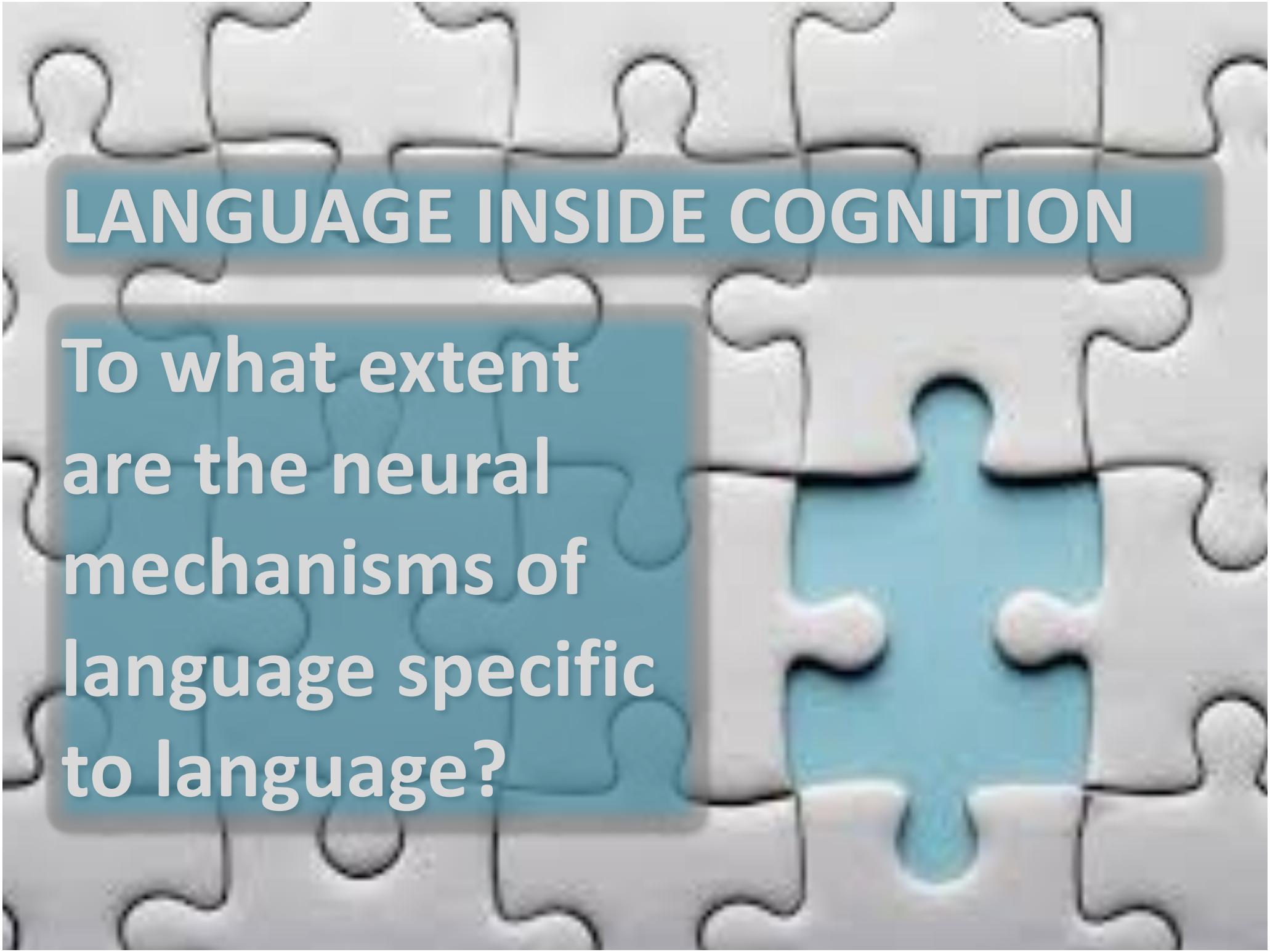
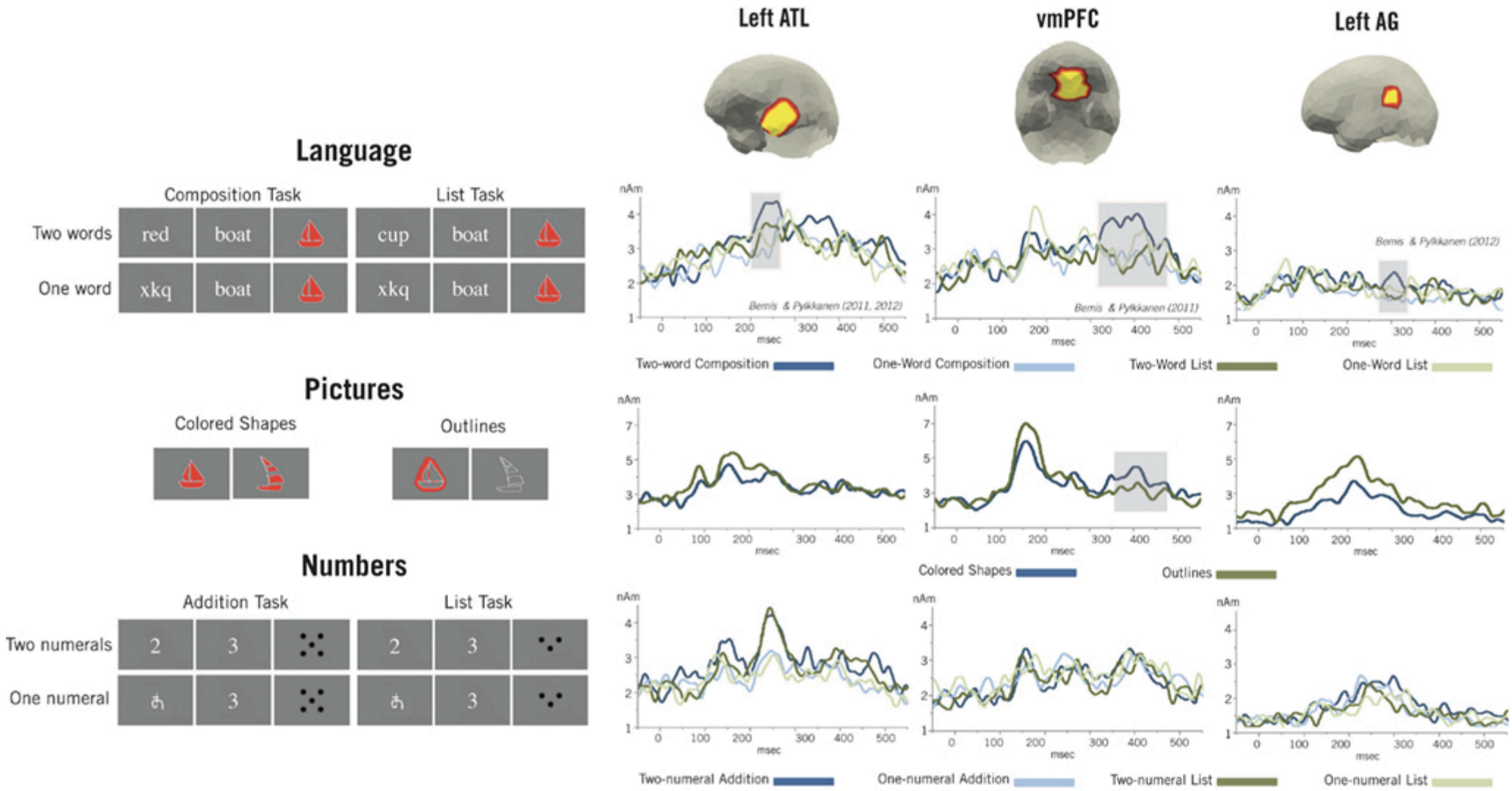

