NEUROSCIENTIFIC STUDIES OF POVERTY
Inputs for the science of learning

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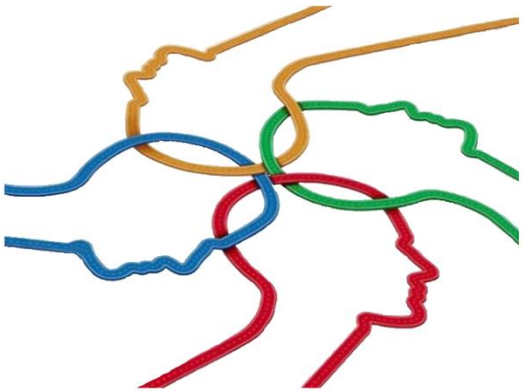
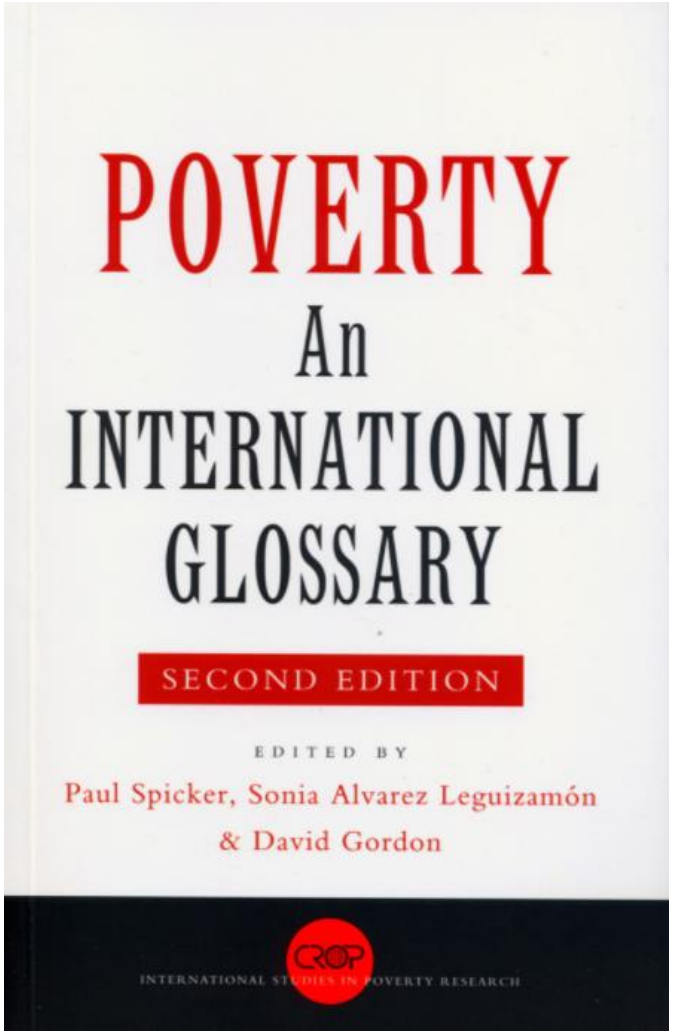


GLOBAL CONVERGENCE ON THE SCIENCE OF LEARNING
Washington, DC – February 2018

DEFINITIONS, INDICATORS AND EXPERIENCE OF POVERTY

More than 200 definitions and indicators of poverty (3% childhood)



SOURCE: Spicker et al., 2009.

DEFINITIONS, INDICATORS AND EXPERIENCE OF POVERTY

More than 200 definitions and indicators of poverty

The experience of poverty differs among cultures

SOURCE: Duncan et al., 2017; Gutierrez, 1972; Lipina, 2016; Narayan et al., 2000; Spicker et al., 2009.

DEFINITIONS, INDICATORS AND EXPERIENCE OF POVERTY

More than 200 definitions and indicators of poverty

The experience of poverty differs among cultures

All poverty definitions refer to some kind of loss of skills and rights

SOURCE: Duncan et al., 2017; Gutierrez, 1972; Lipina, 2016; Narayan et al., 2000; Spicker et al., 2009.

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Different measures could be associated with distinct outcomes

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The psychological experience of poverty is associated with stress, pain, and some times with impairments in the consciousness of being a person

SOURCE: Duncan et al., 2017; Gutierrez, 1972; Lipina, 2016; Narayan et al., 2000; Spicker et al., 2009.

DEFINITIONS, INDICATORS AND EXPERIENCE OF POVERTY

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The experience of poverty differs among cultures

