Data supplement to Freeman et al. Virtual reality in the treatment of persecutory delusions. Br J Psychiatry doi: 10.1192/bjp.bp.115.176438

Online Supplement DS1: The VR laboratory

VR equipment

Our lab uses an nVisor SX111 HMD (see online Fig DS1). It combines a 102 degree horizontal field of view and 64 degree vertical field of view with very high resolution: 1280x1024. A stereo image is presented using a screen for each eye that is updated at 60hz. We use a 12 Intersense SoniStrip ceiling and an Intersense IS-900 SimTracker system that combines an inertial and time of flight audio sensor to specify the viewer's position and orientation with six degrees of freedom. The resolution of the IS900 is within 0.75 millimetres. The update rate is 180hz, and the latency is 4 milliseconds. The computer running the application was custom built for the lab and includes a core i7 processor, and a NVIDIA GeForce GTX 780 ti graphics card with 3072mb of memory. This machine has 16GB of RAM and an Asus Maximus VII Ranger motherboard. The tracking pc is a Dell T5500 workstation with a core i7 processor and 4gb RAM. Audio is rendered using the Realtek audio controller provided by the ASUS Maximus VII Ranger motherboard.

The VR scenarios

The train model was rendered using the XVR application platform.[22] The avatars were responsive in gaze as to whether the participant was in their field of view and if the head orientation of the participant was directed at a particular avatar. There were four different train scenarios. First, participants experienced a train ride with no avatars in the carriage, in order to get used to the basic experience and procedures. In scenario level one, there were three male and three female avatars placed in the distal regions of the carriage. In scenario level two, there were 11 male and 12 female avatars along the length of the carriage. Here a number of the avatars were standing in the same area of the carriage as the participant. In scenario level three, there were 11 males and 11 females in the train carriage, but this time the avatars were arranged so that there were a greater number of people in the area where a participant could walk. A soundtrack of a tube journey, including low-level conversation appropriate to the version, was played. For each of the 60 frames per second refreshes of the NVIS SX111, the position was read from the IS-900 and written to an output data file for the train scenario, which was used to calculate the total movement of each participant.

The lift was rendered using the Unity3D application platform. The model consisted of a virtual lift lobby with six adjoining lift doors, and one lift. The lighting was baked into the model using the built-in light probes feature in Unity. This allowed the avatars to have real-time dynamic shadows. Facial animations were also used. The avatars in the study were again responsive with regard to gaze. Each avatar had a basic idle motion from which they would, at random, perform some habitual movement such as scratching their head or shifting their feet. The sound of a lift played during each version. Each lift scenario consisted of the same journey from the ground floor lobby up to the third floor of the building with stops at the first and

second floors along the way. Participants were asked to note the time on the clock in the lobby of the top floor. In scenario level four, there were two male avatars in the lift. In scenario level five, there were three male avatars and one female avatar. In scenario level six, there were five male avatars and one female avatar in the lift.

Additional reference

22 Tecchia F, Carrozzino, M., Bacinelli, S., Rossi, F., Vercelli, D., Marino, G., Gasparello, P., & Bergamasco, M. (2010) A Flexible Framework for Wide-Spectrum VR Development. Presence: Teleoperators and Virtual Environments, 19, 302-312.

Figure DS1 A picture of a person wearing the head mounted display in the VR lab.