LANGUAGE INSIDE COGNITION
To what extent are the neural mechanisms of language specific to language?

Neural signal that responds to language

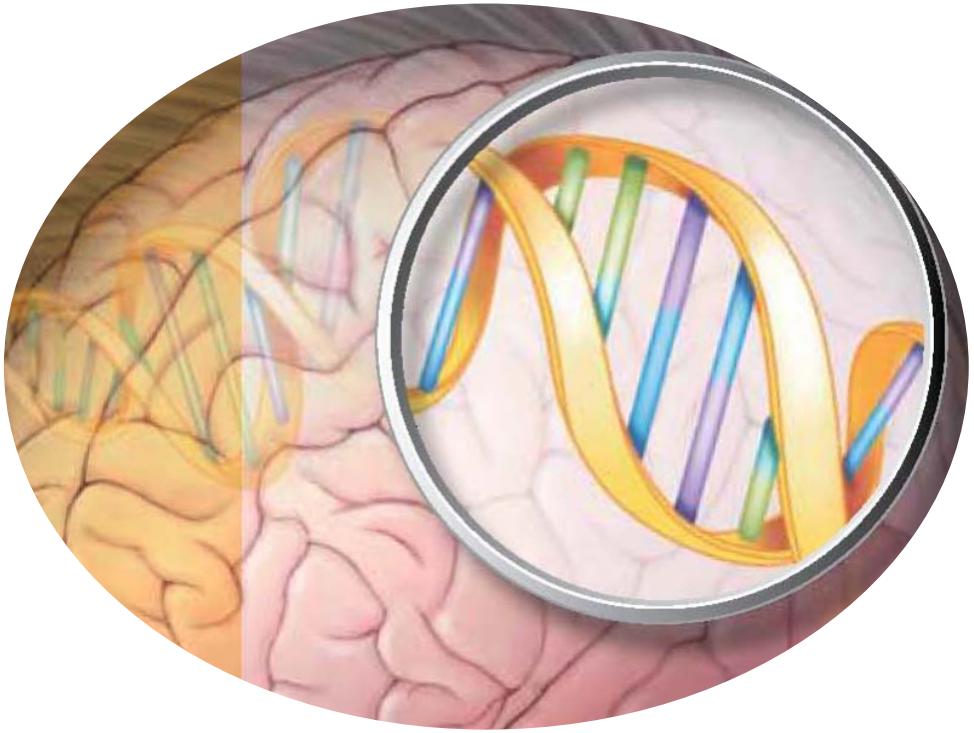
Q: Does this neural signal only operate on language?
To do: Test all other types of stimuli.
Problem: There could always be some stimulus type that you didn't think of or couldn't test. It's not possible to test all other types of stimuli.
Conclusion: "Is X language specific" is a problematic way to formulate a research question.



