How to conduct Analysis of Regression Residuals (ANORES) with PASW/SPSS

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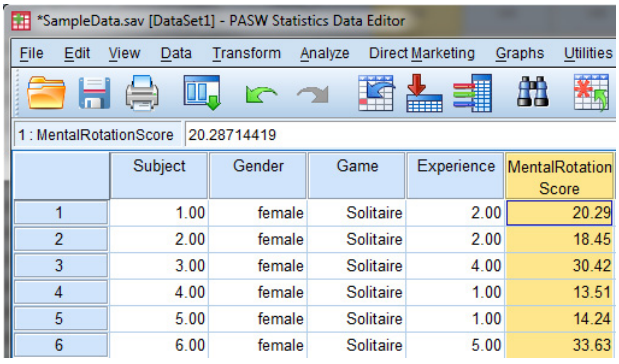
Overview and Data

The following sections provide a complete walkthrough of how to conduct an **Analysis of Regression Residuals (ANORES)** in the SPSS software package. The walkthrough is based on a fictive experiment in which 80 participants (40 males) played either Tetris or Solitaire and completed a mental rotation test afterwards. We are interested in the effects of the **computer game** as well as the participants' **gender** on **mental rotation scores**. To enable a sound analysis, we are interested in removing the impact of computer gaming experience, a variable that we assume to confound the factor gender.

Figure 1 shows the raw data for conducting an ANORES in the SPSS/ PASW software package (PASW 18; see the Appendix for the actual data). Four variables are of interest for the present analysis: The participants' gender, a computer game played by the participant, his experience coded as hours/week (0-12) as well as a fictive mental rotation score, ranging from 7 to 77.



	Subject	Gender	Game	Experience	MentalRotation Score
1	1.00	female	Solitaire	2.00	20.29
2	2.00	female	Solitaire	2.00	18.45
3	3.00	female	Solitaire	4.00	30.42
4	4.00	female	Solitaire	1.00	13.51
5	5.00	female	Solitaire	1.00	14.24
6	6.00	female	Solitaire	5.00	33.63

Figure 1. Raw data in the PASW data editor. See text for details.

To assess the potential benefit of conducting an ANORES instead of an ANOVA, we first **correlate** the variables gender and experience with each other and (separately) with the participants' mental rotation scores. This is done by the *Analyze* > *Correlate* > *Bivariate* dialogue of SPSS or the following syntax:

```
CORRELATIONS
  /VARIABLES=Gender Experience MentalRotationScore
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE..
```

This **screening** reveals strong correlations between gender and gaming experience (r = .658) as well as between gaming experience and mental rotation (r = .988). These two correlations indicate that any statistical effect of gender on mental rotation could be caused by the higher experience of male participants – and justifies the use of ANORES instead of standard ANOVA. Please note that the artificially high correlation of gaming experience and mental rotation scores overestimates the impact of ANORES because R^2 = 97.6% of the dependent variable's variance is explained by gaming experience – far more than it will explain in natural settings.

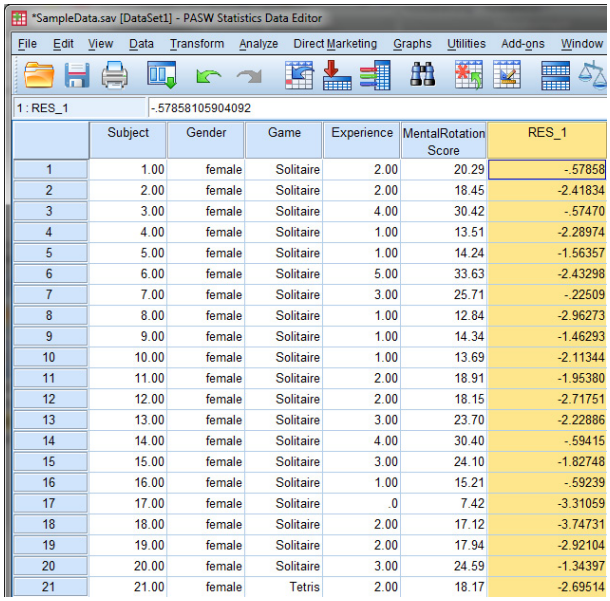
The ANORES is performed in two steps. First, a **linear regression** removes the impact of gaming experience from the mental rotation scores. Second, the regression residuals are subjected to a 2x2 between-subjects **ANOVA** with the factors gender and game.