All poverty definitions refer to some kind of loss of skills and rights

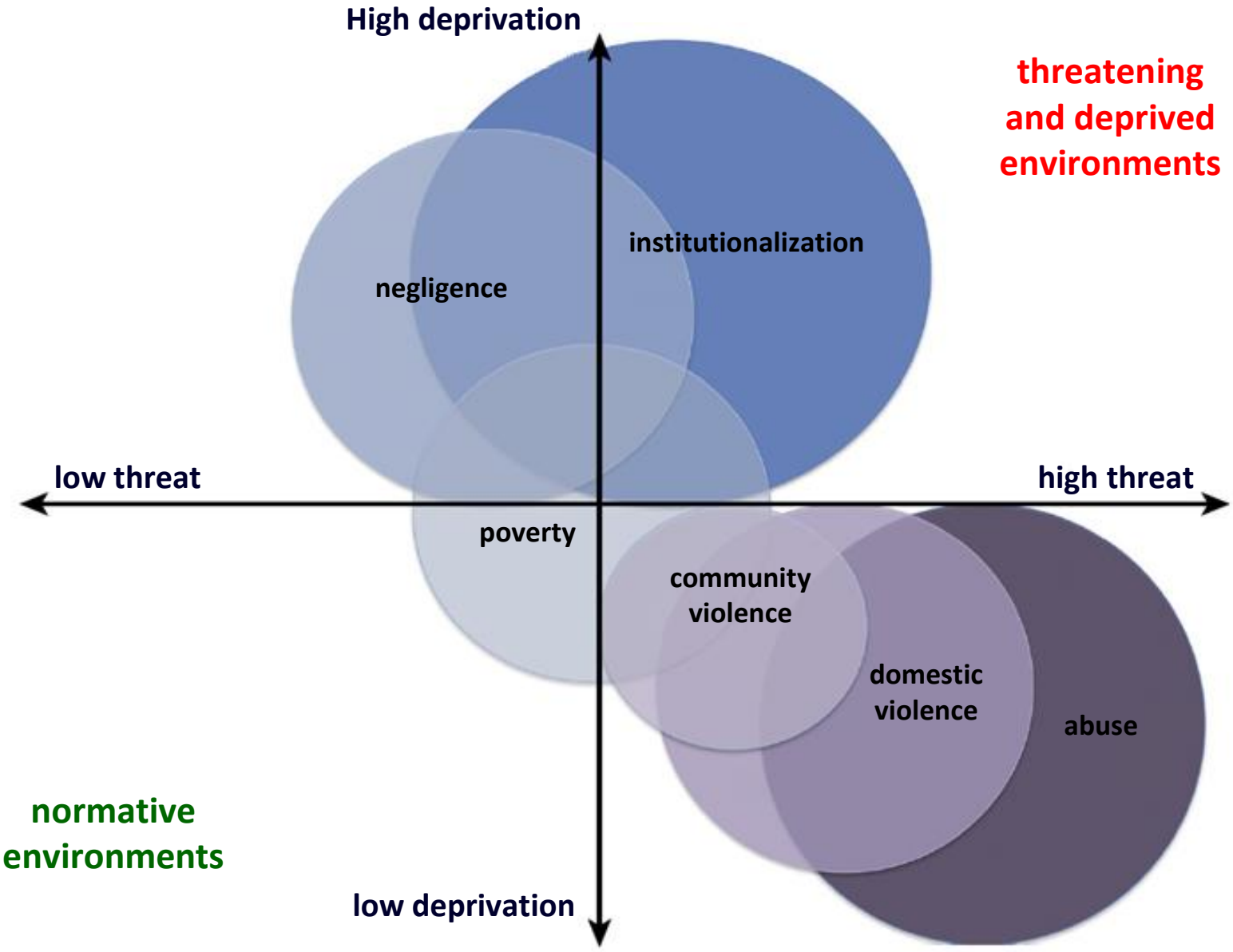
Different measures could be associated with distinct outcomes

The psychological experience of poverty is associated with stress, pain, and some times with impairments in the consciousness of being a person

The experience of childhood poverty is not necessarily well represented in the classic indicators of income and SES

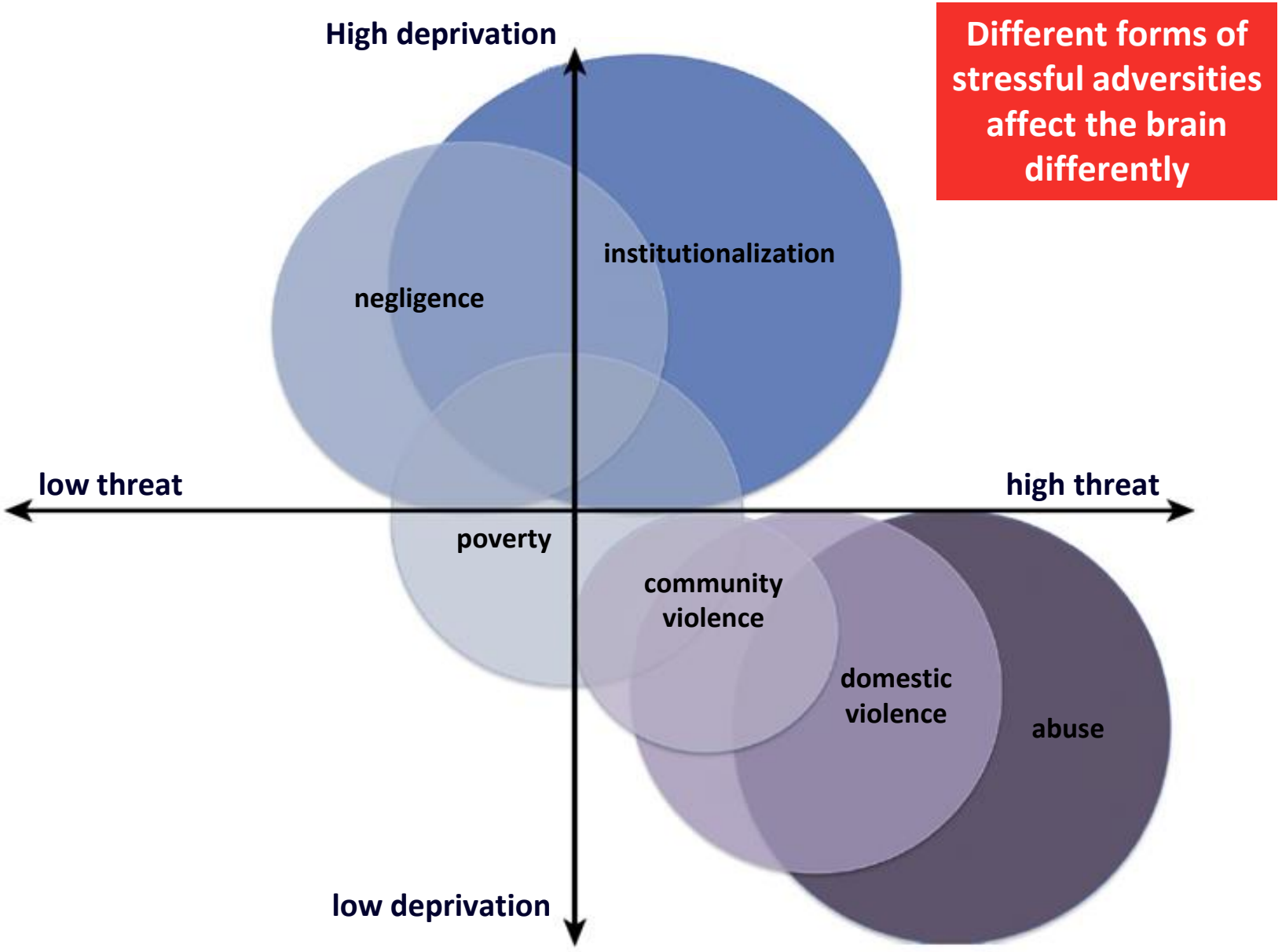
SOURCE: Duncan et al., 2017; Gutierrez, 1972; Lipina, 2016; Narayan et al., 2000; Spicker et al., 2009.