- Results show that the effects elicited for linguistic phrases mostly do not extend to these examples of combination in the pictorial and number domains.
- They do not show that the effects are language specific.

Bemis, D. K., & Pylkkanen, L. (2013). Combination across domains: an MEG investigation into the relationship between mathematical, pictorial, and linguistic processing. Frontiers in psychology, 3, 583.

Language genes?



Q: Do we have genetic material that only controls aspects of language?

To do: Find a candidate (in humans): a gene whose mutation causes some language problem. Test all other types of stimuli.

Problem: Same as before. Can't test "all other types of stimuli."

Conclusion: "Is X language specific" is a problematic way to formulate a research question.

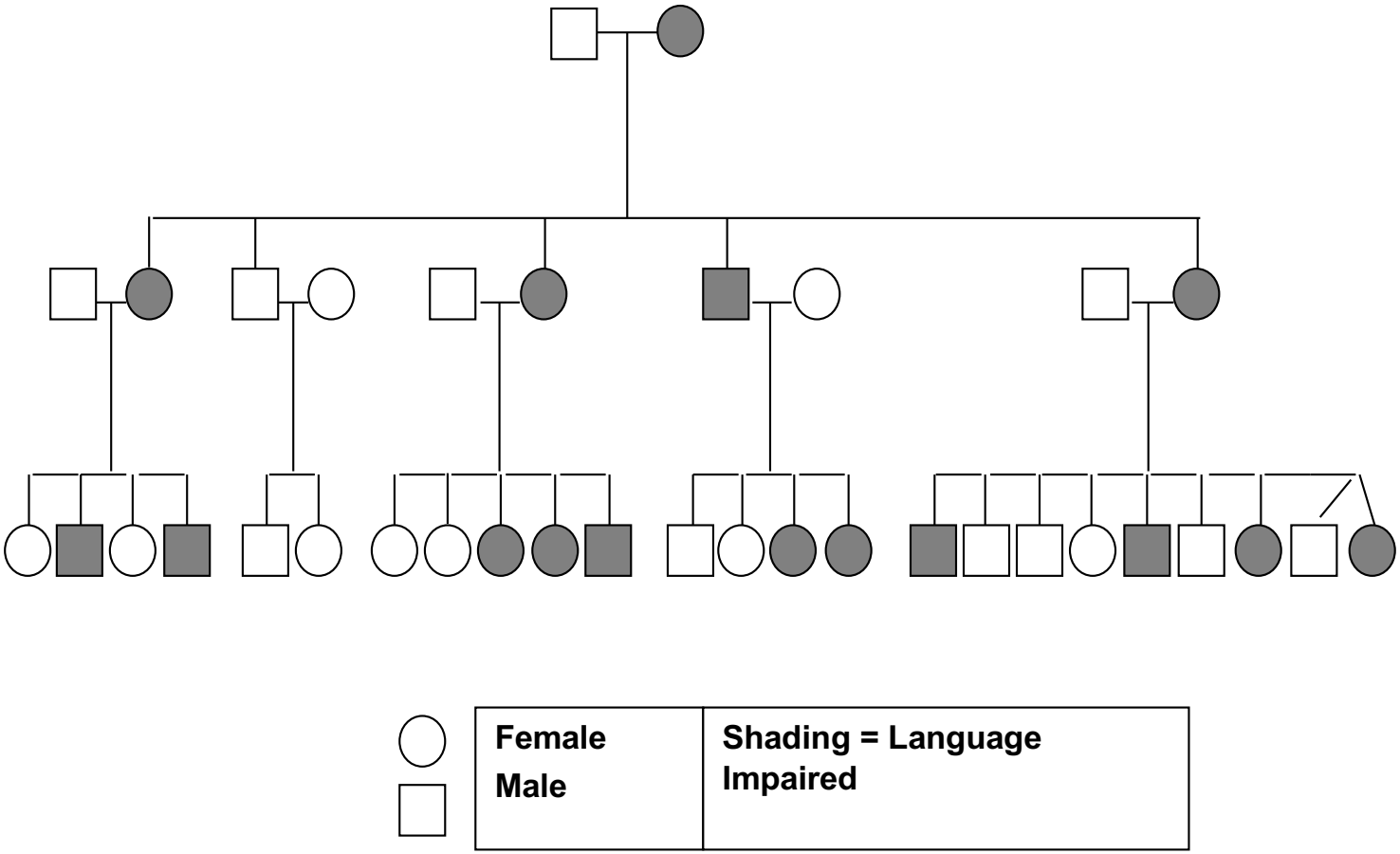
A developmental disorder with a genetic basis:

Specific Language Impairment

- Language impairment without any obvious cause
  - Affects approximately 7-8 % of children in kindergarten (Tomblin et al., 1997)
  - Cognitive skills are otherwise within normal limits
  - No hearing loss
- Runs in families but genetic basis of the disorder is not known in the general population.
- Individuals diagnosed as having SLI are likely quite heterogenous.
- Many hypotheses about the underlying problem have been entertained, but it is not clear whether different research groups have studied similar individuals.
  - Morphology impairment (Gopnik)
  - Verbal inflection impairment (Rice & Wexler)
  - Problem with rapid auditory processing (Tallal)
  - Etc..

KE family

- A heavily studies SLI family in which the genetic basis of their impairment is known: **a mutation in the gene FOXP2**
- Half of the family is affected



Hurst, J. A., Baraitser, M., Auger, E., Graham, F., & Norell, S. (1990). An extended family with a dominantly inherited speech disorder. Developmental Medicine & Child Neurology, 32(4), 352-355.

KE family

- Gene mutation is not shared in the general SLI population.
- The SLI in this family is not typical: language deficit is more severe
- Tests affected members are impaired on →

Test (ref.) [Instructions]
Digit span (9, 10) [Repeat this list of numbers (forwards and backwards)]
Alphabet words [Repeat this word (each begins with a different letter)]
Repetition of words (11) [Repeat this word]
Repetition of nonwords (11) [Repeat this nonword exactly as I say it]
Lexical decision (11) [Is this a real English word?]
Sentence repetition (12) [Repeat this sentence exactly as I say it]
~~Object naming* (13) [Tell me the name of the object in this picture]~~
Picture vocabulary* (14) [Show me the picture for this word]
Phoneme deletion (15) [Say this nonword without its first sound—e.g., varg → arg]
Phoneme addition (15) [Say this nonword adding this first sound—e.g., arg → varg]
Nonword reading (15) [Read this nonword (pronounceable but meaningless)]
Nonword spelling (15) [Write this nonword as if it were a real English word]
Rhyme production [Tell me a word that rhymes with this word]
Reception of grammar (16)
Tense production*
Production of morphological markers [includes derivations and inflections]† (17)
Words
Nonwords
Judgements of morphological markers‡ (17)
Words§
Nonwords

