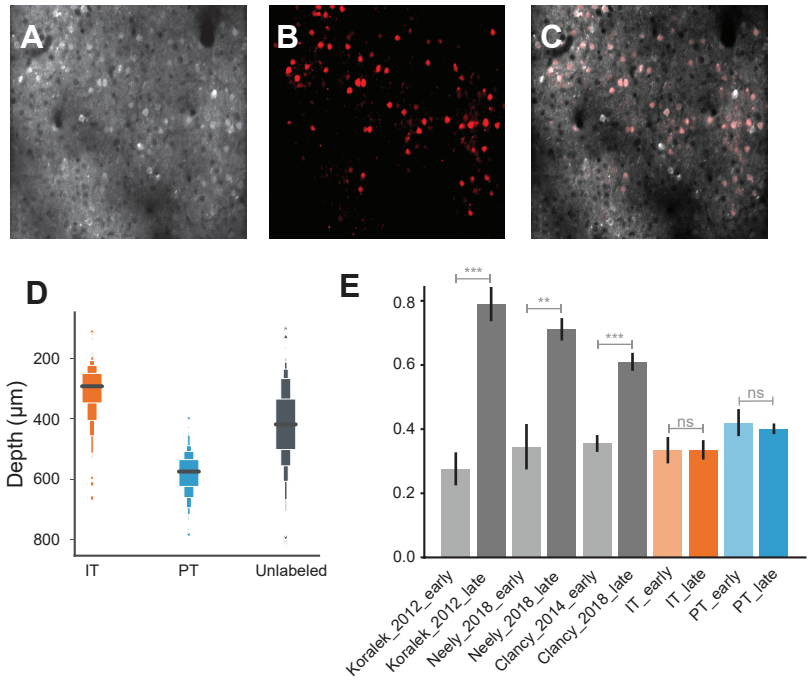

Figure S1: Labeling of IT and PT neurons. Relates to Figure 1 and STAR Methods.
A) GCaMP6 expression under promoter Camk2a. **B)** tdTomato expressing neurons of the same plane as A. **C)** Merge of A and B. **D)** Boxplot of the depth of all the recorded neurons across all planes for the IT and PT group. Unlabeled neurons may belong to either cell-class in both groups. **E)** Comparison of learning with other rodent BMI in early (average of first 2 sessions) and late (average of session 7-8). Koralek_2012[s1] is a BMI performed in rat M1 with electrophysiology, Neely_2018[s2] is a BMI performed in rat V1 with electrophysiology and Clancy_2014[s3] is a BMI performed in mice S1/M1 with calcium imaging. Black lines in bar graphs represent SEM. (ns: no significant, ** : $p<0.005$, ***: $p<0.0005$ with independent t-Test).