CO-OCCURENCE OF ADVERSITIES



SOURCE: Modified from Sheridan & McLaughlin, 2014.

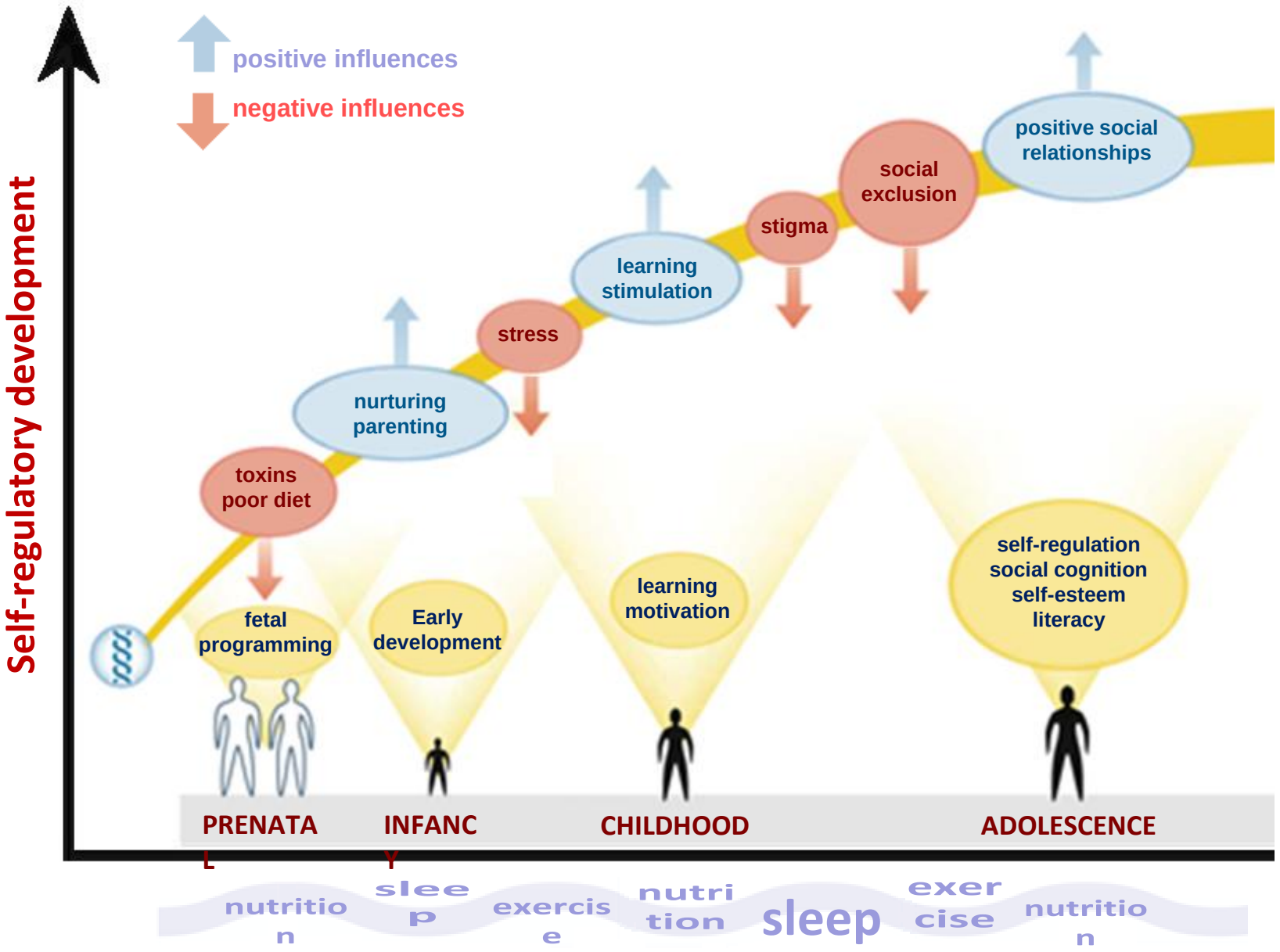
CO-OCCURENCE OF ADVERSITIES



Different forms of stressful adversities affect the brain differently

SOURCE: Lawson et al., 2017; Sheridan & McLaughlin, 2014.