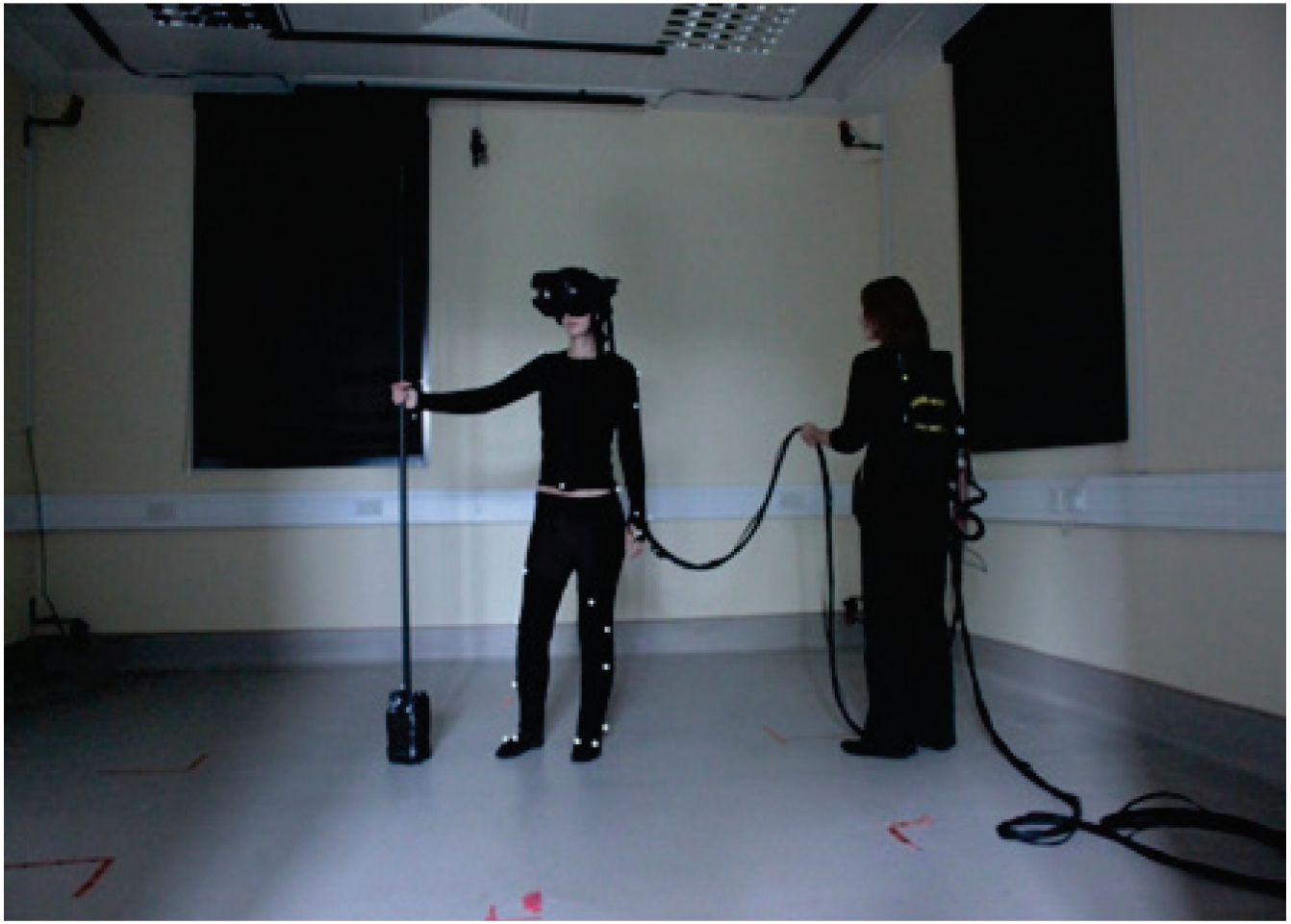
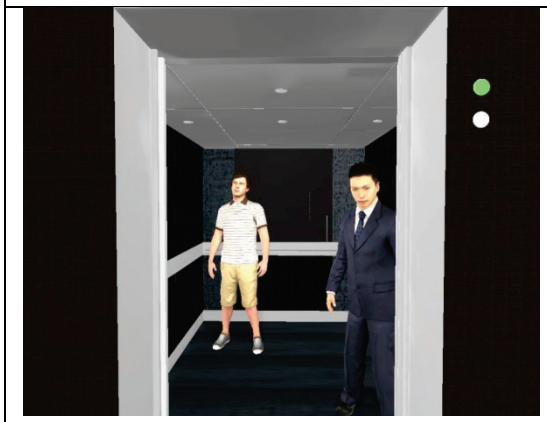
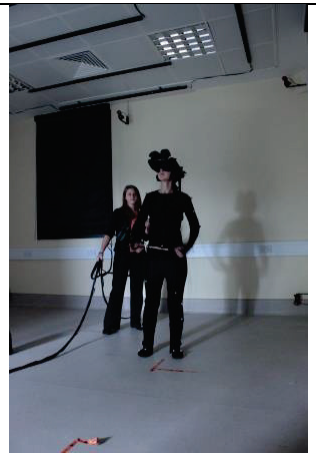


Figure DS2 Still images of the seven virtual reality (VR) situations and a photograph of a person wearing the head mounted display in the VR lab.

Empty train (lasting 2 mins 24 secs)	Train level VR1 (lasting 3mins 41secs)	Train level VR2 (lasting 5mins 41secs)	Train level VR3 (lasting 5mins 22secs)
			
Lift level VR4 (lasting 3mins 40 secs)	Lift level VR5 (lasting 3mins 40 secs)	Lift level VR6 (lasting 3mins 40secs)	The VR lab
			

Online supplement DS2 Random-effects models for the ratings from VR

VR Conviction – Mixed Models

Data Structure
The 'long' form in Stata. 6 records per participant.

