

Supplementary Table1

	lesion side	age	gender	education	Handedness	hand used	performance transitive	performance intransitive
MP	RBD	62	M	na	-100	n-d	MF>ML	<i>ML>MF</i>
JW	RBD	77	M	2	100	d	nd	nd
JQ	RBD	63	M	5	100	d	ML>MF	<i>MF>ML</i>
AS	RBD	73	M	3	90	d	nd	nd
JM	RBD	67	M	na	100	d	MF=ML	<i>MF>ML</i>
AK	RBD	74	M	4	100	d	<i>ML>MF</i>	nd
JE	RBD	61	M	na	100	d	nd	nd
PW	RBD	78	M	2	na	d	MF=ML	MF=ML
JB	RBD	74	F	2	-70	n-d	MF>ML	MF=ML
MC	RBD	75	M	4	100	n-d	nd	MF>ML
QJ	RBD	55	M	na	100	d	nd	nd
DS	LBD	76	M	4	90	d	MF>ML	nd
PH	LBD	36	M	5	100	n-d	MF>ML	MF=ML
MM	LBD	75	M	2	100	d	MF>ML	<i>ML>MF</i>
PJ	LBD	70	M	na	100	d	MF>ML	MF>ML
DE	LBD	68	M	3	100	n-d	nd	<i>MF>ML</i>
BR	LBD	69	M	2	100	d	nd	nd
RH	LBD	75	M	2	-100	d	<i>MF>ML</i>	MF=ML
MMcD	BBD	77	M	1	90	d	MF>ML	MF=ML
GA	BBD	45	M	2	100	d	nd	nd
PM	BBD	68	M	2	100	d	MF=ML	MF=ML

Patients demographic and handedness data - patients' lesion side (LBD= left brain damage; RBD= right brain damage; BBD= bilateral brain damage) age, gender (M= male; F= female), education, handedness (i.e. scores on the Edinburgh Handedness Inventory (Oldfield 1971)) and hand used for imitation (d= dominant; n-d= non-dominant). Levels of education based on categorization of the 2001 Census (Level 0 - no academic, vocational or professional qualifications, including those with City and Guilds, RSA/OCR, BTEC/Edexcel qualifications and including unknown qualifications; Level 1 – 1+ O and A levels, NVQ level 1 to 3, Foundation GNVQ to advance GNVQ, up to higher school certificate; Level 4-5 – degree +, NVQ level 4-5, NHD, NHC, qualified teacher status, qualified medical or allied health professional status). The entries labeled as “na” means that the data was not available. The last two columns on the right report, for each patient, if there was a **strong (in bold – e.g. MF>ML)** or a *classic (in italic – e.g. MF>ML)* **dissociation** between MF and ML, either transitive (second-last column) or intransitive (last column), gestures. A **strong** dissociation indicated that a patient was defective with both MF and ML gestures although there was a significant difference between the scores obtained with the two gestures types (e.g. ‘**MF>ML**’ means that a patient had a deficit in imitating both MF and ML but did significantly better with the MF). In a *classic* dissociation instead a patient reported a deficit with one gesture type only, obtaining scores that differed significantly (e.g. ‘*MF>ML*’ means

that the patient did at control level with the MF while being defective with the ML. Moreover the MF were performed significantly better than the ML). Where 'MF=ML' is reported the performances were equally defective. 'nd' means that both scores were at control level.

Supplementary Table2

ID	PI	T & S	F Acc	F Rule	P N	M s O	G P	G R	Im	F C
MP	7	6	3	1	12	12	12	5	4	31
JW	8	6	3	0	13	9	11	5	9	38
JQ	7	6	16	3	11	11	11	4	11	43
AS	8	6	16	3	13	9	10	5	9	39
JM	na	na	na	na	na	na	na	na	na	Na
AK	8	6	12	2	9	11	9	5	8	38
JE	na	na	na	na	na	na	na	na	na	Na
PW	8	6	13	2	14	11	11	4	9	44
JB	8	6	11	3	14	8	7	4	na	Na
MC	8	6	6	0	13	8	11	6	8	33
QJ	na	na	na	na	na	na	na	na	na	Na
DS	8	6	16	2	8	12	7	5	11	44
PH	8	6	15	2	6	12	10	5	9	42
MM	0	5	1	0	0	11	5	3	6	45
PJ	na	na	na	na	na	na	na	na	na	Na
DE	7	5	10	3	5	2	12	4	8	44
BR	8	5	2	0	11	12	12	6	10	37
RH	7		1	0	8	10	8	6	9	44
MMcD	8	6	9	2	9	12	12	5	9	37
GA	6	6	16	3	2	9	11	4	12	46
PM	3	5	0	0	2	11	8	6	9	25