MULTIPLE DETERMINANTS OF SELF-REGULATORY DEVELOPMENT



SOURCE: Beddington et al., 2008; Lipina, 2016.

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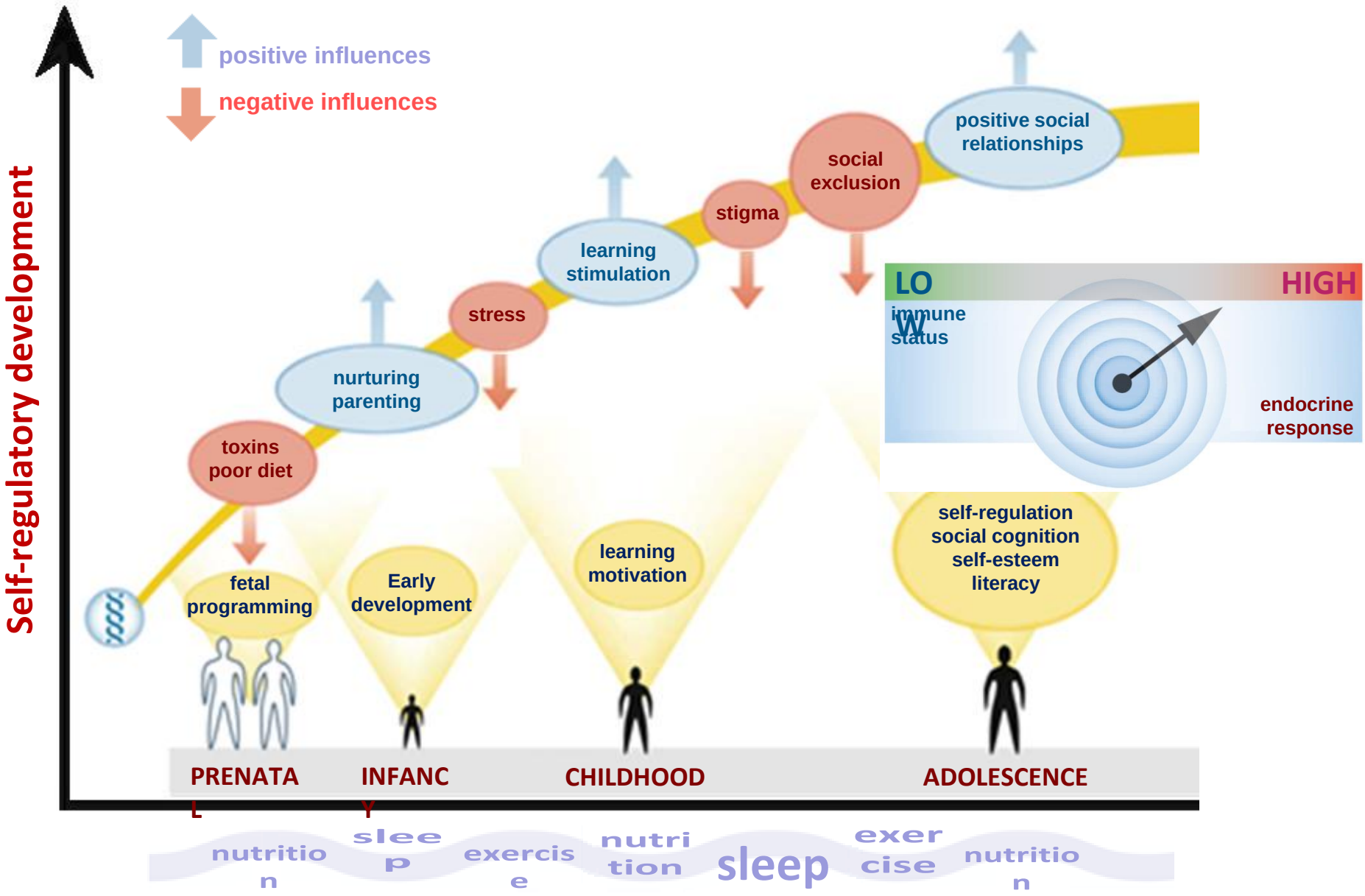