Id	Condition	time*	Conv-PRE	Conv_POST	Conv_CHA	Conv_MEAN
1	0	1	35	60	-25	47.5
1	0	2	.	. etc.		
1	0	3				
1	0	4				
1	0	5				
1	0	6				
30	1	1				
30	1	2				
30	1	3				
30	1	4				
30	1	5				
30	1	6				

*time is equivalent to VR level

Analysis method
Each participant provides six pairs of pre/post VR measurements of conviction. We wish to determine the effect of the intervention/treatment on these measures, looking at pre-VR conviction, post-VR conviction, the pre-post VR change, and the average of the two.

1. Analysis of pre-VR scores. Random effects model (to allow for correlation between measures repeated over time) looking at the effect of treatment, time (VR level), and the treatment by time (VR level) interaction.
2. Same analysis of post-VR scores.
3. If the parameter estimates look very similar then it suggests that pre- and post-VR measures are changing in parallel (the treatment effect is the same in both). An analysis of the pre-post differences will make this explicit (there will be no need for a treatment by time interaction).
4. The random effects/repeated measures model for the mean of the pre- and post-VR scores will produce estimates of treatment and treatment-by time interaction effects that are assumed to be the same for both the pre- and the post-VR measures.

1. PRE-VR

```
. xi: xtreg Conv_PRE i.Condition*i.time, re
```

Conv_PRE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]	
_ICondition_1	-.0678493	9.426603	-0.01	0.994	-18.54365	18.40795	No difference in PRE for VR1
_Itime_2	5.066667	3.957237	1.28	0.200	-2.689375	12.82271	
_Itime_3	9	3.957237	2.27	0.023	1.243958	16.75604	
_Itime_4	6.333333	3.957237	1.60	0.110	-1.422708	14.08938	
_Itime_5	5.6	3.957237	1.42	0.157	-2.156042	13.35604	
_Itime_6	2.609966	4.040572	0.65	0.518	-5.30941	10.52934	
_IConXtim_1_2	-13.46548	5.655612	-2.38	0.017	-24.55028	-2.380688	Fairly large effects for VR2 etc.
_IConXtim_1_3	-18.39882	5.655612	-3.25	0.001	-29.48361	-7.314021	
_IConXtim_1_4	-16.39882	5.655612	-2.90	0.004	-27.48361	-5.314021	
_IConXtim_1_5	-20.46548	5.655612	-3.62	0.000	-31.55028	-9.380688	
_IConXtim_1_6	-20.87545	5.714232	-3.65	0.000	-32.07514	-9.675761	
_cons	65.66667	6.64057	9.89	0.000	52.65139	78.68194	
sigma_u	23.422286						
sigma_e	10.883						
rho	.82244072	(fraction of variance due to u_i)					

2. POST-VR

```
. xi: xtreg Conv_POST i.Condition*i.time, re
```

Conv_POST	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]	
_ICondition_1	-12.06667	9.517797	-1.27	0.205	-30.72121	6.587873	Fairly large, but not significant effect, for VR1
_Itime_2	3.8	4.402635	0.86	0.388	-4.829005	12.42901	
_Itime_3	7.333333	4.402635	1.67	0.096	-1.295672	15.96234	
_Itime_4	-.8666667	4.402635	-0.20	0.844	-9.495672	7.762338	
_Itime_5	-.4	4.402635	-0.09	0.928	-9.029005	8.229005	
_Itime_6	2.378101	4.495192	0.53	0.597	-6.432313	11.18852	
_IConXtim_1_2	-3.066667	6.226265	-0.49	0.622	-15.26992	9.136589	Effects increasing for VR2 etc.
_IConXtim_1_3	-12.4	6.226265	-1.99	0.046	-24.60326	-.196744	
_IConXtim_1_4	-7.2	6.226265	-1.16	0.248	-19.40326	5.003256	
_IConXtim_1_5	-8.466667	6.226265	-1.36	0.174	-20.66992	3.736589	
_IConXtim_1_6	-12.9781	6.292054	-2.06	0.039	-25.3103	-.6459027	
_cons	67.86667	6.730099	10.08	0.000	54.67591	81.05742	
sigma_u	23.16746						
sigma_e	12.087458						
rho	.78603026	(fraction of variance due to u_i)					

