Neural Factors that Contribute to the Development of Visual Word Form Area (VWFA) Laterality during Early Childhood and Relevance for Reading Behavior

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Z-lab

Introduction

- Laterality: many functional regions are more specialized in one hemisphere than the other (i.e. language, word, face processing)[1,2]
- The Visual Word Form Area (VWFA) is a region of ventral temporal cortex (VTC) that shows selectivity to visual words after reading aquistion[3,4]. In literate adults, the VWFA is left-lateralized[5].
- Connectivity to the language network drives the instantiation of the VWFA.[6] The language network tends to be left lateralized[7].
- Therefore, VWFA laterality may be driven by language *connectivity* (**Connectivity Hypothesis**)
- **Interactive Specialization Hypothesis**: the functional specialization of a region also relates to specialization of *function* in regions it is connected to; VWFA laterality may relate to language laterality[8]
- The role of cross-hemispheric connectivity in laterality has yet to be adequately explored

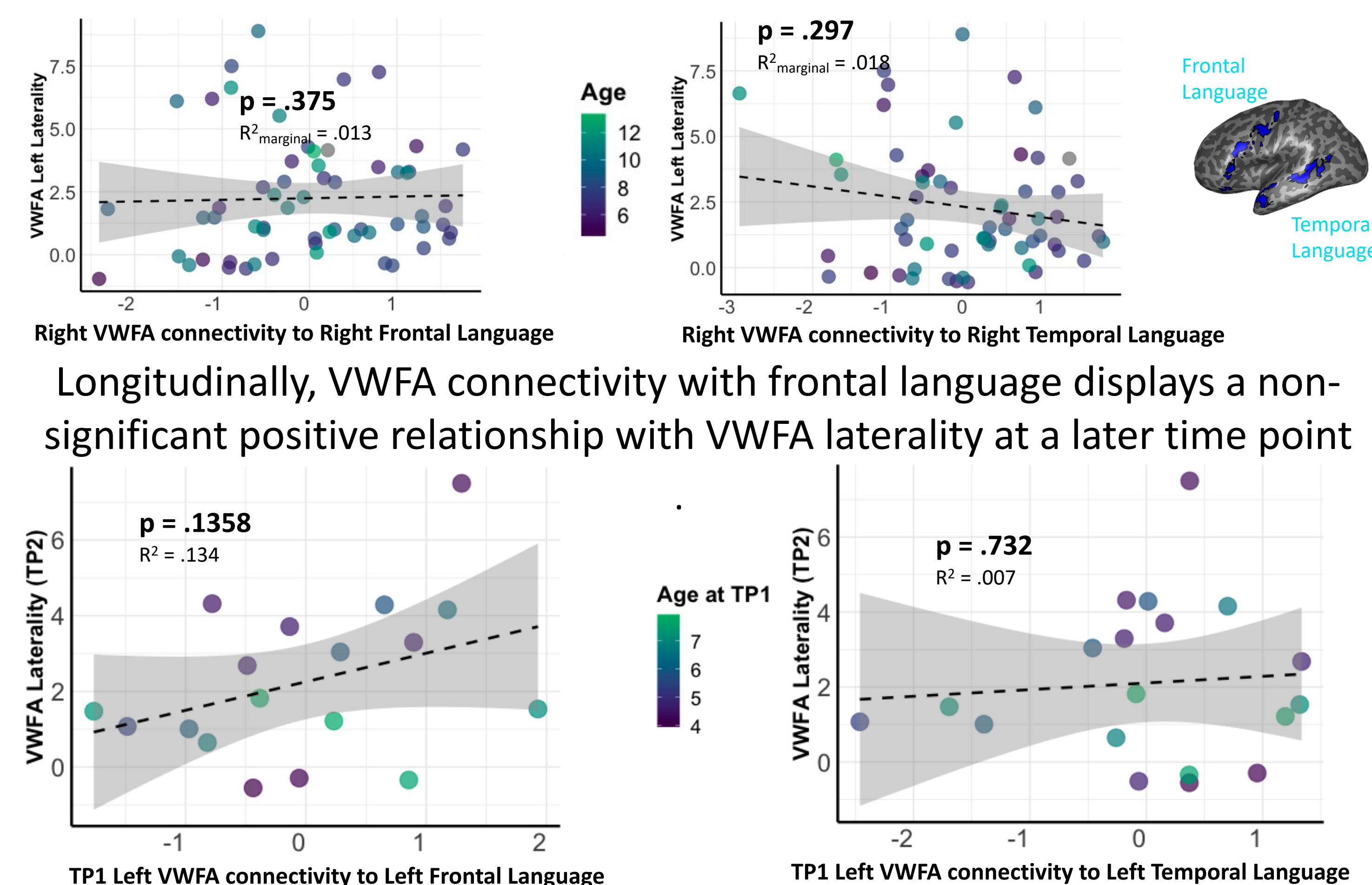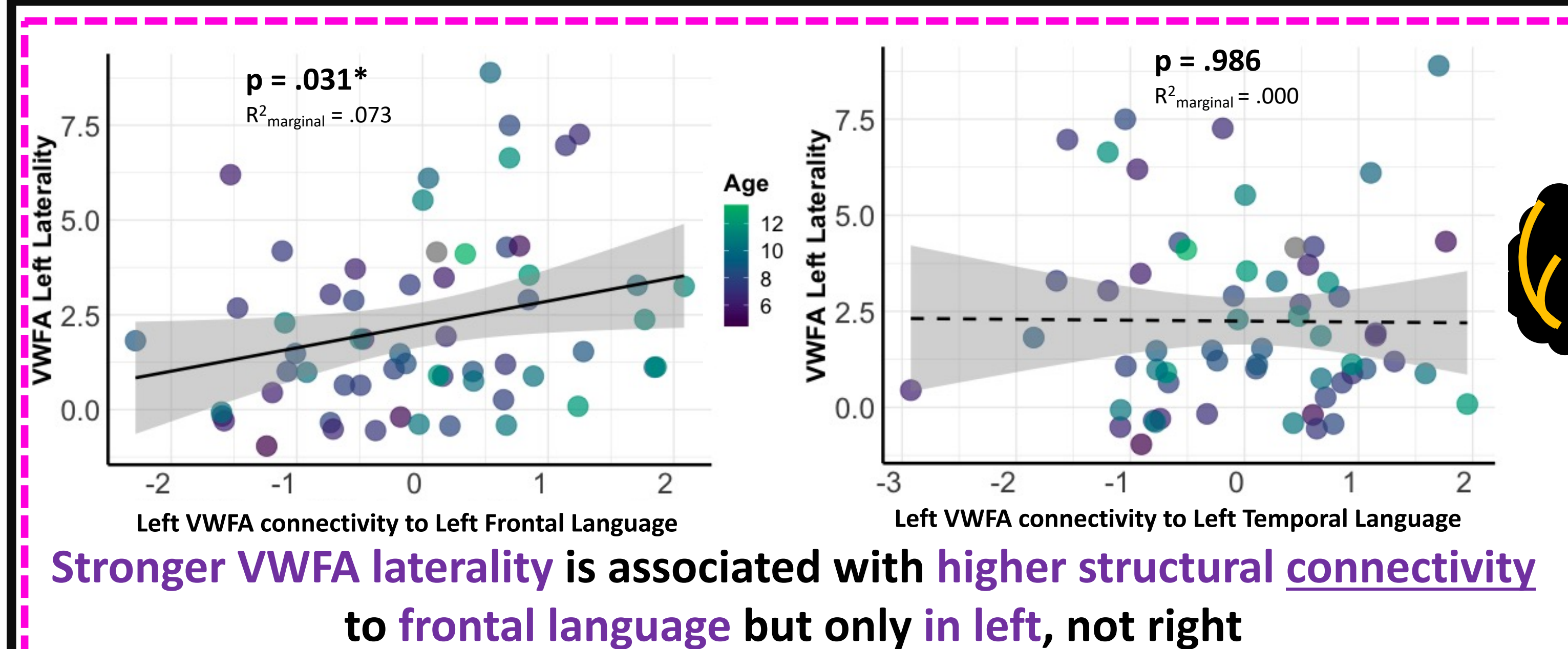Left VWFA   Right VWFA