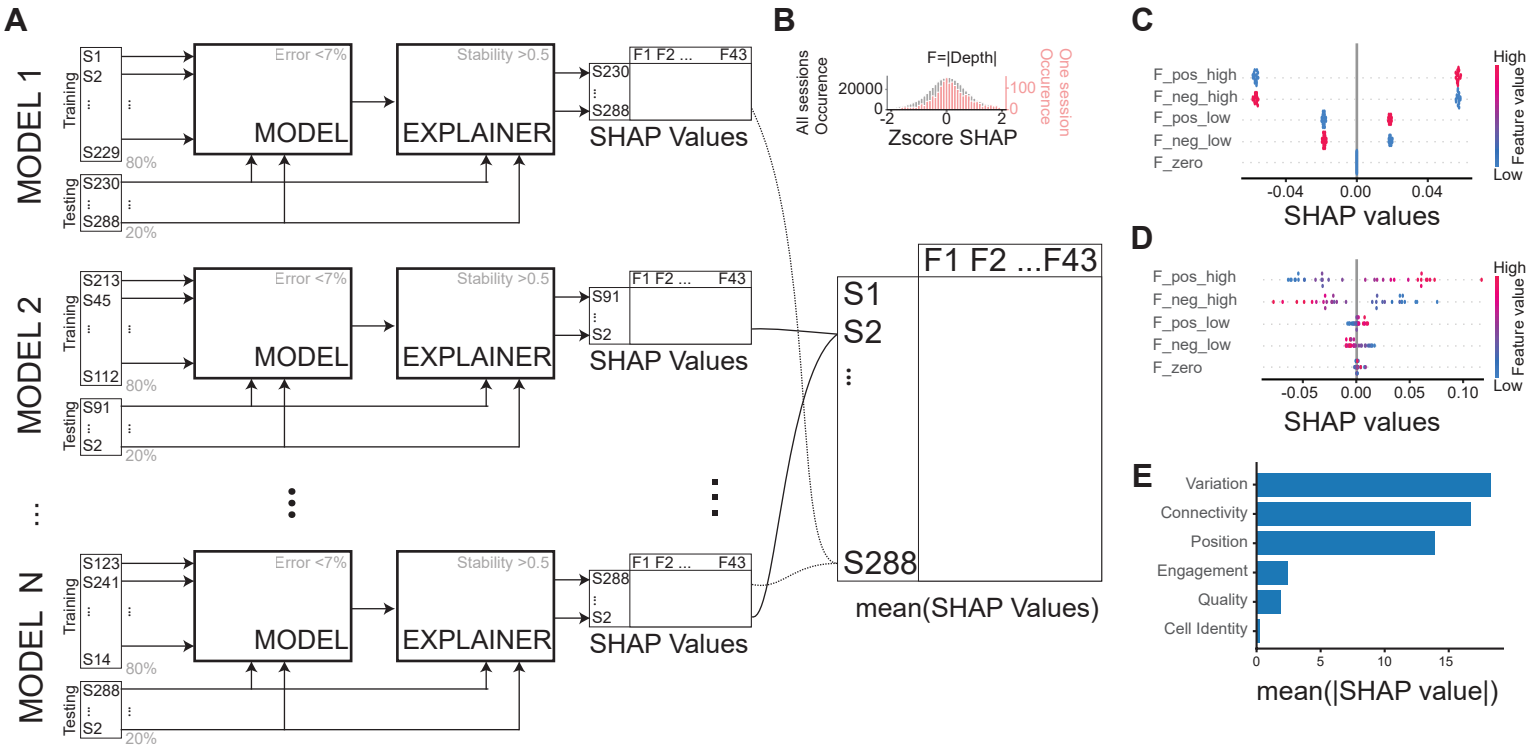

Figure S2: Strategy for XGBoost models and SHAP values. Relates to STAR methods and Figure 2.
A) To obtain robust SHAP[s4] values for each session and feature, we trained XGBoost[s5] models to predict the learning readout percentage-correct for each animal and session. We only selected models (N=10000) with high accuracy and stability. Because the number of learning sessions was small relative to the number of models (288 sessions with a minimum of 15 days per animal), we trained the models with different splits of training and testing sets using random sampling. After obtaining the models, we used SHAP on each session of the testing dataset. Each of those sessions was part of a model an average of 2010 times. Thus, we averaged across all occurrences of the same session, to obtain the best approximated single SHAP value for the same session and feature. XGBoost models were calculated over all sessions jointly. SHAP values were computed on those models and separated on IT and PT sessions for some analysis a posteriori. **B)** Distribution of the zscore values for different occurrences of the same SHAP value across all models and sessions (grey) or all the models that included an individual example session (pink). **C-D)** Ground truth for the XGBoost/SHAP pipeline. Summary of the SHAP values for the synthetic datasets (N=32 sessions, features=5) with independent **(C)** or dependent and random **(D)** features with added noise. Each dot represents a session. Features 1-2 impact positively, 3-4 impact negatively and 5 had no impact. **E)** Total impact on model output for different group of features. For the features belonging to each group see Figure 2.A.