Psychology: Vargha-Khadem *et al. Proc. Natl. Acad. Sci. USA 92 (1995)*

KE family: Not just language problems

Past tense production

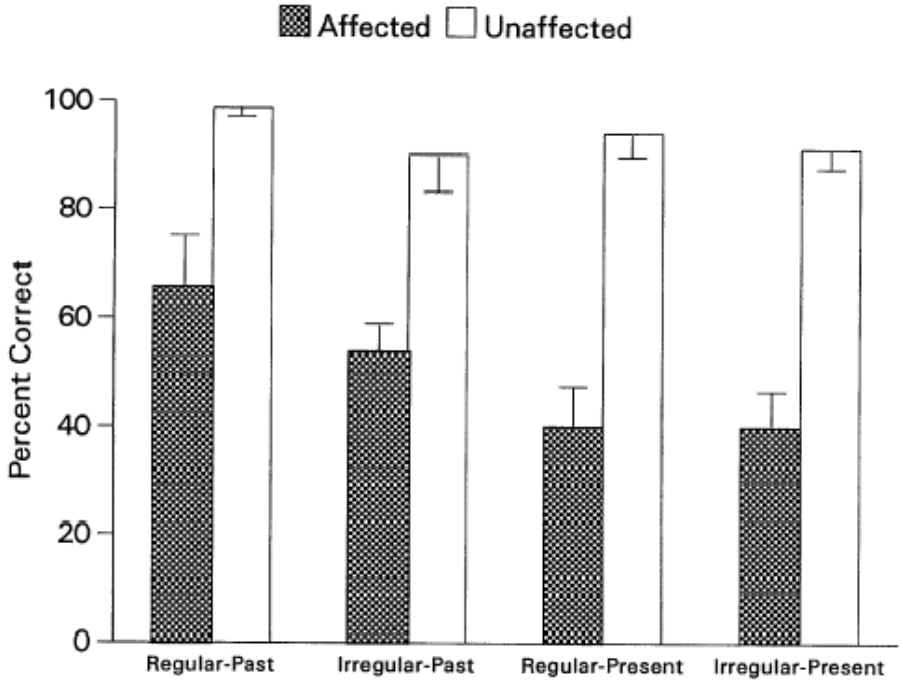


FIG. 2. Production of tenses. Scores are means ± standard errors. See Table 2 for examples of test items.

Imitation of oral and facial movements

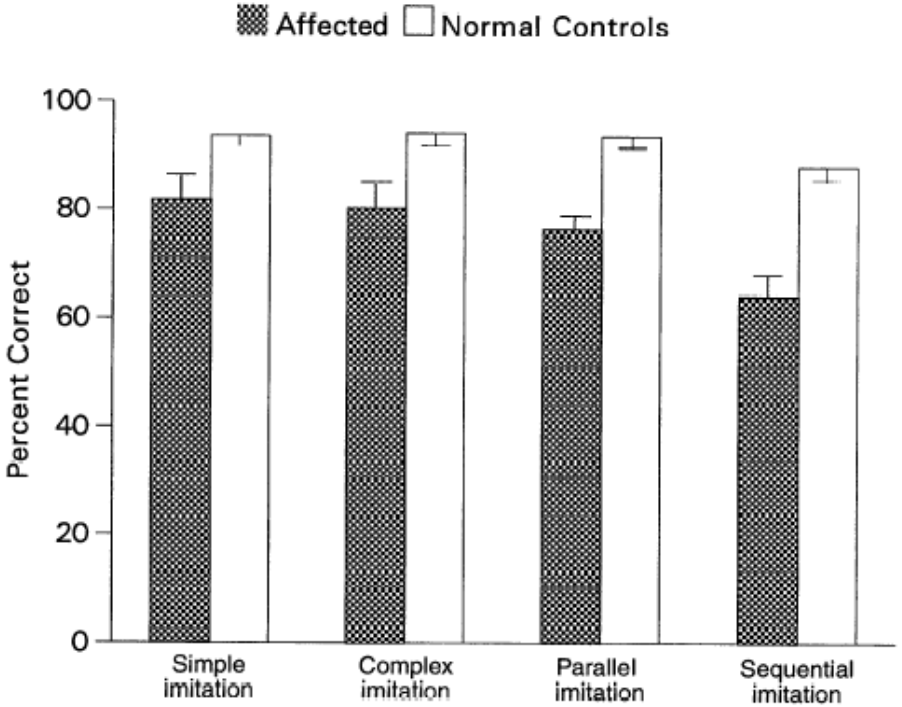
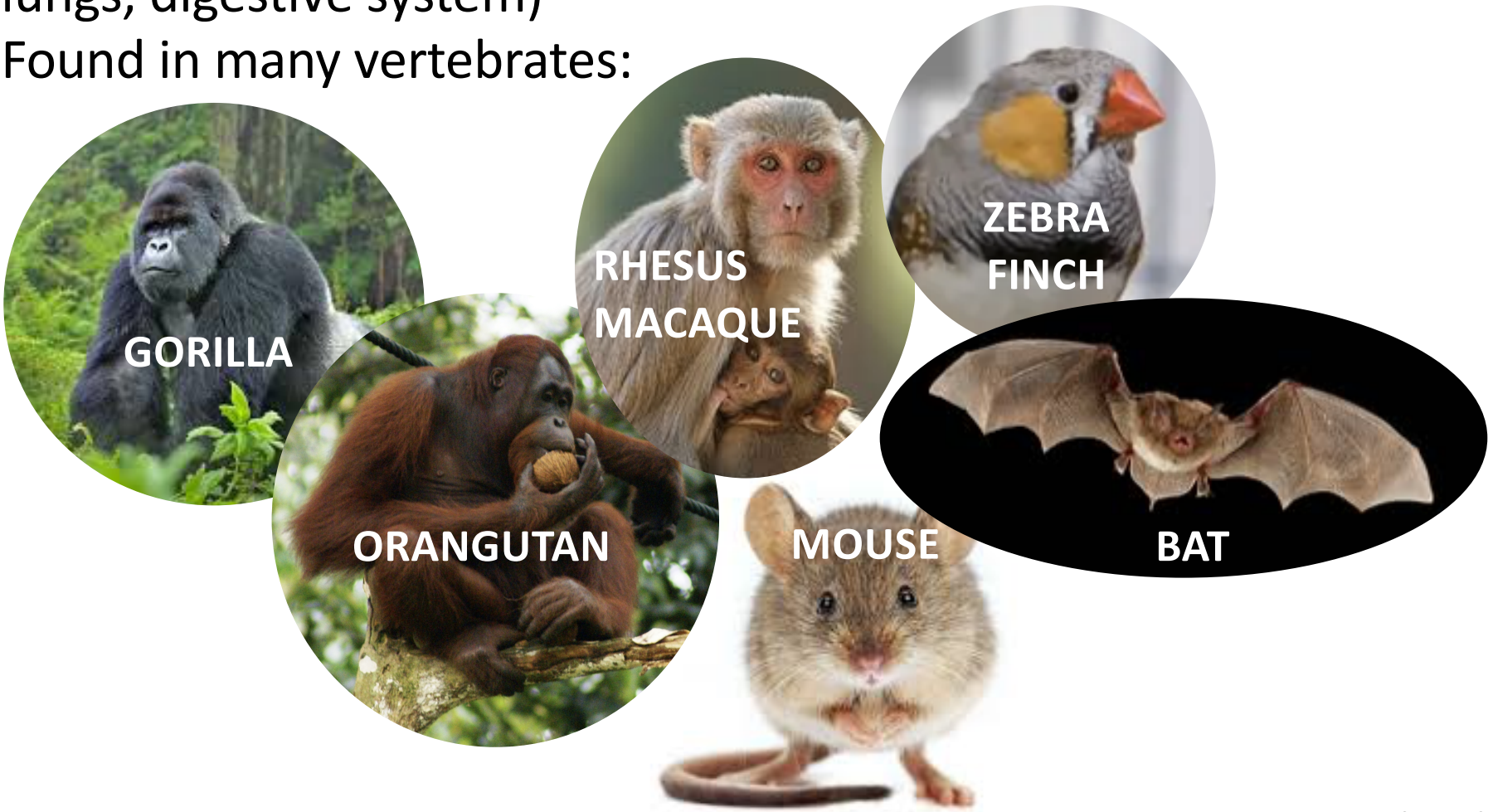


