



The Role of Specific and Non-Specific Genetic Factors in Language Development

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Key Genetics Questions

- Do genetic factors affect people's ability to acquire and use language?
- Do these factors affect 'normal' people's linguistic abilities or just those with language disorders?
- Do language-specific genes exist?
- Are genetic factors involved in all aspects of language?
- Are the same genetic factors involved in all aspects of language?
- [How do genes and the environment interact?]

Twin Study Rationale



Identical Twins (Monozygotic, MZ)
• Cotwins share ~ 100% environment
• Cotwins share ~ 100% DNA



Fraternal Twins (Dizygotic, DZ)
• Cotwins share ~ 100% environment
• Cotwins share ~ 50% DNA

⇒ If MZ cotwins are more similar than DZ cotwins, this reflects the role of DNA
⇒ Can quantify the relative importance of DNA and environment by comparing the linguistic similarity of MZ cotwins and DZ cotwins



Existing Twin Results (Stromswold, 2001, *Language*)

- Genetic factors play a greater role for language-impaired people (~1/2 - 2/3) than "normals" (~1/4-1/2)
- Genetic factors affect all aspects of language
- Probable existence of some language-specific genes
- Possible existence of some genes specific to different aspects of language



We need to know more about ..

- The heritability of phonology
- The heritability of syntax
- The specificity of the heritable factors affecting language
 - Do the heritable factors that affect language also affect cognitive, social, gross motor, fine motor, and oral motor development?
 - Are there syntax-specific, phonology-specific, vocabulary-specific heritable factors?
- [Interactions among heritable and environmental factors]

Participants in Current Study

Same sex twin pairs from the Perinatal Environment-Genetics Interactions (PEGI) study who were between 2 and 6 years of age.

N = 267 same sex twin pairs

145 monozygotic (MZ); 122 dizygotic (DZ)

Sex: 53% male, 47% female

Birth Weight

MZ: 2294 grams (SD = 583 grams)

DZ: 2368 grams (SD = 635 grams)

Gestational Age at Birth

MZ: 35.1 weeks (SD = 2.8 weeks)

DZ: 35.4 weeks (SD = 3.0 weeks)

Linguistic Measures

4 Linguistic milestones

Babbling
Words
Sentences
Clear articulation

Language test scores

ASQ Communication Scores (all children)

For children < 3 years old

MacArthur CDI spoken vocabulary

MacArthur CDI sentence scores

For children ≥ 3 years old

PAL Articulation (imitation of onsets)

PAL Syntax (comprehension of actives, passives, pronouns)

PAL Lexical Access (rapid naming task)

PAL Total Oral Score

Speech & language therapy/year

Non-Linguistic Measures

2 General measures:

Total ASQ score, All Therapies and Special Services/year

7 Gross motor measures:

ASQ gross motor score, 5 milestones (sit, crawl, walk, run, stairs), Physical Therapy/year

5 Fine motor measures:

ASQ fine motor score, 3 milestones (finger feed, fork feed, scribble), Occupational Therapy/year

2 Oral motor measures:

1 milestone (cup drinking), Feeding Therapy/year

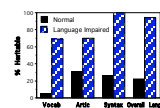
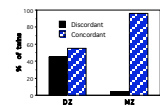
3 Social measures:

ASQ personal-social score, 1 milestone (social smiling), Psych & Behav Therapy/year

2 Cognitive measures:

ASQ problem-solving score, Special Education Services/year

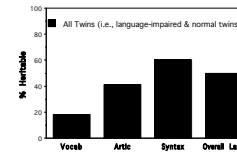
The Role of Genetics in the Language of Normal & Language Impaired Twins



- Concordance analysis reveals genetic factors account for 82% of language disorders in twins, $p < .00001$

- Genetic factors account for more of the variance in linguistic abilities for language-disordered twins than linguistically-normal twins for
 - Vocabulary
 - Articulation
 - Syntax
 - Overall linguistic ability

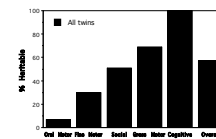
Heritability For Aspects of Language



Heritable factors account for different amounts of variance for different aspects of language:

Vocabulary < Articulation < Overall language < Syntax

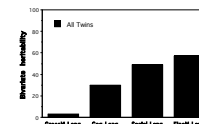
Heritability of Non-Linguistic Abilities



Heritable factors account for different amounts of variance for different non-linguistic abilities:

Oral Motor < Fine Motor < Social < Gross Motor < Cognitive < Overall

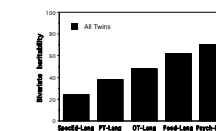
Genetic Overlap Between Linguistic & Non-Linguistic Abilities: ASQ Scores



The amount of genetic overlap between linguistic and nonlinguistic ability varies for nonlinguistic skills

Gross Motor < Cognitive < Social < Fine Motor

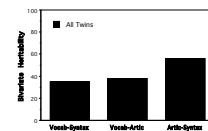
Genetic Overlap Between Linguistic & Non-Linguistic Abilities: Therapy



The amount of genetic overlap between linguistic and nonlinguistic ability varies for nonlinguistic domain:

Cognitive < Gross Motor < Fine Motor < Oral Motor < Psychosocial

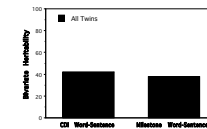
Genetic Overlap for Different Aspects of Language: PAL scores



The amount of genetic overlap for different linguistic skills varies for the different sub-components of language:

Vocabulary-Syntax = Vocabulary-Articulation < Articulation-Syntax

Genetic Overlap for Vocabulary & Syntax: CDI and Milestone Measures



The genetic overlap for vocabulary and syntax is moderate by both CDI (expressive vocabulary and sentence) and milestone (age of onset of words and sentences) measures.

Conclusion 1: Genes Are Important

- Heritable factors play a role for both normal and language-impaired children's language, though heritable factors play a larger role for language-impaired children.
- Heritable factors play a substantial role for all aspects of language, but the role is greater for syntax and articulation than for vocabulary.
- Heritable factors play a substantial role for nonlinguistic abilities, with the exception of oral motor skills.

Conclusion 2: General & Specific Genes are Important for Language

- There is genetic overlap for linguistic and non-linguistic skills (particularly between language and fine motor, oral motor, and social skills).
- There are also specific-to-language (and subcomponents of language) genetic factors.
- The genetic overlap between syntax and articulation is greater than the genetic overlap between vocabulary and syntax or vocabulary and articulation. This may reflect the hierarchical nature of both syntax and phonology.
- Taken as a whole, our results are most consistent with language acquisition models that invoke both general and language-specific learning mechanisms.