Question

- **In early childhood, what factors contribute to the development of VWFA laterality?**
- **How does VWFA laterality and its related neural factors relate to reading performance?**
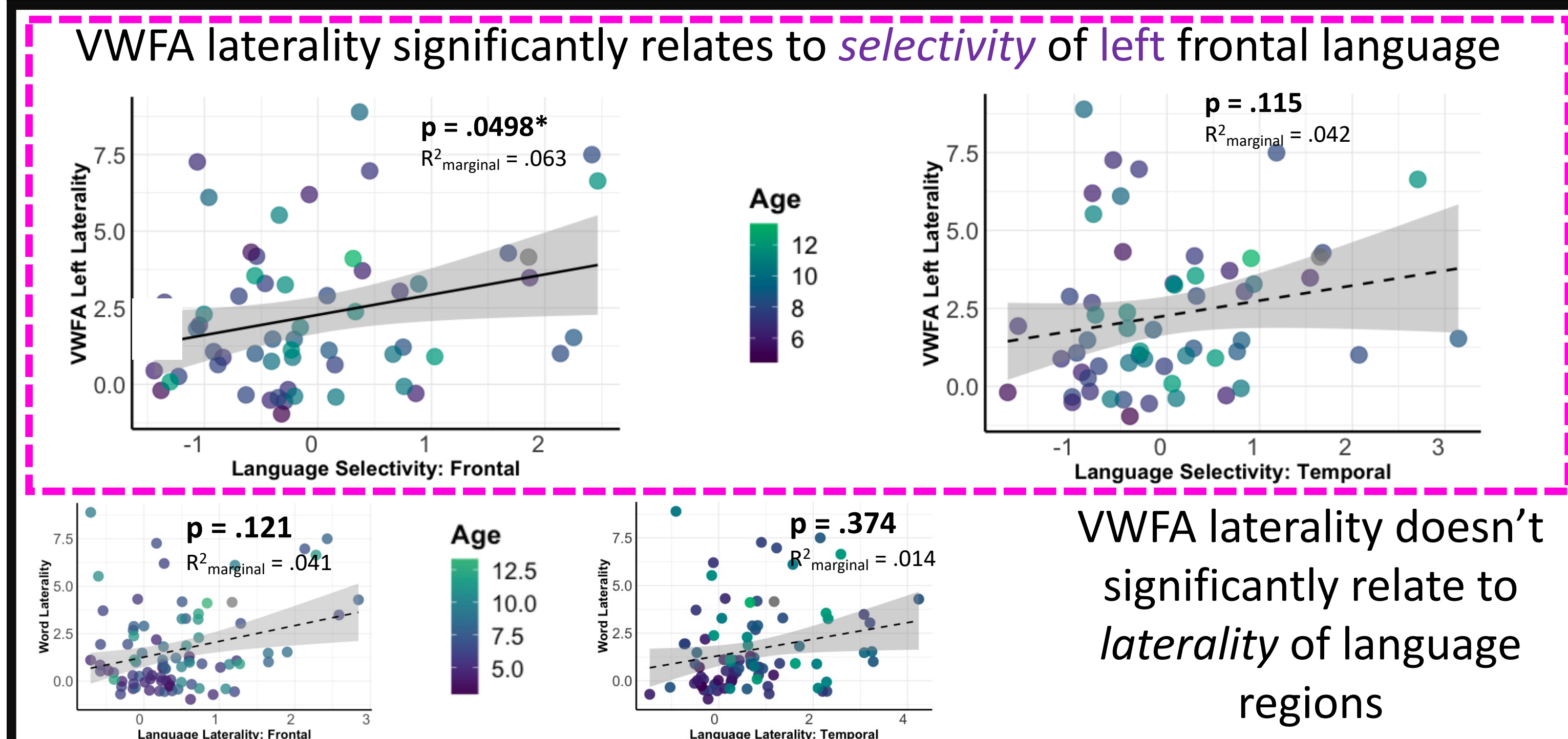
Methods

Participants:
- N = 94, mean age = 7.18 yrs (age range: 3-13)
- Reading subsample: N = 60, mean age = 8.47 yrs (age range: 4-13)
- 19 longitudinal subjects (reading by TP2)
- fMRI localizer tasks to fROIs
  - Visual localizer[6]: static images from 4 visual categories (words, scrambled words, line-drawn objects, line-drawn faces)
  - Language task[9]: 3 categories of auditory stimuli (English, Nonsense, Texturized Speech)
- Functional regions of interest (fROIs) created *individually* by selecting the most selective voxels within the appropriate search space
  - VWFA: words > all -other visual stimuli
  - Language: English > Nonsense
- Diffusion Weighted Images collected
- Structural connectivity between fROIs was estimated using probabilistic tractography (FSL's ProbtrackX)
  - Each fROI treated as a seed region with all other fROIs as targets
- Reading behavior was assessed in a subset of participants: (KTEA-3 Weighted Raw Score)[10]