FIG. 3. Imitation of oral and facial movements. Scores are means ± standard errors.

FoxP2: Not a language gene, nor a human gene

- FOXP2 is a gene that controls the activity of other genes
- Has an effect on the development of many organs (brain, heart, lungs, digestive system)
- Found in many vertebrates:



Enard et al. (2002). Molecular evolution of FOXP2, a gene involved in speech and language. *Nature*, 418(6900), 869-872.

Vernes, S. C. (2017). What bats have to say about speech and language. Psychonomic Bulletin & Review, 24(1), 111-117.

Heston, J. B., & White, S. A. (2015). Behavior-linked FoxP2 regulation enables zebra finch vocal learning. Journal of Neuroscience, 35(7), 2885-2894.

FoxP2: Animal models

- The cross-species generality offers many opportunities to study the gene's function in ways that wouldn't be possible in humans.
- What would happen to **mice if they were given the human version of FOXP2**?
  - Altered ultrasonic (>20KHz) vocalizations.
- What would happen to **mice if their FOXP2 underwent the mutation that SLI individuals have**?
  - On isolation from the mother/nest, healthy pups emit ultrasounds that elicit retrieval by the parent (cf. crying baby).
  - Mice lacking a functional FOXP2 do not produce these calls.

Enard, W., Gehre, S., Hammerschmidt, K., Hölter, S. M., Blass, T., Somel, M., ... & Becker, L. (2009). A humanized version of Foxp2 affects cortico-basal ganglia circuits in mice. *Cell*, *137*(5), 961-971.

FoxP2: Animal models

- FOXP2 is a promising window into the evolution of speech and language.
- But it is just one piece of an incredibly complex puzzle.
- We are still far from understanding why we have language but our closest evolutionary relatives do not.

Fisher, S. E. (2019). Human genetics: the evolving story of FOXP2. Current Biology, 29(2), R65-R67.

- Via gene mutation, it's possible to lose aspects of language while retaining many other aspects of cognition.

Is the reverse attested?