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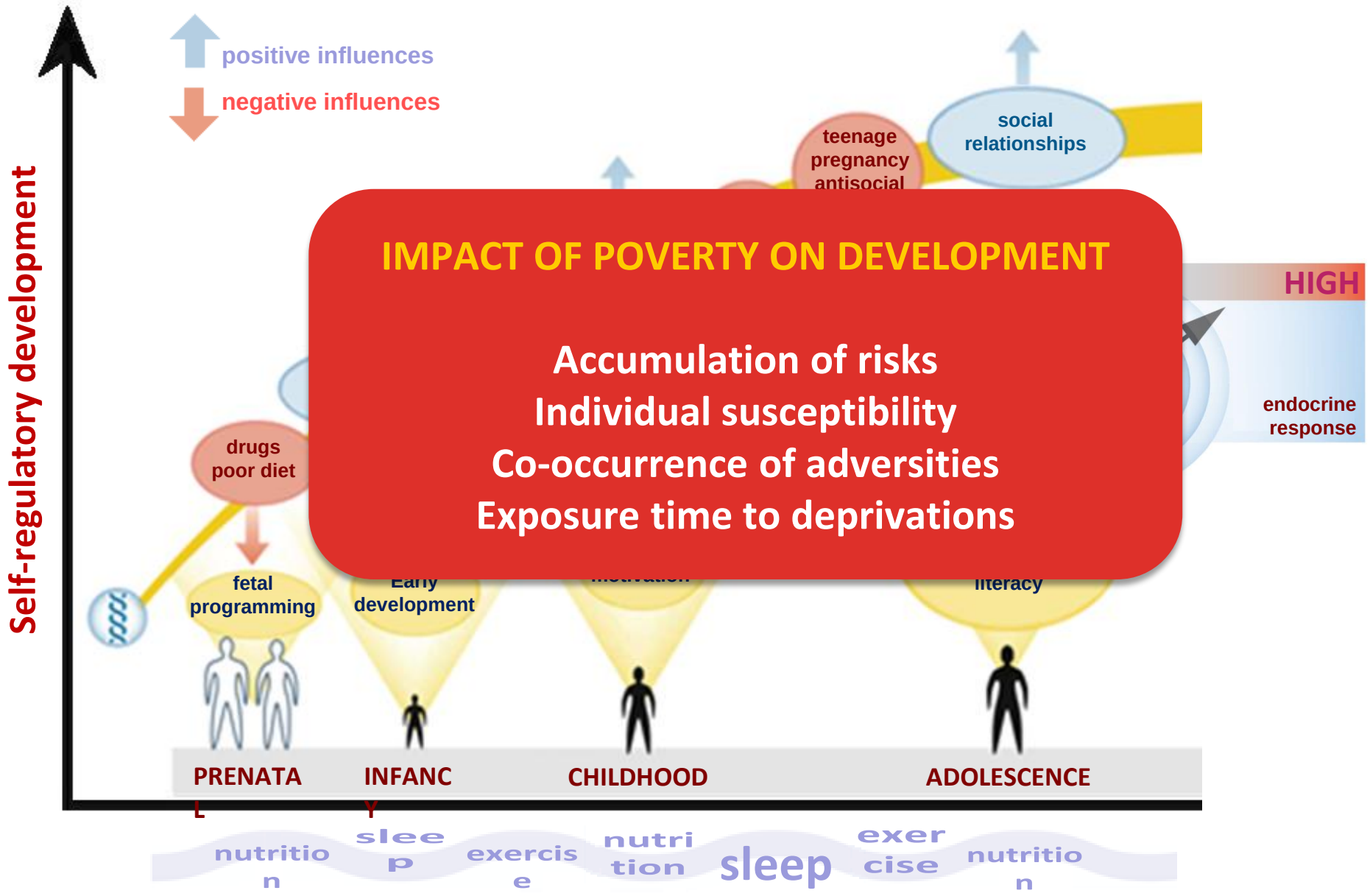

SOURCE: Beddington et al., 2008; Lipina, 2016.

OVERVIEW

What is the evidence of the associations between poverty and NS?

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What are the hypothetical mechanisms that underlie these associations?

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What is the degree of change of these associations (interventions)?

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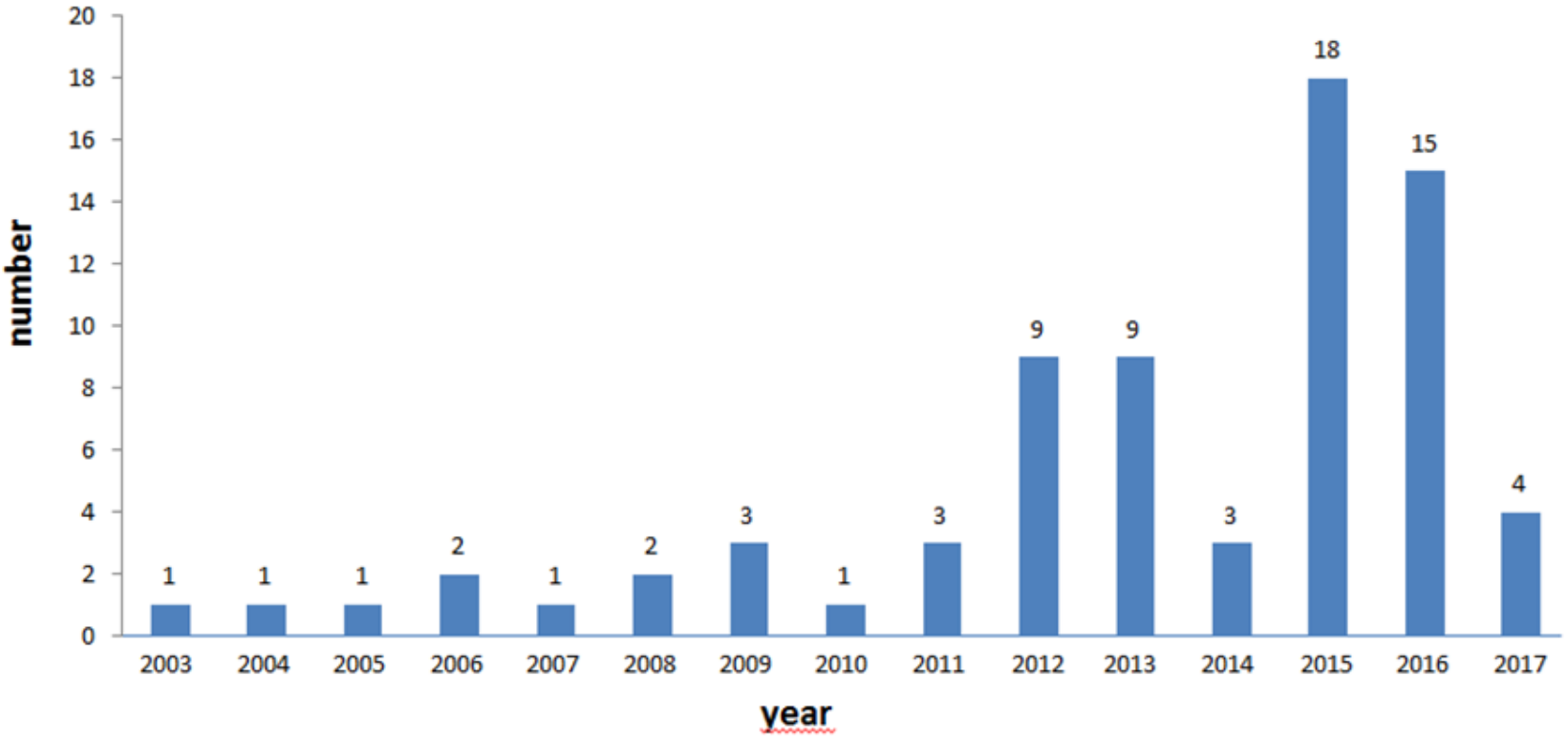
Future directions