3. PRE-POST CHANGE

```
. xi: xtreg Conv_CHA i.Condition*i.time, re
```

Conv_CHA	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]	
_ICondition_1	9.7	4.49592	2.16	0.031	.8881579	18.51184	Effect of treatment for VR1
_Itime_2	1.266667	4.417725	0.29	0.774	-7.391914	9.925248	
_Itime_3	1.666667	4.417725	0.38	0.706	-6.991914	10.32525	
_Itime_4	7.2	4.417725	1.63	0.103	-1.458581	15.85858	
_Itime_5	6	4.417725	1.36	0.174	-2.658581	14.65858	
_Itime_6	.8428571	4.49592	0.19	0.851	-7.968985	9.654699	
_IConXtim_1_2	-8.1	6.303141	-1.29	0.199	-20.45393	4.25393	
_IConXtim_1_3	-3.7	6.303141	-0.59	0.557	-16.05393	8.65393	
_IConXtim_1_4	-6.9	6.303141	-1.09	0.274	-19.25393	5.45393	
_IConXtim_1_5	-9.7	6.303141	-1.54	0.124	-22.05393	2.65393	
_IConXtim_1_6	-6.209524	6.358192	-0.98	0.329	-18.67135	6.252303	
_cons	-2.2	3.123803	-0.70	0.481	-8.322541	3.922541	
sigma_u	0						
sigma_e	12.433762						
rho	0	(fraction of variance due to u_i)					

Interactions small and nothing like significant. Therefore, drop them from the model:

```
. xi: xtreg Conv_CHA i.Condition i.time, re
------------------------------------------------------------------------------
     Conv_CHA |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
_ICondition_1 |   3.900775   1.803403     2.16   0.031      .3661707     7.43538
     _Itime_2 |  -2.683347   3.132394    -0.86   0.392    -8.822726    3.456032
     _Itime_3 |  -.0833467   3.132394    -0.03   0.979    -6.222726    6.056032
     _Itime_4 |   3.849987   3.132394     1.23   0.219    -2.289392    9.989366
     _Itime_5 |   1.249987   3.132394     0.40   0.690    -4.889392    7.389366
     _Itime_6 |  -2.168992   3.159284    -0.69   0.492    -8.361076    4.023092
        _cons |   .5996258   2.397199     0.25   0.802    -4.098798     5.29805
--------------+---------------------------------------------------------------
      sigma_u |          0
      sigma_e |  12.348396
          rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

The pre-post change (common to all six VR sessions) is on average 3.9 points higher in the treatment group. The average pre-post change in the controls is about 0.6 (the estimate of _cons).

4. PRE-POST MEAN

```
. xi: xtreg Conv_MEAN i.Condition*i.time, re
```

Conv_MEAN	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ICondition_1	-5.105179	9.265294	-0.55	0.582	-23.26482	13.05446
_Itime_2	4.433333	3.481869	1.27	0.203	-2.391004	11.25767
_Itime_3	8.166667	3.481869	2.35	0.019	1.34233	14.991
_Itime_4	2.733333	3.481869	0.79	0.432	-4.091004	9.55767
_Itime_5	2.6	3.481869	0.75	0.455	-4.224337	9.424337
_Itime_6	2.48176	3.555307	0.70	0.485	-4.486513	9.450034
_IConXtim_1_2	-9.228155	4.976305	-1.85	0.064	-18.98153	.5252246
_IConXtim_1_3	-16.36149	4.976305	-3.29	0.001	-26.11487	-6.608109
_IConXtim_1_4	-12.76149	4.976305	-2.56	0.010	-22.51487	-3.008109
_IConXtim_1_5	-15.42815	4.976305	-3.10	0.002	-25.18153	-5.674775
_IConXtim_1_6	-17.87658	5.027963	-3.56	0.000	-27.73121	-8.021955
_cons	66.76667	6.531802	10.22	0.000	53.96457	79.56876
sigma_u	23.548393					
sigma_e	9.5830083					
rho	.8579214	(fraction of variance due to u_i)				

Parameter estimates mid-way between those for analysis of pre- and that of post-VR measures.

VR Paranoia Distress – Mixed models

Separate analyses of Dist_PRE, Dist_POST, Dist_CHA and Dist_MEAN

Interpretation almost exactly the same as for conviction.

Assume no treatment (condition) effect on Dist_PRE for VR1.
But there is one for Dist_POST for VR1.

Treatment effects then increase with train session, dip when move to lift but then level off.