Losing a lot of your cognition but not language because of a genetic disorder?

Yes: Williams Syndrome

Williams Syndrome

- (rather) general intellectual disability except in language
- Caused by a sporadic deletion of one copy of 20 or so genes chromosome 7.
- Affects about 1/20000 births, boys and girls equally.
- Low IQ but cognitive profile very uneven.

a Teen with Williams Syndrome

"What an elephant is, it is one of the animals. And what an elephant does, it lives in the jungle. It can also live in the zoo. And what it has, it has long, gray ears, fan ears, ears that can blow in the wind. It has a long trunk that can pick up grass or pick up hay. If they're in a bad mood, it can be terrible. If the elephant gets mad, it could stomp; it could charge. Sometimes elephants can charge. They have big long tusks. They can damage a car. It could be dangerous. When they're in a pinch, when they're in a bad mood, it can be terrible. You don't want an elephant as a pet. You want a cat or a dog or a bird."

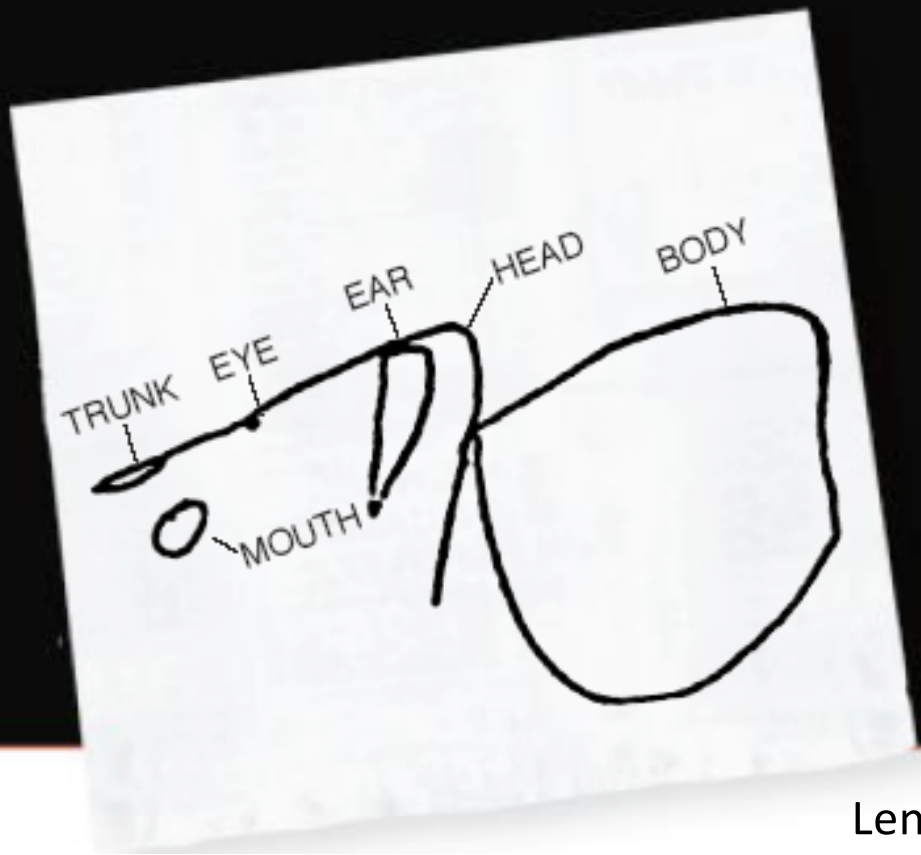
WS weaknesses

- Spatial cognition
- Math
- Motor skills
- Conservation tasks

WS strengths

- Language
- Music
- Face recognition
- Hypersocial

Drawing and Description of an Elephant by a Teen with Williams Syndrome



"What an elephant is, it is one of the animals. And what an elephant does, it lives in the jungle. It can also live in the zoo. And what it has, it has long, gray ears, fan ears, ears that can blow in the wind. It has a long trunk that can pick up grass or pick up hay. If they're in a bad mood, it can be terrible. If the elephant gets mad, it could stomp; it could charge. Sometimes elephants can charge. They have big long tusks. They can damage a car. It could be dangerous. When they're in a pinch, when they're in a bad mood, it can be terrible. You don't want an elephant as a pet. You want a cat or a dog or a bird."

Lenhoff et al. 1997 SCIENTIFIC AMERICAN December 1997 69

WS weaknesses

- Spatial cognition
- Math
- Motor skills
- Conservation tasks

WS strengths

- Language
- Music
- Face recognition
- Hypersocial

- Williams syndrome teaches us about how cognitive abilities can cluster together and gives us clues about how this may be genetically determined.

