57 6(2)  3.38e-09 1.2e+02
##
## Coefficients:
##                      Estimate Std. Error z value Pr(>|z|)
## Violence1             0.09561    0.10668   0.896    0.370
## Difficulty1           0.11088    0.10666   1.040    0.299
## Violence1:Difficulty1 -0.15580   0.10673  -1.460    0.144
##
## Threshold coefficients:
##     Estimate Std. Error z value
## 1|2  -3.1981    0.3083 -10.374
## 2|3  -2.3614    0.2142 -11.023
## 3|4  -1.6430    0.1636 -10.041
## 4|5  -0.9891    0.1360  -7.272
## 5|6  -0.2306    0.1219  -1.891
## 6|7   0.1806    0.1216   1.485
## 7|8   0.7418    0.1294   5.732
## 8|9   0.8973    0.1333   6.731

## formula: ordered(DV) ~ Violence * Difficulty + feedback.NA
## data:    dat
```

```
##
##  link  threshold nobs logLik  AIC    niter max.grad cond.H
##  logit flexible  251  -480.61 985.22 6(2)  2.72e-08 1.0e+02
##
## Coefficients:
##                      Estimate Std. Error z value Pr(>|z|)
## Violence1              0.0433     0.1125   0.385    0.700
## Difficulty1            0.1032     0.1125   0.918    0.359
## feedback.NA            0.7363     0.1345   5.472 4.44e-08 ***
## Violence1:Difficulty1 -0.0934     0.1126  -0.830    0.407
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##     Estimate Std. Error z value
## 1|2 -3.5080     0.3467 -10.120
## 2|3 -2.5693     0.2357 -10.902
## 3|4 -1.8072     0.1799 -10.046
## 4|5 -1.0709     0.1478  -7.243
## 5|6 -0.2608     0.1320  -1.975
## 6|7  0.1611     0.1315   1.225
## 7|8  0.7955     0.1405   5.662
## 8|9  0.9809     0.1453   6.751
## (24 observations deleted due to missingness)

## formula: ordered(DV) ~ Violence * Difficulty * L2d4d_std
## data:    dat
##
##  link  threshold nobs logLik  AIC     niter max.grad cond.H
##  logit flexible  273  -535.89 1101.78 7(2)  2.93e-07 1.3e+02
##
## Coefficients:
##                               Estimate Std. Error z value Pr(>|z|)
## Violence1                      0.08131    0.10718   0.759    0.448
## Difficulty1                    0.09869    0.10720   0.921    0.357
## L2d4d_std                     -0.12382    0.11158  -1.110    0.267
## Violence1:Difficulty1         -0.15046    0.10725  -1.403    0.161
## Violence1:L2d4d_std           -0.11239    0.11153  -1.008    0.314
## Difficulty1:L2d4d_std          0.06108    0.11151   0.548    0.584
## Violence1:Difficulty1:L2d4d_std -0.02564   0.11148  -0.230    0.818
##
## Threshold coefficients:
##     Estimate Std. Error z value
## 1|2 -3.2011     0.3086 -10.372
## 2|3 -2.4108     0.2189 -11.015
## 3|4 -1.6694     0.1657 -10.076
## 4|5 -1.0040     0.1373  -7.315
## 5|6 -0.2352     0.1227  -1.916
## 6|7  0.1824     0.1224   1.490
## 7|8  0.7521     0.1304   5.767
## 8|9  0.8919     0.1339   6.659
## (2 observations deleted due to missingness)

## formula: ordered(DV) ~ Violence * Difficulty * R2d4d_std
## data:    dat
```

```
##
##  link   threshold nobs logLik  AIC      niter max.grad cond.H
##  logit flexible  274  -540.39 1110.78 6(2)  3.73e-09 1.2e+02
##
## Coefficients:
##                               Estimate Std. Error z value Pr(>|z|)
## Violence1                      0.08163    0.10779   0.757    0.449
## Difficulty1                    0.11255    0.10783   1.044    0.297
## R2d4d_std                      0.05494    0.11089   0.495    0.620
## Violence1:Difficulty1         -0.15561    0.10787  -1.443    0.149
## Violence1:R2d4d_std           -0.04242    0.11082  -0.383    0.702
## Difficulty1:R2d4d_std         -0.06875    0.11087  -0.620    0.535
## Violence1:Difficulty1:R2d4d_std -0.07450   0.11100  -0.671    0.502
##
## Threshold coefficients:
##      Estimate Std. Error z value
## 1|2  -3.1895      0.3084 -10.342
## 2|3  -2.3540      0.2144 -10.979
## 3|4  -1.6339      0.1640  -9.961
## 4|5  -0.9764      0.1367  -7.141
## 5|6  -0.2144      0.1230  -1.742
## 6|7   0.1853      0.1230   1.506
## 7|8   0.7510      0.1310   5.732
## 8|9   0.9072      0.1349   6.726
## (1 observation deleted due to missingness)
```

Exploratory analyses.

The 18 items about the gameplay session were submitted to parallel analysis. Parallel analysis recommended four factors. Loadings with absolute value greater than .1 are displayed below. The first factor appears to represent excitement and enjoyment of the game. The second factor appears to represent the extent to which the game was stressful. The third factor appears to represent whether the participant struggled with the game's controls and navigation. The fourth factor featured items indicating whether the player perceived the game as involving violence and gore, but it also featured loadings regarding whether the player's guns/zorchers were satisfying and effective.