Step 1: Linear Regression

Using the function *Analyze* > *Regression* > *Linear*, SPSS is able to extract regression residuals automatically. To obtain these values, we simply tick the appropriate box in the **Save** dialogue (**Figure 2**). This will create the following syntax:

```
REGRESSION
 /MISSING LISTWISE
 /STATISTICS COEFF OUTS R ANOVA
 /CRITERIA=PIN(.05) POUT(.10)
 /NOORIGIN
 /DEPENDENT MentalRotationScore
 /METHOD=ENTER Experience
 /SAVE RESID.
```

The output of the regression analysis is not important for conducting an ANORES. However, the save option we enabled before has created a new variable called **RES_1**. This variable contains regression residuals for each participant – ready for entering the ANOVA of Step 2 (see **Figure 3**).



	Subject	Gender	Game	Experience	MentalRotation Score	RES_1
1	1.00	female	Solitaire	2.00	20.29	-.57858
2	2.00	female	Solitaire	2.00	18.45	-2.41834
3	3.00	female	Solitaire	4.00	30.42	-.57470
4	4.00	female	Solitaire	1.00	13.51	-2.28974
5	5.00	female	Solitaire	1.00	14.24	-1.56357
6	6.00	female	Solitaire	5.00	33.63	-2.43298
7	7.00	female	Solitaire	3.00	25.71	-.22509
8	8.00	female	Solitaire	1.00	12.84	-2.96273
9	9.00	female	Solitaire	1.00	14.34	-1.46293
10	10.00	female	Solitaire	1.00	13.69	-2.11344
11	11.00	female	Solitaire	2.00	18.91	-1.95380
12	12.00	female	Solitaire	2.00	18.15	-2.71751
13	13.00	female	Solitaire	3.00	23.70	-2.22886
14	14.00	female	Solitaire	4.00	30.40	-.59415
15	15.00	female	Solitaire	3.00	24.10	-1.82748
16	16.00	female	Solitaire	1.00	15.21	-.59239
17	17.00	female	Solitaire	.0	7.42	-3.31059
18	18.00	female	Solitaire	2.00	17.12	-3.74731
19	19.00	female	Solitaire	2.00	17.94	-2.92104
20	20.00	female	Solitaire	3.00	24.59	-1.34397
21	21.00	female	Tetris	2.00	18.17	-2.69514

Figure 3. Unstandardized regression residuals are automatically saved as a new variable **RES_1**. Please note that an existing variable RES_1 will cause SPSS to assign a different name to the regression residuals of the analysis (RES_i); existing values will not be overwritten.