Patients BCoS scores - patients' results at the Birmingham Cognitive Screen (BCoS; Humphreys et al. 2012 (see

www.BCoS.bham.ac.uk) sub-tests: 1) Personal Information (P I); 2) Time and Space (T & S); 3) Birmingham

Frontal_Accuracy (F Acc); 4) Birmingham Frontal_Rule Detection (F Rule); 4) Picture Naming (P N); 5) Multiple Step

Object Use (M s O); 6) Gesture Production (G P); 7) Gesture Recognition (G R); 8) Imitation (Im); Figure Copy (F C).

Scores below the cut off for the normal English population are in bold.

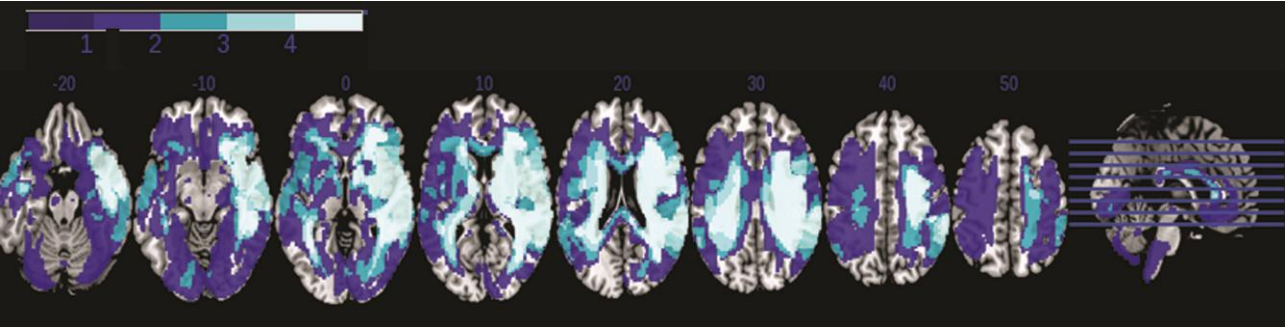
Supplementary Figure 1. Example of meaningful pantomime (left), in this case “drinking from a glass”, and its meaningless version (right).



Supplementary Figure 2. Examples of meaningful intransitive action (i.e. “mad”) (left) and of meaningless intransitive action (right).



Supplementary Figure 3. Lesion overlap map representing the spatial distribution of lesions for the 21 patients in the current study. The lesion overlap map is shown on the axial slices in standard MNI space. The blue colour shows the number and of patients with a lesion within particular voxel. The bar on top of the figure shows the number of patients corresponding to each color shade. MNI Z-coordinates of the axial sections are given.



Supplementary Analyses

Betas Extraction

For each model, the contrasts were run and results were displayed, with statistical values and coordinates. After selecting the peak coordinates for a significant cluster of voxels, the betas (β) were extracted for that cluster using the SPM8 '*eigenvariate*' tool with a 'sphere radius' of 9mm. The procedure was repeated for each significant cluster of voxels from each model.

REGRESSIONS

Patients' raw scores at imitation of transitive (TR) meaningful (MF) and meaningless (ML) and intransitive (INT) MF and ML gestures were used as covariate of interest, together or in separate models, to predict MRI signal changes from grey matter (GM) and white matter (WM).

Note: Higher scores correspond to better performance. So, the hypothesis was that higher scores predicted the integrity of GM and WM tissues from areas involved in the task.

GM – Overall model - Transitive MF&ML and Intransitive MF&ML

The overall model including the scores at imitation of transitive MF and ML and intransitive MF and ML gestures highlighted a significant cluster of voxels on the left hemisphere including the precuneus (PCUN), the cuneus (CUN) and the Supplementary Motor Area (SMA). See Table 1 in the main text for the coordinates and the statistics.

Regression

Dependent variable: Average β from the cluster of voxels of 9mm having its peak on the Left PCUN (-6 -58 46).

