# White matter tracts traveling between cortical regions associated with the dorsal and ventral visual streams predict learning a perceptual-motor task

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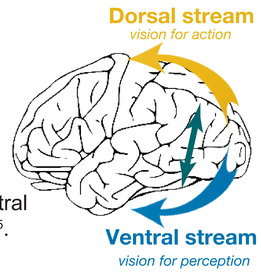
# Introduction

## *Two visual streams*

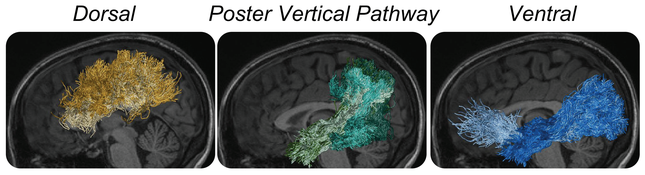
Two visual streams process visual information for different ends: action and perception[1, 2, 3].




Communication between dorsal and ventral streams may be important for learning [4, 5].

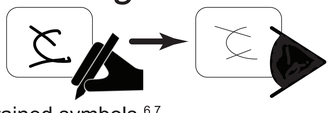
## *White matter*

The Posterior Vertical Pathway (PVP) is a set of four white matter tracts that directly connect cortical regions associated with the dorsal and ventral visual streams [8].




## *Drawing facilitates recognition*

Drawing is a perceptual-motor task with two specific learning outcomes: drawing ability and visual recognition for trained symbols [6,7].



# Experimental questions

Do the tissue properties of PVP white matter tracts predict learning to draw symbols?

Do the tissue properties of PVP white matter tracts predict learning to visually recognize symbols after drawing?

# Methods

*Participants*

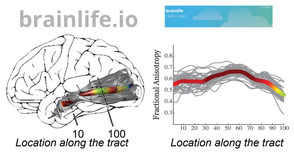
n = 48 adults
(M = 21.6 years, [18.6, 24.1])

*Neuroimaging*

1.5 mm$^3$ voxels,
38 directions in AP, b = 1000 s/mm$^2$ ,
37 directions in AP, b = 2500 s/mm$^2$,
38 directions in PA, b = 1000 s/mm$^2$,
37 directions in PA, b = 2500 s/mm$^2$

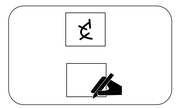
Day 1

*White matter measurement*




Day 2

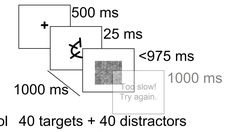
*Drawing training*



40 symbols * 10 trials/symbol = 400 drawing trials

"We will test you on how well you learned these symbols."

*Recognition testing*




40 targets + 40 distractors = 80 recognition trials

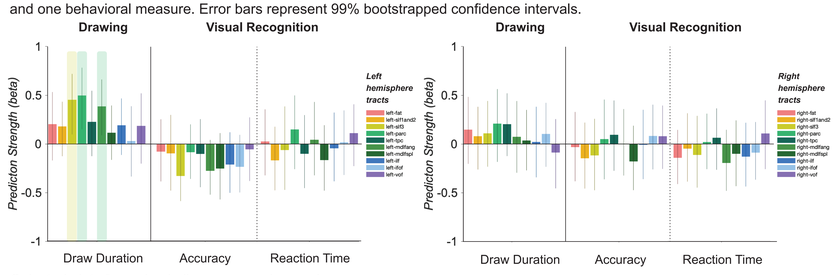
"Did you learn this symbol?" (yes/no)

# Results

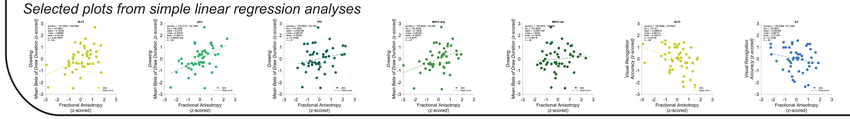
## PVP white matter predicts learning to draw symbols

*Simple linear regression analyses*

To estimate the relationship between pre-training white matter and learning, we performed simple linear regression analyses to predict drawing and visual recognition learning from the mean fractional anisotropy (FA) of tracts. Each model included one tract and one behavioral measure. Error bars represent 99% bootstrapped confidence intervals.

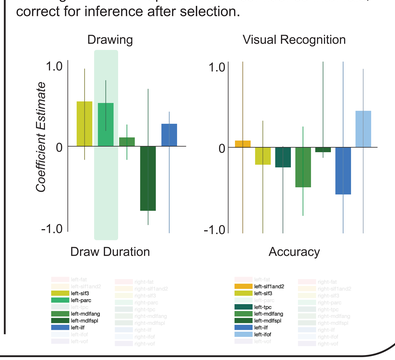



*Selected plots from simple linear regression analyses*



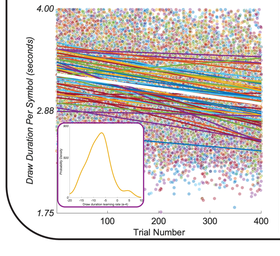
*Relaxed lasso analyses*

To compare among tracts and between behavioral measures, we performed two relaxed lasso analyses to identify which tracts were the strongest predictors of drawing and recognition learning. Error bars represent 90% confidence intervals, correct for inference after selection.



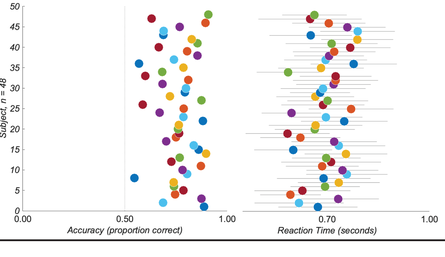

**Participants learned to draw the symbols.**

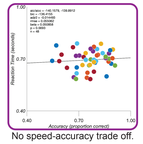
Draw duration decreased as trial number increased, $t(47) = 12.61$, $p < 0.001$, suggesting that participants learned to draw the novel symbols.




**Participants learned to recognize the symbols.**

Accuracy was above chance, $t(47) = 13.08$, $p < 0.001$, suggesting that participants learned to recognize the trained symbols.

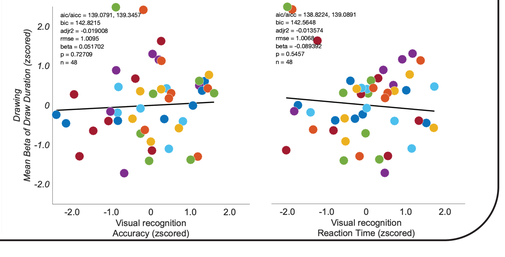



No speed-accuracy trade off.

**No relationship between drawing and recognition learning.**

The slope of draw duration over trials was not related to visual recognition accuracy, $b = 0.052$, $p = 0.73$, or reaction time, $b = -0.09$, $p = 0.55$, suggesting that participants who were better at learning to draw the symbols were not also the same participants who were better at recognition.




# Conclusions

The white matter tissue properties of the left pArc, a tract that directly connects posterior ventral-temporal and posterior parietal cortices, predicts drawing learning but not recognition.

These results suggest:

(1) Individual differences in white matter microstructure may be related to individual differences in learning.

(2) PVP white matter may be important for learning new perceptual-motor skills, likely due to its ability to facilitate interactions between dorsal and ventral visual streams.

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