```
##
## Loadings:
##                  MR2   MR1   MR4   MR3
## easy.nav         0.15        -0.76
## excited          0.86        -0.19
## engaged          0.82        -0.14
## challenging      0.30  0.38  0.30 -0.28
## stressful              0.67  0.17
## violence         0.20  0.35         0.53
## diff.nav        -0.14  0.28  0.43
## reflexes         0.34  0.34  0.23
## satisfying       0.53        0.13  0.38
## effective        0.42 -0.15         0.44
## difficult              0.40  0.26 -0.32
## good.fight       0.31  0.27  0.29 -0.42
## hard.control           0.17  0.46 -0.17
## mental.effort    0.30  0.42  0.13
## comfort.control  0.25        -0.36
```

```
## exhausting      -0.18  0.75
## aggressed              0.30  0.14  0.42
## enjoyed          0.82 -0.18  0.16
##
##                  MR2    MR1    MR4    MR3
## SS loadings     3.118  2.068  1.569  1.213
## Proportion Var  0.173  0.115  0.087  0.067
## Cumulative Var  0.173  0.288  0.375  0.443
```

Participants' gameplay variables were submitted to parallel analysis. However, factor extraction resulted in Heywood cases. As such, each variable was analyzed singly as a potential predictor of aggressive behavior. Players with more kills/zorches gave lower coldpressor assignments ($t(272)$ = -2.51, p = .013, r = -.16 [-.28, -.03]). Players firing more total combined bullets and shotgun shells also gave lower coldpressor assignments ($t(272)$ = -2.51, p = .013, r = -.16 [-.28, -.03]). No other effects were statistically significant. Because these are exploratory tests and would not survive multiple comparison correction, we do not offer further consideration of these effects.

Questions about the players' experience of the game had a four-factor structure with factors representing enjoyment, challenge, difficulty with the game controls, and experience of violent content. Of these, only enjoyment was significantly related to aggression, $t(245)$ = 2.66, p = .008, r = .17 [.04, .29]. Experienced challenge was not related to aggression, contrary to our hypotheses regarding mental fatigue and aggression, $t(245)$ = 0.75, p = .452, r = .05 [-.08, .17]. Discomfort with the game controls was also not related to aggression, $t(245)$ = 0.17, p = .866, r = .01 [-.12, .14], contrary to previous findings by Przybylski et al. (2014).

History of game use was found to have a two-factor structure, with the first factor reflecting experience with video games in general and the second factor reflecting experience with first-person shooters in specific. One of the six items, "I've often played games like the one I played today," had to be discarded to prevent a Heywood case. Neither factor significantly predicted aggression (general experience, $t(245)$ = -0.09, p = .93, r = -.01 [-.13, .12]; FPS experience, $t(245)$ = 0.58, p = .566, r = .04 [-.09, .16]). These results are not consistent with reports of cross-sectional associations between use of violent video games and aggression.

Nonparametric correlations

Because the outcome was not normally distributed, one may want a nonparametric approach to the correlations. Here's a table of Kendall's Tau.

```
##             vioNum diffNum     DV feedback.NA L2d4d_std R2d4d_std
## vioNum       1.000   0.011  0.049      -0.007    -0.011    -0.022
## diffNum      0.011   1.000  0.054       0.009    -0.027    -0.049
## DV           0.049   0.054  1.000       0.260    -0.025     0.021
## feedback.NA -0.007   0.009  0.260       1.000     0.039     0.040
## L2d4d_std   -0.011  -0.027 -0.025       0.039     1.000     0.559
## R2d4d_std   -0.022  -0.049  0.021       0.040     0.559     1.000
```

Average 2D:4D

Although it is traditional to test each hand's 2D:4D ratio separately, one could try averaging the two hands for a more reliable measure. As seen below, this approach still does not yield a significant result in our general linear model.

```
##
## Call:
## lm(formula = DV ~ Violence * Difficulty * avg_2d4d, data = .)
##
```

```
## Residuals:
##    Min     1Q Median     3Q    Max
## -5.336 -1.580  0.009  2.621  3.450
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                  6.06575    0.14912  40.676   <2e-16 ***
## Violence1                    0.13012    0.14912   0.873    0.384
## Difficulty1                  0.12976    0.14912   0.870    0.385
## avg_2d4d                    -0.04220    0.16148  -0.261    0.794
## Violence1:Difficulty1       -0.22695    0.14912  -1.522    0.129
## Violence1:avg_2d4d          -0.09906    0.16148  -0.613    0.540
## Difficulty1:avg_2d4d        -0.01763    0.16148  -0.109    0.913
## Violence1:Difficulty1:avg_2d4d -0.05480 0.16148  -0.339    0.735
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.448 on 264 degrees of freedom
##   (3 observations deleted due to missingness)
## Multiple R-squared:  0.01681,    Adjusted R-squared:  -0.009255
## F-statistic: 0.645 on 7 and 264 DF,  p-value: 0.7184
```

Summary stats

A table of summary stats by condition is available in the repository as means_sds.txt.

```
## # A tibble: 9 x 9
##   variable   `Less Violent_Easy_~ `Less Violent_Easy~ `Less Violent_Hard_~
##   <chr>                    <dbl>               <dbl>                <dbl>
## 1 aggressed                 2.60                1.53                 2.93
## 2 challenge                -0.350               0.820                0.270
## 3 discomfort               -0.410               0.560                0.460
## 4 DV                        5.53                2.54                 6.29
## 5 excitement               -0.790               0.840                0.200
## 6 feedback.~               -0.0200               0.860                0.0600
## 7 feedback.~               -0.0500               0.920                0.0200
## 8 gore                     -0.150               0.640               -0.640
## 9 violence                  2.16                1.42                 2.26
## # ... with 5 more variables: `Less Violent_Hard_sd` <dbl>,
## #   Violent_Easy_mean <dbl>, Violent_Easy_sd <dbl>,
## #   Violent_Hard_mean <dbl>, Violent_Hard_sd <dbl>
```