Regressors: Imitation raw scores – i.e. transitive MF, transitive ML, intransitive MF, intransitive ML and the covariates of non-interest – i.e. age, gender, education, handedness and lesion volume.

Regression Results

The results of the ANOVA carried out on residuals of the multiple regression indicated that the model including all the covariates of interest and non-interest predicted the β from the ROIs that had the peak on the Left PCUN (-6 -58 46) ($F(9,11) = 3,697$, $p = 0,023$).

The analysis on single coefficients, testing the effects of single regressors after the other regressors were factored out, showed that, among the four covariate of interest, INT ML scores had a significant effect. ($t(20) = 2,588$, $p = 0,025$).

The plot in Supplementary Figure 4a shows the distribution of the standardized predicted value of the dependent variable according to their standardized 'distance' (residuals) from the real values of the dependent variable. All the predicted value fell between values <2 and >-2 .

GM – Transitive MF

From the model including the performances with the transitive MF gestures as the unique covariate of interest we obtained a significant cluster on the left hemisphere including the posterior cingulate cortex (PCC) and the PCUN. See statistics and coordinates in Table 1 in the main text.

Regression

Dependent variable: Average β from the cluster of voxels of 9mm having its peak on the Left PCUN (-8 -38 26).

Regressors: transitive MF gestures imitation raw scores and the covariates of non-interest – i.e. age, gender, education, handedness and lesion volume.

Regression Results

The model including the raw scores at the transitive MF gestures imitation as covariate of interest, along with the covariates of non-interest, appeared to predict the β from the ROI that has the peak on the Left PCUN (-8 -38 26) ($F(6,14) = 4,736$, $p = 0,008$).

The analysis of each single coefficient showed that the transitive MF scores had a significant effect in predicting the β from the ROI ($t(20)= 4,555, p< 0,0001$).

The plot in Supplementary Figure 4b shows the distribution of the predicted value of the dependent variable, expressed as standard scores, according to their standardized ‘distance’ (residuals) from the real values of the dependent variable. All the predicted value fell between values <2 and >-2 .

GM – Transitive ML

The analysis on the model including only the scores for imitation of the transitive ML gestures as covariate of interest highlighted one cluster on the left hemisphere, including the PCUN extending further in the superior parietal cortex (SPC), the occipital cortex (OCC) and the cingulate cortex (CC), as well as a cluster on the right hemisphere encompassing the superior frontal cortex (SFC) and the CC. Statistics and coordinates associated to this contrast are in Table 1 in the main text.

Regression

Dependent variable: Average β from two clusters of voxels of 9mm having their peak on the Left PCUN (-14 -50 22 – *first cluster*) and on the Right superior frontal cortex (SFC) (20 8 40 – *second cluster*)

Regressors: TR ML gestures imitation raw scores and the covariates of non-interest – i.e. age, gender, education, handedness and lesion volume.

Regression – First cluster – Results

The regression including the scores at the transitive ML gestures, along with the covariates of non-interest, revealed a significant effect of the covariates in predicting the β from the ROI with the peak on the Left PCUN (-14 -50 22) ($F(6,14)= 6,544, p= 0,002$).

Moreover, the performance with transitive ML gestures, taken as single regressor after the other regressors were factored out, had a significant effect ($t(20)= 5,359, p< 0,0001$).

The plot in Supplementary Figure 4c shows the distribution of the predicted value of the dependent variable, expressed as standard scores, according to their standardized ‘distance’ (residuals) from the real values of the dependent variable. All the predicted value fell between values <2 and >-2 .

Regression – Second cluster – Results

The imitation scores for the transitive ML gestures, along with the covariates of non-interest, predicted the β from the ROI that has the peak on the Right superior frontal cortex (20 8 40) ($F(6,14)= 5,567, p= 0,004$).

When the effects of single regressors were tested, after the other regressors were factored out, it appeared that TR ML scores had a significant effect ($t(20)= 4,802, p< 0,0001$).

The plot in Supplementary Figure 4d shows the distribution of the standardized predicted value of the dependent variable according to their standardized ‘distance’ (residuals) from the real values of the dependent variable. All the predicted value appears fell between values <2 and >-2 .

GM – Intransitive ML

The analysis on the model with the scores for the intransitive ML gestures as single covariate of interest gave a significant cluster mainly involving the right SFC, but also including the right SMA and extending to the left SMA and left PCUN.