```
. xi: xtreg Dist_PRE i.Condition*i.time, re
```

Dist_PRE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]	
_ICondition_1	2.337388	9.08133	0.26	0.797	-15.46169	20.13647	'Wrong' direction but not signif.
_Itime_2	1.666667	4.357886	0.38	0.702	-6.874632	10.20797	
_Itime_3	7.6	4.357886	1.74	0.081	-.9412987	16.1413	
_Itime_4	6.666667	4.357886	1.53	0.126	-1.874632	15.20797	
_Itime_5	-.5333333	4.357886	-0.12	0.903	-9.074632	8.007965	
_Itime_6	-2.753145	4.449418	-0.62	0.536	-11.47384	5.967555	
_IConXtim_1_2	-10.13739	6.228041	-1.63	0.104	-22.34412	2.069347	
_IConXtim_1_3	-21.27072	6.228041	-3.42	0.001	-33.47746	-9.063987	
_IConXtim_1_4	-18.80406	6.228041	-3.02	0.003	-31.01079	-6.59732	
_IConXtim_1_5	-15.67072	6.228041	-2.52	0.012	-27.87746	-3.463987	
_IConXtim_1_6	-18.31758	6.292428	-2.91	0.004	-30.65051	-5.984646	
_cons	59.6	6.390008	9.33	0.000	47.07582	72.12418	
sigma_u	21.785169						
sigma_e	11.992113						
rho	.76744863	(fraction of variance due to u_i)					

Effect on Dist_PRE is presumably effect of treatment during session before (but obviously not for VR1).

Effects of treatment at six time points:

VR1 +2.34
VR2 +2.34 – 10.14
VR3 +2.34 – 21.27
VR4 +2.34 – 18.80
VR5 +2.34 – 15.67
VR6 +2.34 – 18.32

. xi: xtreg Dist_POST i.Condition*i.time, re

Dist_POST	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]	
_ICondition_1	-6.2	8.778841	-0.71	0.480	-23.40621	11.00621	Right direct; not signif
_Itime_2	11.73333	4.445444	2.64	0.008	3.020424	20.44624	
_Itime_3	8.066667	4.445444	1.81	0.070	-.6462427	16.77958	
_Itime_4	-3.866667	4.445444	-0.87	0.384	-12.57958	4.846243	
_Itime_5	-5.4	4.445444	-1.21	0.224	-14.11291	3.312909	
_Itime_6	.902548	4.538701	0.20	0.842	-7.993142	9.798238	
_IConXtim_1_2	-13.53333	6.286807	-2.15	0.031	-25.85525	-1.211419	
_IConXtim_1_3	-16.13333	6.286807	-2.57	0.010	-28.45525	-3.811419	
_IConXtim_1_4	-4.466667	6.286807	-0.71	0.477	-16.78858	7.855248	
_IConXtim_1_5	-3.266667	6.286807	-0.52	0.603	-15.58858	9.055248	
_IConXtim_1_6	-14.63588	6.353092	-2.30	0.021	-27.08771	-2.184051	
_cons	60	6.207578	9.67	0.000	47.83337	72.16663	
sigma_u	20.785943						
sigma_e	12.206313						
rho	.74357765	(fraction of variance due to u_i)					

Effects of treatment at six time points:

VR1 -6.20
VR2 -6.20 – 13.53
VR3 -6.20 – 16.13

VR4 -6.20 - 4.47
VR5 -6.20 - 3.27
VR6 -6.20 - 14.64

```
. xi: xtreg Dist_CHA i.Condition*i.time, re
```

Dist_CHA	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ICondition_1	6.114286	4.947088	1.24	0.216	-3.581828	15.8104
_Itime_2	-10.06667	4.861045	-2.07	0.038	-19.59414	-.5391938
_Itime_3	-.4666667	4.861045	-0.10	0.924	-9.99414	9.060806
_Itime_4	10.53333	4.861045	2.17	0.030	1.00586	20.06081
_Itime_5	4.866667	4.861045	1.00	0.317	-4.660806	14.39414
_Itime_6	-2.314286	4.947088	-0.47	0.640	-12.0104	7.381828
_IConXtim_1_2	5.819048	6.935664	0.84	0.401	-7.774604	19.4127
_IConXtim_1_3	-2.714286	6.935664	-0.39	0.696	-16.30794	10.87937
_IConXtim_1_4	-11.91429	6.935664	-1.72	0.086	-25.50794	1.679366
_IConXtim_1_5	-9.980952	6.935664	-1.44	0.150	-23.5746	3.612699
_IConXtim_1_6	-2.6	6.996239	-0.37	0.710	-16.31238	11.11238
_cons	-.4	3.437278	-0.12	0.907	-7.136941	6.336941
sigma_u	0					
sigma_e	13.063888					
rho	0	(fraction of variance due to u_i)				