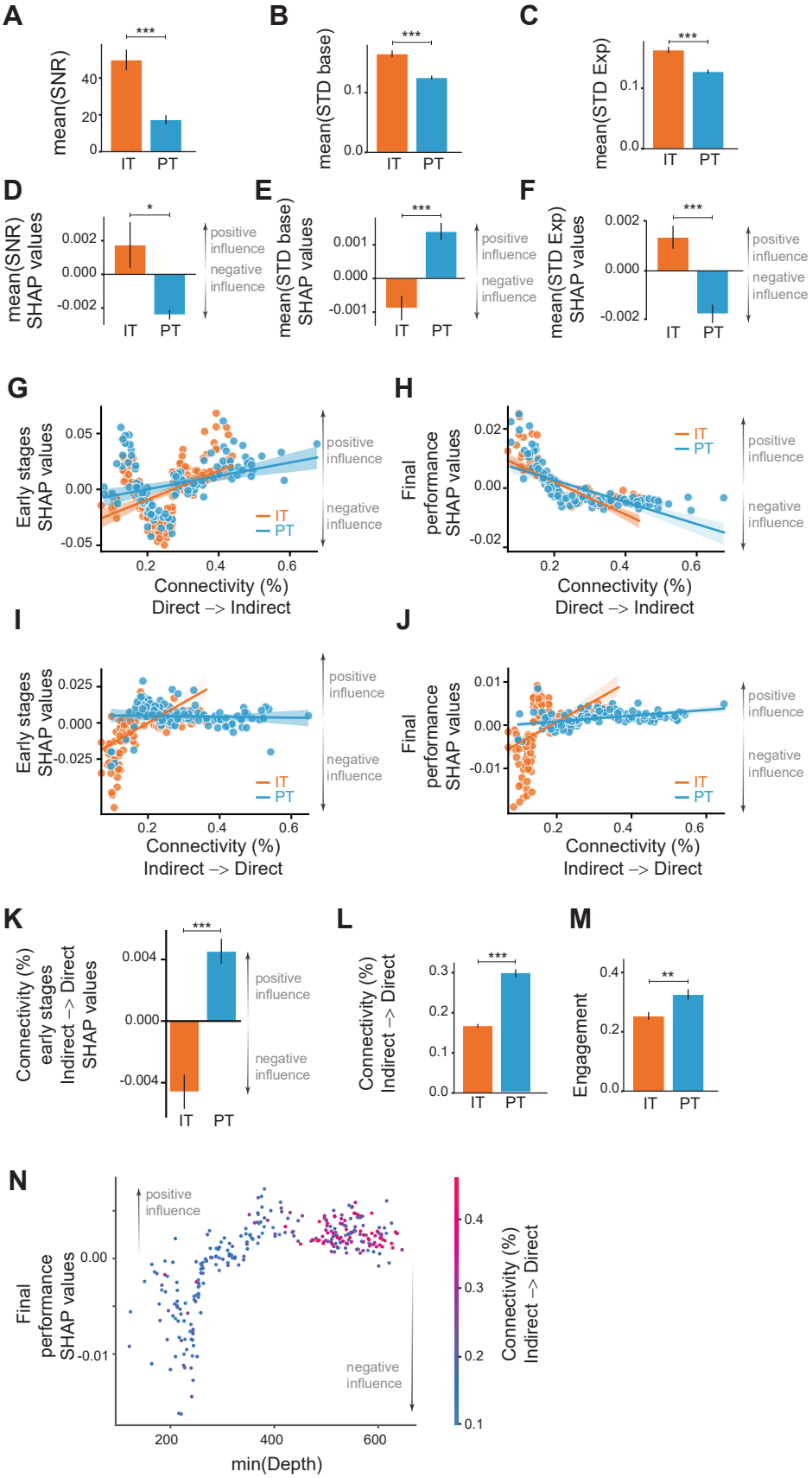

Figure S3: Raw value and mean SHAP values for different features and stages of learning. Relates to Figure 2 and Figure 3.

Raw value of features fed to the XGBoost model **(A-C)** and the mean SHAP values **(D-F)** of those features separated in sessions of the IT or PT groups for SNR **(A,D)**; STD of the baseline **(B,E)** or STD of the whole experiment **(C,F)**. **G-J)** Linear regression of the SHAP values and the connectivity from direct to indirect neurons **(G-H)** or vice versa **(I-J)**. The regression model+explainer was performed on the percentage correct at 10min of a session **(G,I)** or at the final performance **(H,J)**. **K)** SHAP values obtained after regressing the percentage correct at 10min for the effective connectivity from indirect to direct neurons (see Fig.3.B for final performance). Raw value of the effective connectivity from indirect to direct neurons **(L)** and engagement of indirect neurons **(M).** IT group in orange and PT group in blue. **N)** Dependence plot between SHAP values, depth and connectivity. Colors show the value of connectivity. Each dot represents a session. Black lines in bar graphs represent SEM.(*: p<0.05, , ** : p<0.005, ***: p<0.0005 with independent t-Test).

Supplemental References

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