Regression

Dependent variable: Average β from the clusters of voxels of 9mm having its peak on the Right medial superior frontal cortex (8 46 40).

Regressors: INT ML gestures imitation raw scores and the covariates of non-interest – i.e. age, gender, education, handedness and lesion volume.

Regression Results

The multiple regression including scores at imitation of intransitive ML gestures and the covariates of non-interest appeared to predict the β from the ROI that has the peak on the Right medial SFC (8 46 40) ($F(6,14) = 11,741, p < 0,0001$).

When the effects of single regressors were tested, after the other regressors were factored out, the analysis showed that the performance intransitive ML scores had a significant effect in predicting the signal ($t(20) = 15,945, p < 0,0001$).

The plot in Supplementary Figure 4e shows the distribution of the standardized predicted value of the dependent variable according to their standardized 'distance' (residuals) from the real values of the dependent variable. All the predicted value fell between values <2 and >-2 .

WM – Transitive ML

The performances with the transitive ML gestures predicted the signal changes from the corticospinal tract, the corpus callosum and the white matter running within the temporal lobe on the left hemisphere. See Table 2 in the main text for the statistics and coordinates associated to these results.

Regression

Dependent variable: Average β from the cluster of voxels of 9mm having its peak at the coordinates (-24 -28 40), on the white matter tract involving the corpus callosum, the corticospinal tract and the superior temporal gyrus.

Regressors: TR ML gestures imitation raw scores and the covariates of non-interest – i.e. age, gender, education, handedness and lesion volume.

Regression Results

The regression including the raw scores at the transitive ML gestures imitation and the covariates of non-interest predicted the β from the ROI in the white matter tract that has the peak at the coordinates (-24 -28 40) (F (6,14)= 3,218, p= 0,034).

The imitation scores with the intransitive ML gestures gave significant results also when the effects of single regressors were tested, after the other regressors are factored out (t (20)= 3,936, p= 0,001).

The plot in Figure 4f shows the distribution of the standardized predicted value of the dependent variable according to their standardized 'distance' (residuals) from the real values of the dependent variable. All the predicted value fell between values <2 and >-2.

CORRELATIONS

Beside investigating the extent to which the covariates of interest could predict the β from each ROI, the correlations between β , and imitation scores with the transitive MF and ML and the intransitive MF and ML gestures were explored.

Results

The results are summarized on Supplementary Table 3.

GM: The β from the cluster on the left PCUN, SMA and CUN obtained for the model including the four covariates of interest taken together correlated significantly with the scores at the transitive MF ($r= 0,43$; $p=0,05$ – see Supplementary Figure 5a) and the intransitive ML gestures ($r= 0,43$; $p=0,05$ – Supplementary Figure 5b). The β from the cluster on the left PCC, PCUN and CC found for the model including the transitive MF only correlated significantly with the scores at the transitive MF ($r= 0,59$; $p< 0,0001$ – Supplementary Figure 5c). The β from both the clusters obtained from the model with the transitive ML only, on the left PCUN, SPC and OCC and on the right SFC and CC, correlated significantly with the scores at the transitive ML ($r= 0,64$, $p<0,0001$ and $r=0,45$, $p=0,04$ respectively - Supplementary Figure 5d and Supplementary Figure 5e). Finally, the β from the cluster from the model including the intransitive ML only, encompassing the right SFC and SMA, had a strong trend for significance with the scores at the intransitive ML gestures ($r= 0,45$, $p=0,06$ - Supplementary Figure 5f).

WM: The β from the cluster in the WM tract within the temporal lobe correlated, obtained from the analysis on the model including the intransitive ML only, correlated significantly with the scores at the transitive ML ($r= 0,58$, $p=0,01$ - Supplementary Figure 6).