- It is reasonable to use the Williams profile as a motivator for brain experiments.

WS weaknesses

- Spatial cognition
- Math
- Motor skills
- Conservation tasks

WS strengths

- Language
- Music
- Face recognition
- Hypersocial

- ➢ Violations of linguistic and musical wellformedness can elicit similar ERP responses.
- ➢ Music can prime the N400 similarly to language.
- ➢ Agrammatic Broca's aphasics can show impaired processing of musical syntactic relations.

Patel, A. D., Gibson, E., Ratner, J., Besson, M., & Holcomb, P. J. (1998). Processing syntactic relations in language and music: An event-related potential study. *Journal of cognitive neuroscience*, *10*(6), 717-733.

Koelsch, S., Kasper, E., Sammler, D., Schulze, K., Gunter, T., & Friederici, A. D. (2004). Music, language and meaning: brain signatures of semantic processing. *Nature neuroscience*, *7*(3), 302-307.

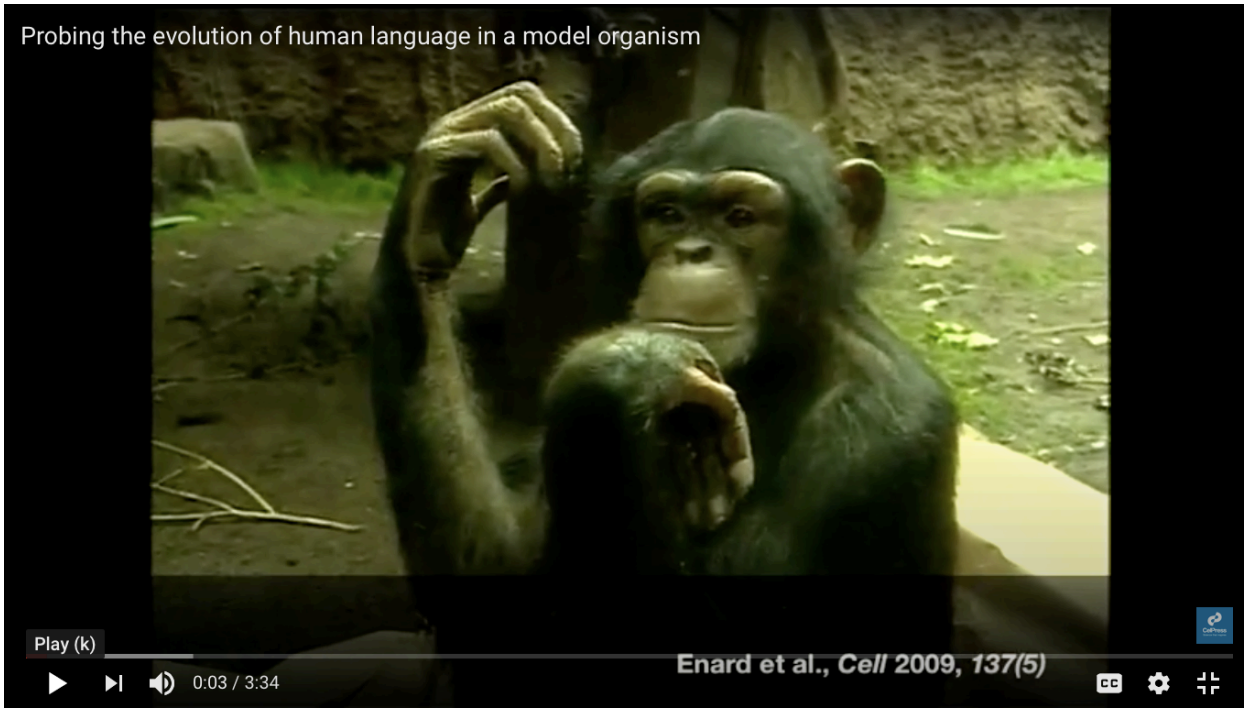
Patel, A. D., Iversen, J. R., Wassenaar, M., & Hagoort, P. (2008). Musical syntactic processing in agrammatic Broca's aphasia. *Aphasiology*, *22*(7-8), 776-789.

IN SUM

- Today, there is no evidence that any specific neural correlate of language is uniquely linguistic, and in general, proving this would be impossible anyway.
- Genetically based developmental disorders with **uneven cognitive profiles** give us clues about how cognitive skills can cluster together.
- In brain experiments, we'll want to understand **how specific computations may (or may not) accept input from multiple domains**.

Further watching

Probing the evolution of human language in a model organism
https://youtu.be/k27DfgKGVp8



Oliver Sacks: The Mind Traveller - 'Don't Be Shy, Mr Sacks'
https://youtu.be/2J8YNyHIT64