NEUROSCIENTIFIC STUDIES OF POVERTY

PUBLISHED EMPIRICAL ARTICLES USING NEURAL TECHNOLOGY (N=85)



SOURCE: Pubmed, 2017.

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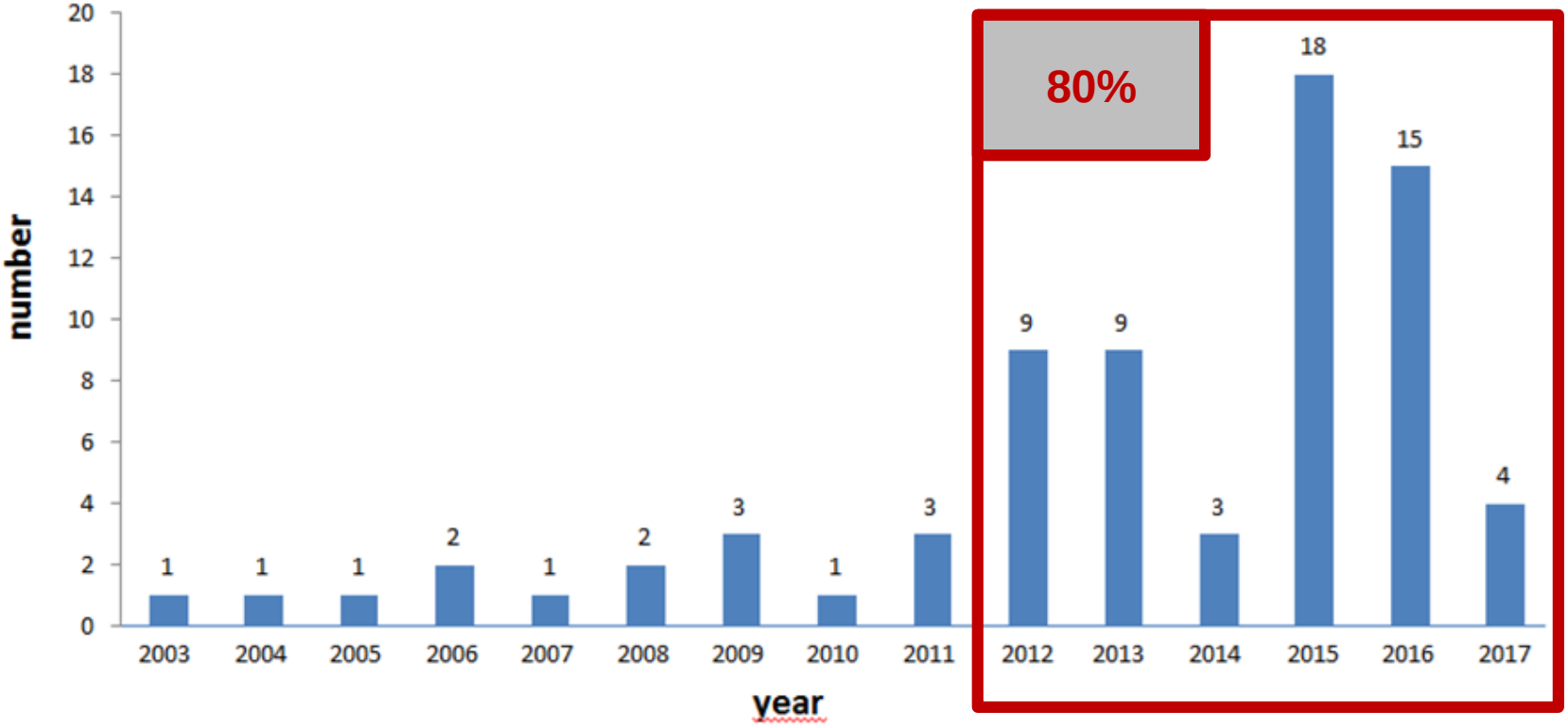