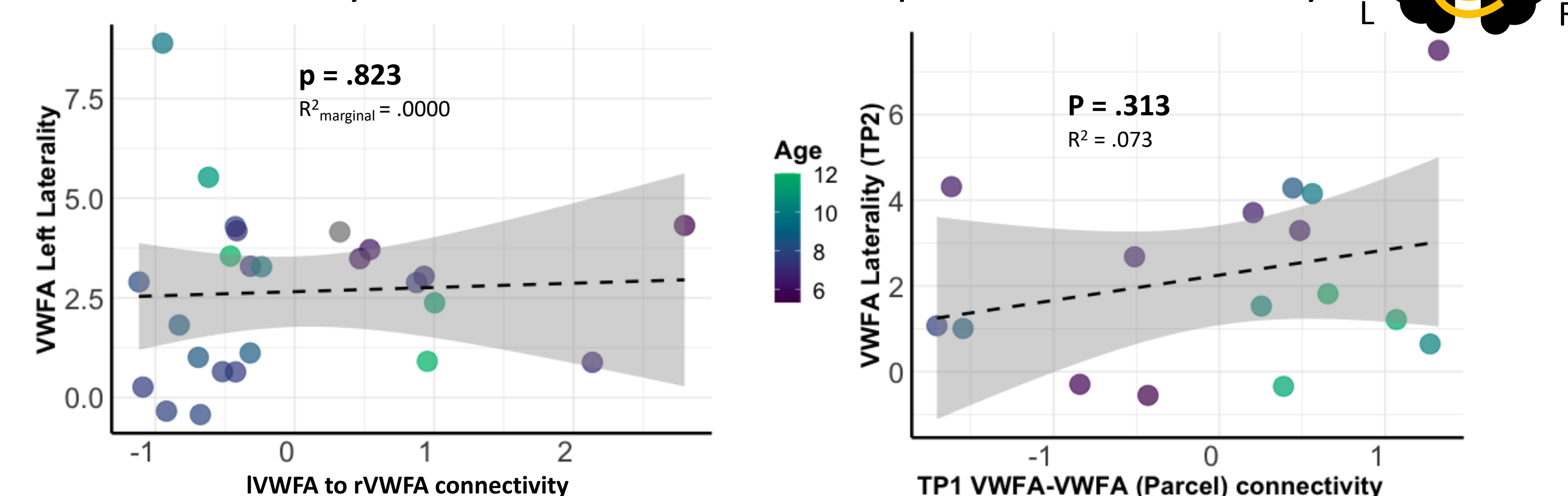## VWFA specialization relates to its *connectivity* with frontal language fROIs

p = .031* $R^2_{marginal}$ = .073

p = .986 $R^2_{marginal}$ = .000

Stronger VWFA laterality is associated with higher structural connectivity to frontal language but only in left, not right

p = .375 $R^2_{marginal}$ = .013

p = .297 $R^2_{marginal}$ = .018

Longitudinally, VWFA connectivity with frontal language displays a non-significant positive relationship with VWFA laterality at a later time point

p = .1358 R^2 = .134

p = .732 R^2 = .007

VWFA specialization relates to language specialization of *function*

VWFA laterality significantly relates to *selectivity* of left frontal language

p = .0498* $R^2_{marginal}$ = .063

p = .115 $R^2_{marginal}$ = .042

p = .121 $R^2_{marginal}$ = .041

p = .374 $R^2_{marginal}$ = .014

VWFA laterality doesn't significantly relate to *laterality* of language regions

VWFA specialization does not relate to cross-hemispheric *connectivity*

Both cross-sectionally and longitudinally, cross-hemispheric connectivity does not have a relationship with VWFA laterality

p = .823 R^2 = .0000

P = .313 R^2 = .073

Stronger VWFA laterality and stronger VWFA *connectivity* to frontal language are associated with stronger reading ability

Stronger VWFA laterality correlated with higher reading scores

VWFA laterality appears to have functional relevance for reading behavior

p = .0196* $R^2_{marginal}$ = .092

VWFA connectivity to frontal language also has significant relevance to reading behavior. VWFA laterality mediates this relationship.