```
. xi: xtreg Dist_CHA i.Condition i.time, re
------------------------------------------------------------------------------
     Dist_CHA |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
_ICondition_1 |   2.522868   2.019266     1.25   0.212    -1.434821    6.480558
     _Itime_2 |  -7.095222   3.507335    -2.02   0.043    -13.96947   -.2209714
     _Itime_3 |  -1.761889   3.507335    -0.50   0.615    -8.636139    5.112362
     _Itime_4 |   4.638111   3.507335     1.32   0.186    -2.236139    11.51236
     _Itime_5 |  -.0618885   3.507335    -0.02   0.986    -6.936139    6.812362
     _Itime_6 |  -3.535271   3.537444    -1.00   0.318    -10.46854    3.397992
        _cons |   1.333788   2.684139     0.50   0.619    -3.927028    6.594604
--------------+---------------------------------------------------------------
      sigma_u |          0
      sigma_e |  13.272137
          rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. xi: xtreg Dist_MEAN i.Condition*i.time, re
------------------------------------------------------------------------------
    Dist_MEAN |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
_ICondition_1 |  -.8057598   8.657936    -0.09   0.926      -17.775    16.16348
     _Itime_2 |         6.7   3.649211     1.84   0.066    -.4523226    13.85232
     _Itime_3 |   7.833333   3.649211     2.15   0.032     .6810107    14.98566
     _Itime_4 |         1.4   3.649211     0.38   0.701    -5.752323    8.552323
     _Itime_5 |  -2.966667   3.649211    -0.81   0.416    -10.11899    4.185656
     _Itime_6 |  -.9266026   3.726055    -0.25   0.804    -8.229536    6.376331
_IConXtim_1_2 |  -12.96091   5.215384    -2.49   0.013    -23.18287   -2.738942
_IConXtim_1_3 |  -19.82757   5.215384    -3.80   0.000    -30.04954   -9.605609
_IConXtim_1_4 |  -12.76091   5.215384    -2.45   0.014    -22.98287   -2.538942
_IConXtim_1_5 |  -10.59424   5.215384    -2.03   0.042     -20.8162   -.3722757
_IConXtim_1_6 |  -17.60097   5.269437    -3.34   0.001    -27.92888   -7.273063
        _cons |       59.8   6.098898     9.81   0.000     47.84638    71.75362
--------------+---------------------------------------------------------------
      sigma_u |   21.52938
      sigma_e |  10.052959
          rho |  .82099496   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

VR Movement Data – mixed model

```
. xi: xtreg Movement_Tube_ i.Condition*i.scenario, re
i.Condition       _ICondition_0-1     (naturally coded; _ICondition_0 omitted)
i.scenario        _Iscenario_1-4      (naturally coded; _Iscenario_1 omitted)
i.Con~n*i.sce~o   _IConXsce_#_#       (coded as above)

Random-effects GLS regression                   Number of obs      =       118
Group variable: ID                              Number of groups   =        30

R-sq:  within  = 0.6309                         Obs per group: min =         3
       between = 0.1805                                        avg =       3.9
       overall = 0.3606                                        max =         4

                                                Wald chi2(7)       =    146.27
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
Movement_Tu~_ |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
_ICondition_1 |   .9203343   3.714714     0.25   0.804     -6.36037    8.201039
 _Iscenario_2 |   1.887826   2.082327     0.91   0.365    -2.193461    5.969112
 _Iscenario_3 |   7.490201   2.129695     3.52   0.000     3.316076    11.66433
 _Iscenario_4 |   8.456326   2.082327     4.06   0.000     4.375039    12.53761
_IConXsce_1_2 |   3.623821   2.978538     1.22   0.224    -2.214006    9.461648
_IConXsce_1_3 |    10.6088   3.011843     3.52   0.000     4.705695     16.5119
_IConXsce_1_4 |   10.51481   2.978538     3.53   0.000     4.676988    16.35264
        _cons |    17.0805   2.607641     6.55   0.000     11.96962    22.19138
--------------+---------------------------------------------------------------
      sigma_u |  8.3351179
      sigma_e |  5.7026051
          rho |  .68116028   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Interaction becomes highly statistically-significant for scenarios 3 & 4 (i.e. VR2 and VR3).