Supplementary Table 3

	β GM all	β GM TR MF
TR_MF	R_VAL= 0,43 P_VAL= 0,05	R_VAL= 0,59 P_VAL<0,00

	β GM all	β GM TR ML1	β GM TR ML2	β WM TR ML
TR_ML	<i>R_VAL= 0,33</i> <i>P_VAL>0,1</i>	R_VAL= 0,64 P_VAL<0,00	R= 0,45 P_VAL=0,04	R_VAL= 0,58 P_VAL=0,01

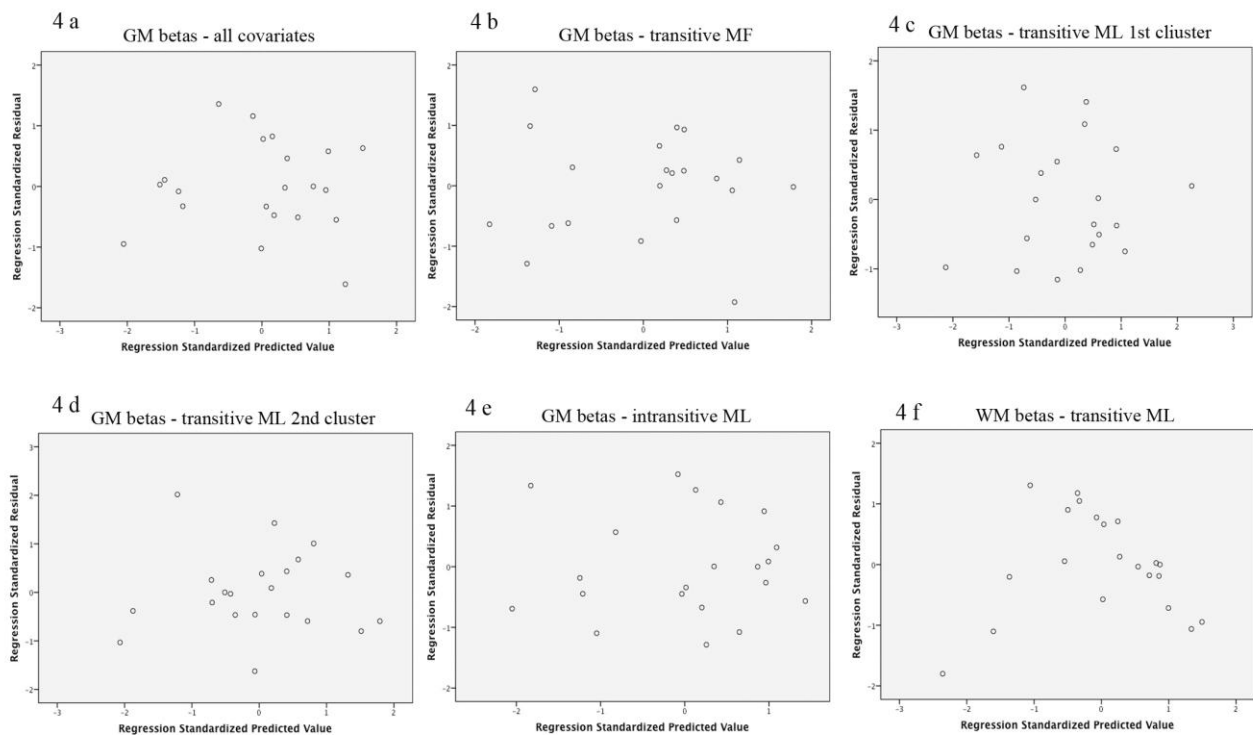
	β GM all
INT_MF	<i>R_VAL= 0,3</i> <i>P_VAL>0,1</i>

	β GM all	β GM INT ML
INT_ML	R_VAL= 0,43 P_VAL= 0,05	<i>R_VAL= 0,42</i> <i>P_VAL=0,06</i>

Abbreviations: β GM all= betas from model with all the covariate of interest; β GM TR MF= betas from model with TR MF as the covariate of interest; β GM TR ML1= betas from 1st cluster from model with TR ML as the covariate of interest; β GM TR ML2= betas from 2nd cluster from model with TR ML as the covariate of interest; β GM INT ML= betas from model with INT ML as the covariate of interest; β WM TR ML= betas from WM model with TR ML as the covariate of interest. TR_MF=TR MF gestures imitation raw scores; TR_ML= TR ML gestures imitation raw scores; INT_MF= INT MF gestures imitation raw scores; INT_ML= INT ML gestures imitation raw scores.