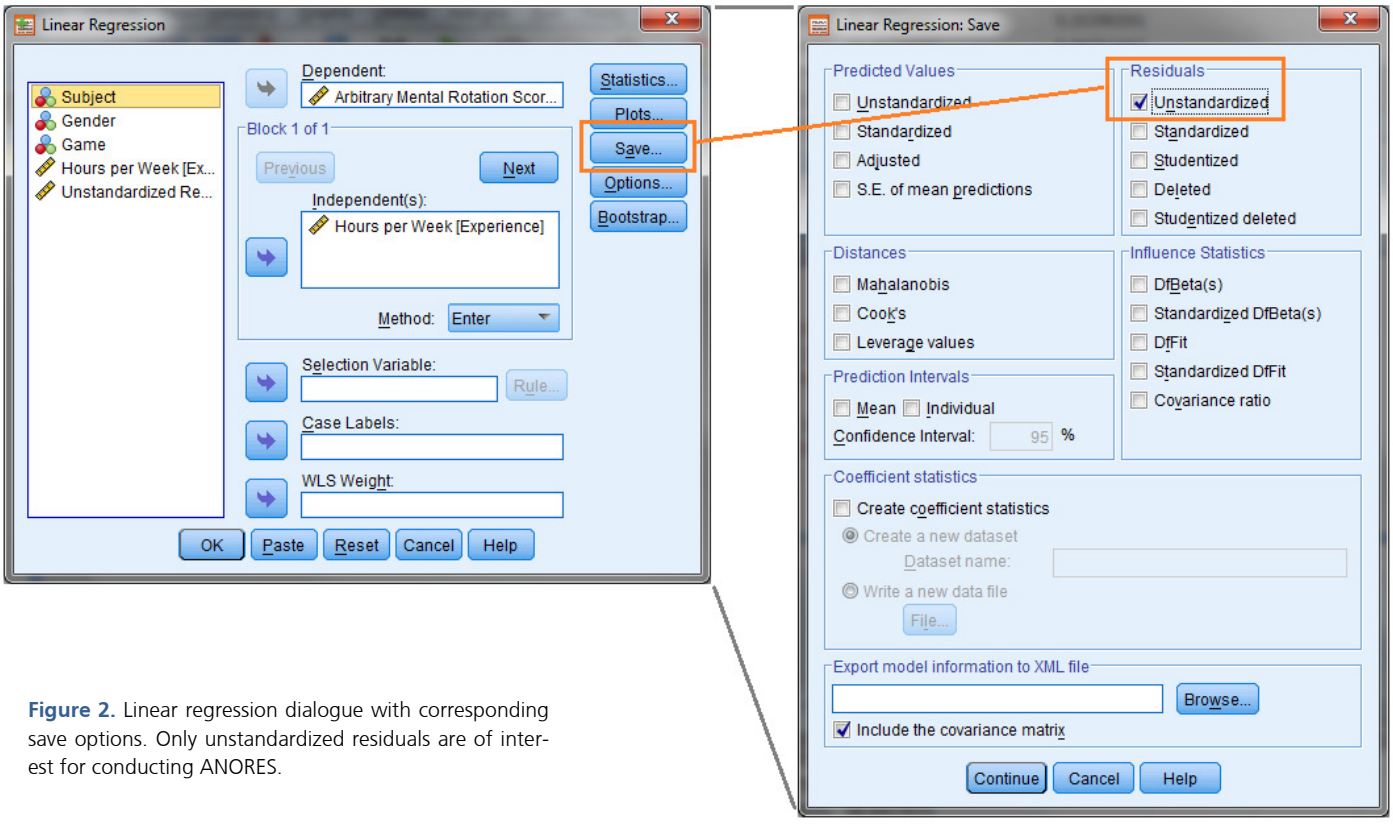


Figure 2. Linear regression dialogue with corresponding save options. Only unstandardized residuals are of interest for conducting ANORES.

Step 2: ANOVA on Regression Residuals

The second step of ANORES is a standard ANOVA on the regression residuals instead of the participants' raw scores. This analysis is performed by choosing *Analyze* > *General Linear Model* > *Univariate* … and entering Gender and Game as fixed factors. Selecting an appropriate interaction plot as well as a measure of effect size will produce the following syntax:

```
UNIANOVA RES_1 BY Gender Game
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PLOT=PROFILE(Game*Gender)
  /PRINT=ETASQ
  /CRITERIA=ALPHA(.05)
  /DESIGN=Gender Game Gender*Game.
```

This ANOVA reveals a significant main effect of Game while the main effect of Gender and the interaction do not approach significance (**Figure 4**).

Tests of Between-Subjects Effects

Dependent Variable:Unstandardized Residual

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	275.359[a]	3	91.786	27.016	.000	.516
Intercept	.000	1	.000	.000	1.000	.000
Gender	2.928	1	2.928	.862	.356	.011
Game	270.896	1	270.896	79.733	.000	.512
Gender * Game	1.535	1	1.535	.452	.504	.006
Error	258.212	76	3.398			
Total	533.571	80				
Corrected Total	533.571	79				

a. R Squared = .516 (Adjusted R Squared = .497)

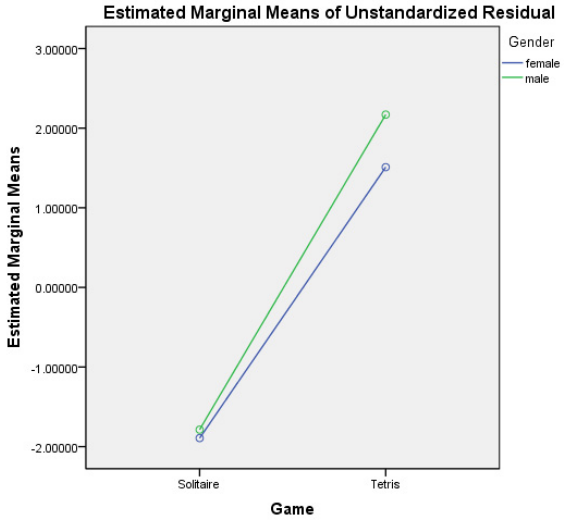


Figure 4. Final results of the ANORES. Controlling for differential gaming experience renders the impact of gender non-significant.

The results of the present ANORES can easily be compared to the traditional ANOVA approach by conducting the 2x2 ANOVA described in the left column on the raw scores of the participants. This procedure reveals a significant main effect of gender that is, however, entirely caused by the higher gaming experience of male participants (**Figure 5**).