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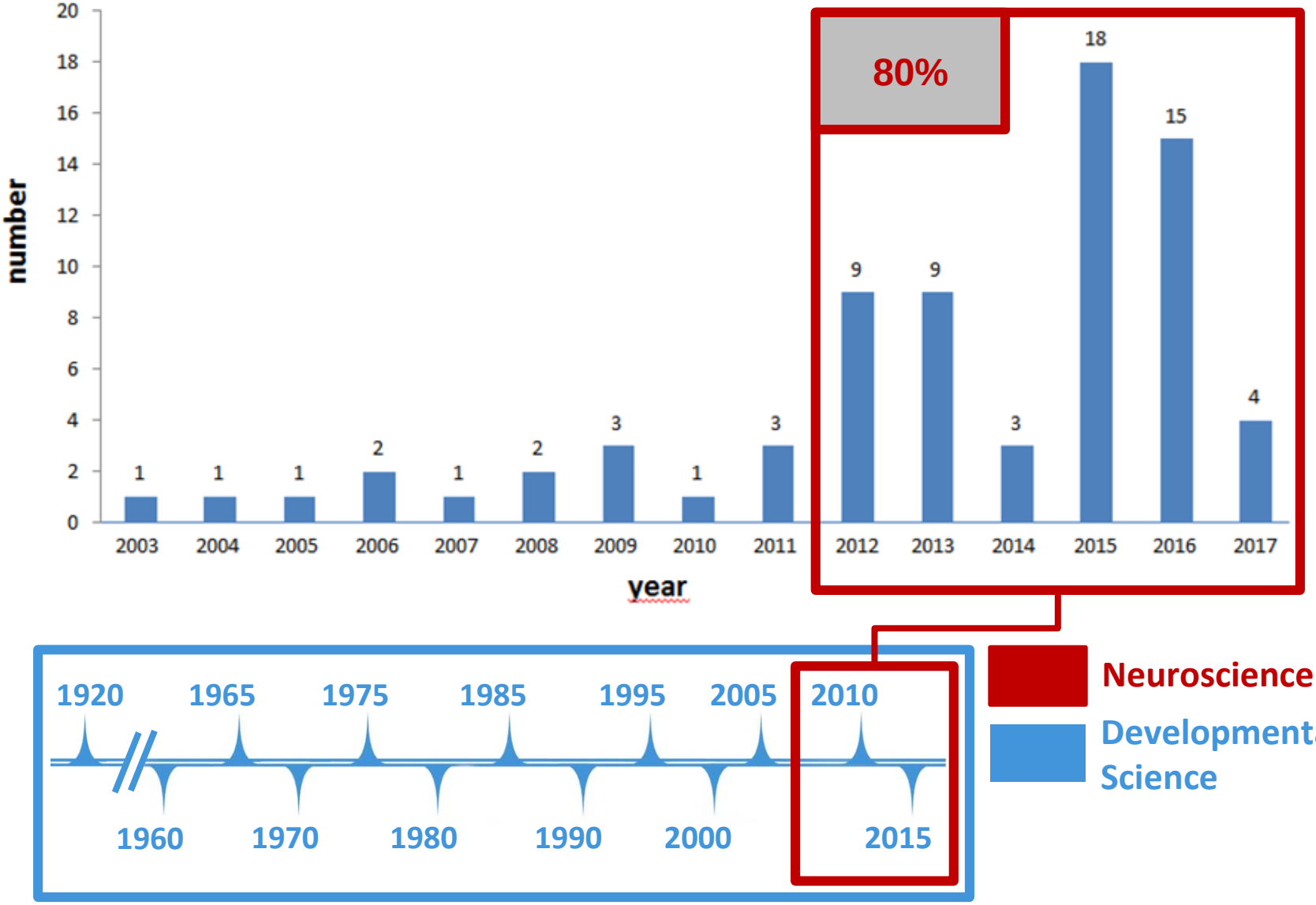
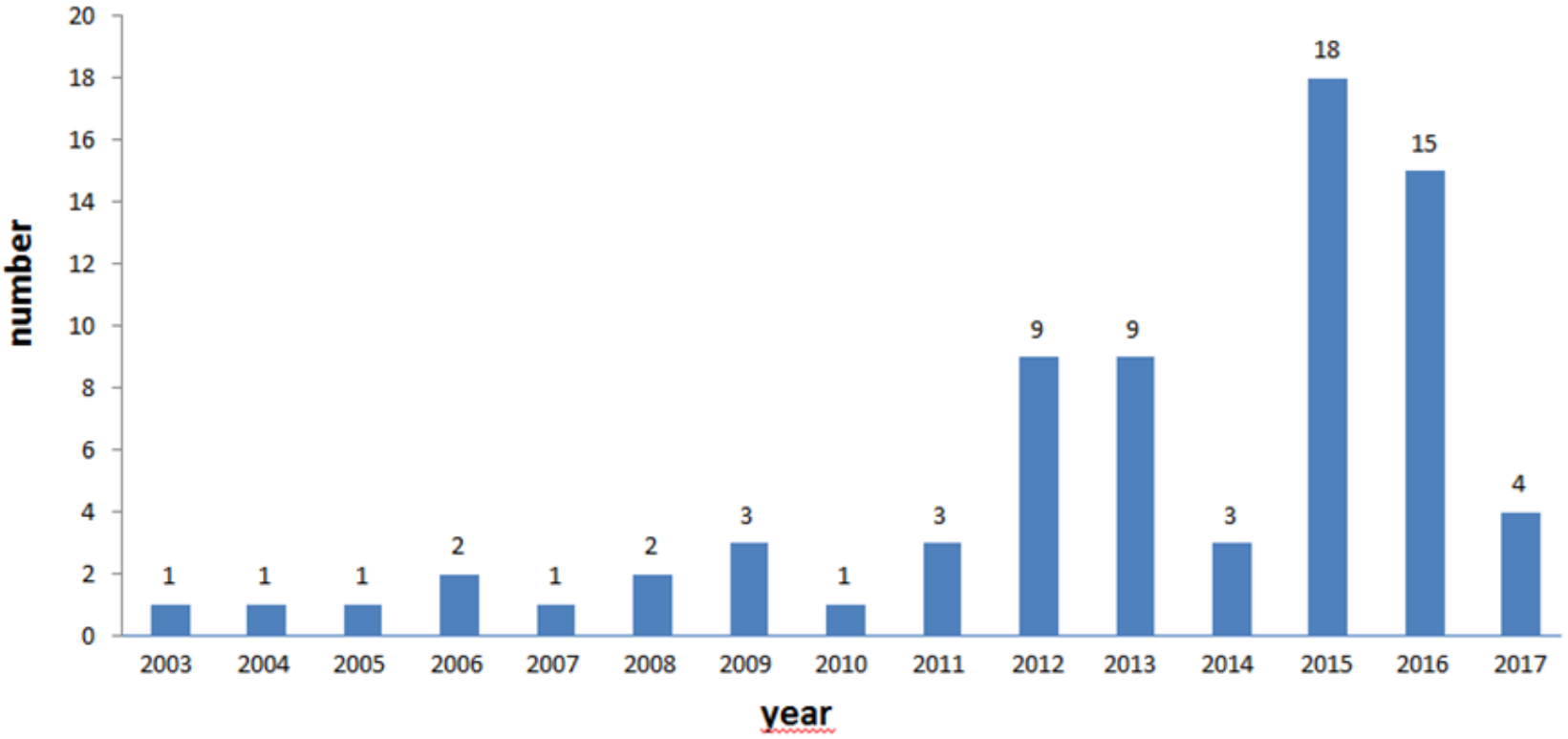