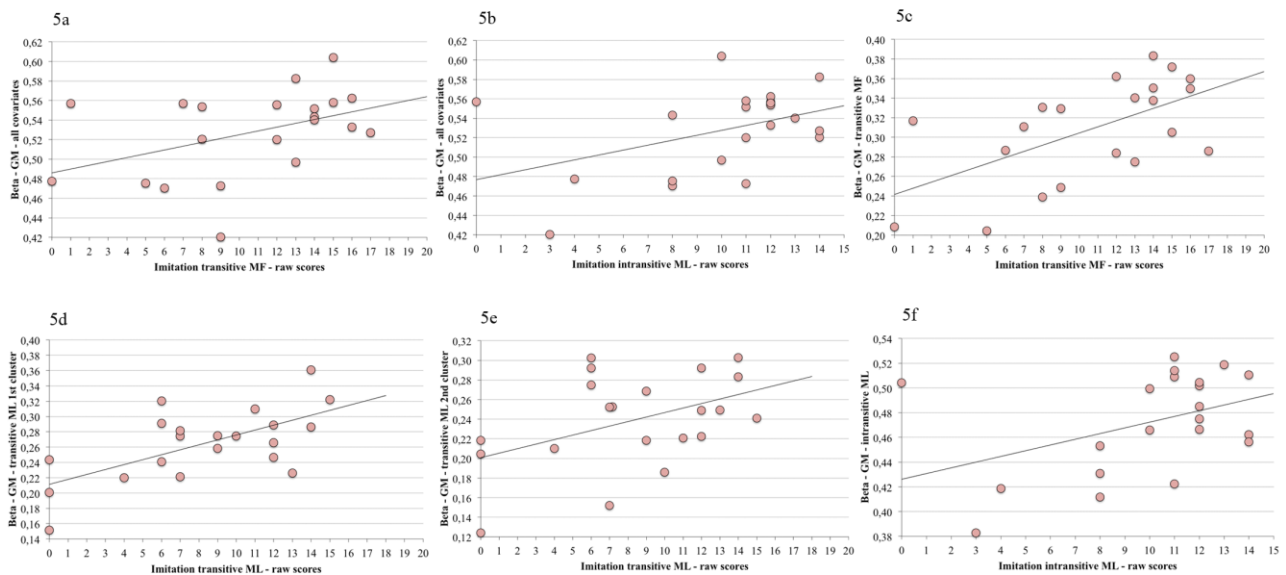
Significant correlations are in **bold and highlighted in grey**. Not-significant correlations are in red. A result that shows a trend for significance is in *italic and highlighted in light grey*.

Supplementary Figure 4 – Distributions of predicted betas according to their residuals (i.e. the differences between the predicted and the actual betas). The X-axes represent the beta values from the ROIs on GM predicted by the four regressors taken together (i.e. transitive MF and ML and intransitive MF and ML gestures imitation scores – Supplementary Figure 4a) or by each single regressor at a time (4b, 4c, 4d, 4e, 4f) and from the ROI on WM predicted by imitation of the Transitive ML gestures (4f), with all values expressed as standard scores. In all the plots, the Y-axes reports standardized residuals (i.e. distance between predicted and real beta values, expressed as standard scores). ‘beta_GM_all’= betas from the ROI in GM obtained with the model including all the covariates of interest; ‘beta_GM_TR_MF’= betas from the ROI in GM for transitive MF gestures only; ‘beta_GM_TR_MLa’= betas from the first ROI in GM for transitive ML gestures only; ‘beta_GM_TR_MLb’= betas from the second ROI in GM for transitive ML gestures only; ‘beta_GM_INT_ML’= betas from the ROI in GM for intransitive ML only; beta_WM_TR_ML’= betas from the ROI in WM for transitive ML gestures only.



PLOTS

Supplementary Figure 5 – Correlations between imitation and betas from ROIs in GM. The X-axes represent the raw scores at Imitation of Transitive MF (Supplementary Figures 5Aa and 5c), Transitive ML (5d, 5e) and Intransitive ML gestures (5b and 5f). The Y-axes represent betas from significant clusters obtained with the overall model (i.e. including transitive MF and ML and intransitive MF and ML gestures imitation scores as covariates of interest - 5a and 5b) or with the models including one covariates of interest at a time (5c, 5d, 5e, 5f).



Supplementary Figure 6. Correlation between imitation of transitive ML gestures and betas from ROI in WM. The X - axis represent the raw scores at imitation of the transitive MF gestures. The Y - axis report the beta values from the cluster in WM obtained with the model including the transitive ML scores as single covariate of interest.