Tests of Between-Subjects Effects

Dependent Variable:Arbitrary Mental Rotation Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10816.127[a]	3	3605.376	23.084	.000	.477
Intercept	95111.672	1	95111.672	608.979	.000	.889
Gender	9939.284	1	9939.284	63.639	.000	.456
Game	869.414	1	869.414	5.567	.021	.068
Gender * Game	7.430	1	7.430	.048	.828	.001
Error	11869.845	76	156.182			
Total	117797.644	80				
Corrected Total	22685.972	79				

a. R Squared = .477 (Adjusted R Squared = .456)

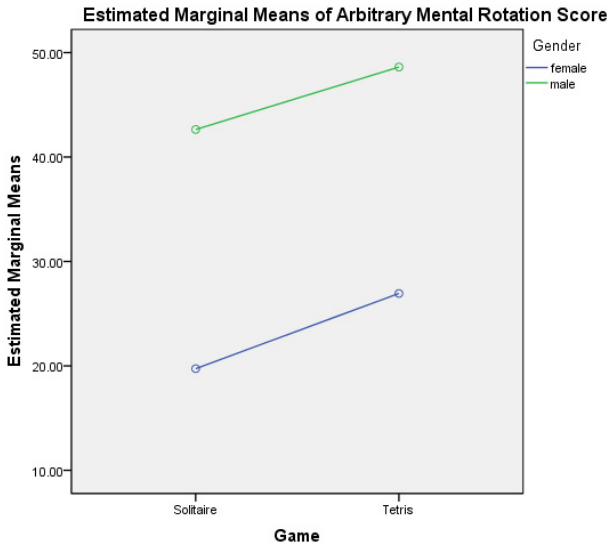


Figure 5. Results of a standard ANOVA on the participants raw scores without controlling for differential gaming experience. Gender seems to have a profound impact that is, however, due to the higher gaming experience of male participants.

Appendix: Raw data

Gender: 0 = female, 1 = male
Experience: Gaming experience in hours per week

Game: 1 = Solitaire, 2 = Tetris
Rotation Score: Arbitrary score.

Subject	Gender	Game	Experience	Rotation Score
1	0	1	2	20.29
2	0	1	2	18.45
3	0	1	4	30.42
4	0	1	1	13.51
5	0	1	1	14.24
6	0	1	5	33.63
7	0	1	3	25.71
8	0	1	1	12.84
9	0	1	1	14.34
10	0	1	1	13.69
11	0	1	2	18.91
12	0	1	2	18.15
13	0	1	3	23.70
14	0	1	4	30.40
15	0	1	3	24.10
16	0	1	1	15.21
17	0	1	0	7.42
18	0	1	2	17.12
19	0	1	2	17.94
20	0	1	3	24.59
21	0	2	2	18.17
22	0	2	2	19.49
23	0	2	2	20.55
24	0	2	4	33.11
25	0	2	3	28.23
26	0	2	2	24.71
27	0	2	4	31.58
28	0	2	1	16.51
29	0	2	5	35.41
30	0	2	1	17.05
31	0	2	5	38.69
32	0	2	4	35.13
33	0	2	5	40.08
34	0	2	1	20.14
35	0	2	4	32.93
36	0	2	4	32.00
37	0	2	3	26.53
38	0	2	2	21.68
39	0	2	1	17.71
40	0	2	3	28.99

Subject	Gender	Game	Experience	Rotation Score
41	1	1	1	13.33
42	1	1	8	46.41
43	1	1	9	56.41
44	1	1	8	52.45
45	1	1	11	63.64
46	1	1	9	51.48
47	1	1	4	29.19
48	1	1	6	37.02
49	1	1	5	35.43
50	1	1	10	58.48
51	1	1	2	19.88
52	1	1	2	22.44
53	1	1	4	31.70
54	1	1	9	54.73
55	1	1	3	25.71
56	1	1	11	65.61
57	1	1	3	24.27
58	1	1	9	55.66
59	1	1	8	48.66
60	1	1	11	60.19
61	1	2	4	30.41
62	1	2	12	71.67
63	1	2	2	23.06
64	1	2	5	37.05
65	1	2	3	29.37
66	1	2	6	48.29
67	1	2	9	57.51
68	1	2	2	26.32
69	1	2	9	57.66
70	1	2	5	39.41
71	1	2	12	73.23
72	1	2	4	32.64
73	1	2	12	76.80
74	1	2	6	45.36
75	1	2	9	55.88
76	1	2	7	48.82
77	1	2	7	47.80
78	1	2	10	60.55
79	1	2	7	48.20
80	1	2	10	62.34