VWFA conn to front lang → direct effect p = .0212* → KTEA_WR
a path: p = .004** → VWFA Laterality → b path: p = .0308* → KTEA_WR
VWFA conn to front lang → indirect effect p <.05* → KTEA_WR

Conclusions and Next Steps

- Support for connectivity hypothesis:
  - Stronger *connectivity* between left VWFA and left frontal language associated with stronger VWFA laterality/specialization
- Support for interactive specialization hypothesis:
  - Stronger selectivity/*function* in connected regions (left frontal language) also associated with stronger VWFA laterality/specialization
- VWFA laterality is functionally relevant for reading ability, not just epiphenomenon
  - Higher *connectivity* between left VWFA and left frontal language is also relevant for reading ability
    - VWFA laterality mediates this relationship
- Moving forward: Does the connectivity hypothesis and the behavioral relevance of laterality apply to other lateralized functions?
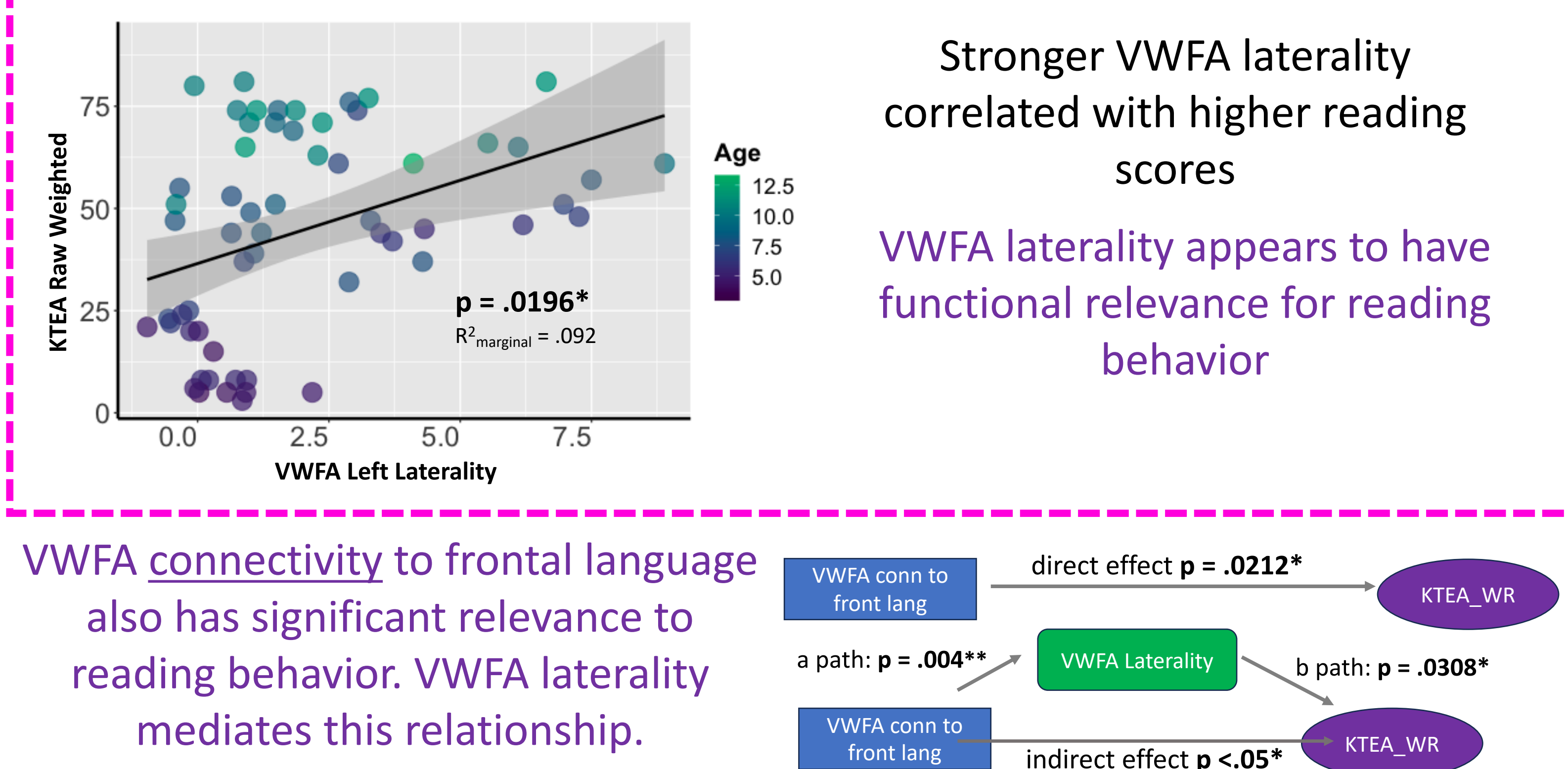
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