SOURCE: Pubmed, 2017.

NEUROSCIENTIFIC STUDIES OF POVERTY

PUBLISHED EMPIRICAL ARTICLES USING NEURAL TECHNOLOGY (N=81)



Designs:	**77% cross-sectional**
Levels:	**51% structural (MRI)**
	(functional: fMRI, EEG/ERP, NIRS)
Learning:	**<5%**
Countries:	**USA (82%)**

SOURCE: Lipina, 2017; Pubmed, 2017.

BEHAVIOURAL LEVEL

FAMILY INCOME, MATERNAL EDUCATION, UBN

LOWER PERFORMANCE

Executive functions, metacognition, phonological awareness, and episodic memory - from infancy to adolescence

SOURCE: Hackman & Farah, 2009; Johnson et al., 2016; Lipina & Colombo, 2009; Urasche & Noble, 2016; Wade et al., 2016.

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FAMILY INCOME, MATERNAL EDUCATION, UBN

LOWER PERFORMANCE

Executive functions, metacognition, phonological awareness, and episodic memory - from infancy to adolescence

MODULATION OF ASSOCIATIONS

Age, health, cognitive paradigm, length and type of poverty experience

SOURCE: Hackman & Farah, 2009; Johnson et al., 2016; Lipina & Colombo, 2009; Urasche & Noble, 2016; Wade et al., 2016.

STRUCTURAL LEVEL: GRAY AND WHITE MATTER

FAMILY INCOME, MATERNAL EDUCATION, QUALITY OF PARENTING

Changes in growth rates and volumes of frontal and parietal cortices (1 mo to 4 yo)

SOURCE: Avants et al., 2015; Betancourt et al., 2015; Hair et al., 2015; Johnson et al., 2016; Mackey et al., 2015; Noble et al., 2015.

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Volumetric changes in hippocampus and amygdala (4 to 22 yo)

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Changes in fronto-temporal fiber integrity (FA) (12 to 24 yo)

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Changes in fronto-temporal fiber integrity (FA) (12 to 24 yo)

Different patterns of corticostriatal conncectivity depending on houshold or community SES (6 to 17 yo)

SOURCE: Avants et al., 2015; Betancourt et al., 2015; Hair et al., 2015; Johnson et al., 2016; Mackey et al., 2015; Marshall et al., 2018; Noble et al., 2015.

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Changes in fronto-temporal fiber integrity (FA) (12 to 24 yo)

Different patterns of corticostriatal conncectivity depending on houshold or community SES (6 to 17 yo)

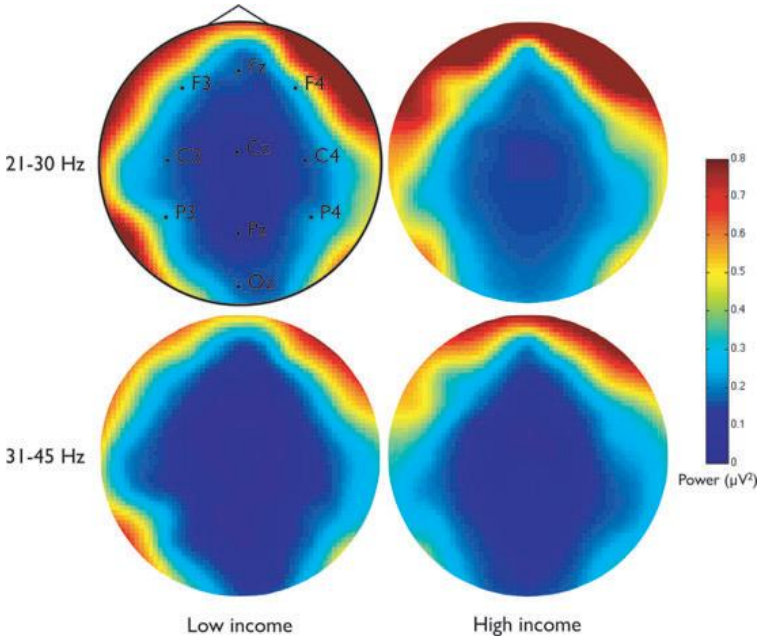
Structural changes were associated with performance on executive functions, language and learning tasks

SOURCE: Avants et al., 2015; Betancourt et al., 2015; Hair et al., 2015; Johnson et al., 2016; Mackey et al., 2015; Marshall et al., 2018; Noble et al., 2015.

FUNCTIONAL LEVEL: EEG/ERP

MATERNAL EDUCATION, PARENTAL OCCUPATION

Changes in topographic maps of different frequencies in resting state (6 to 9 mo)



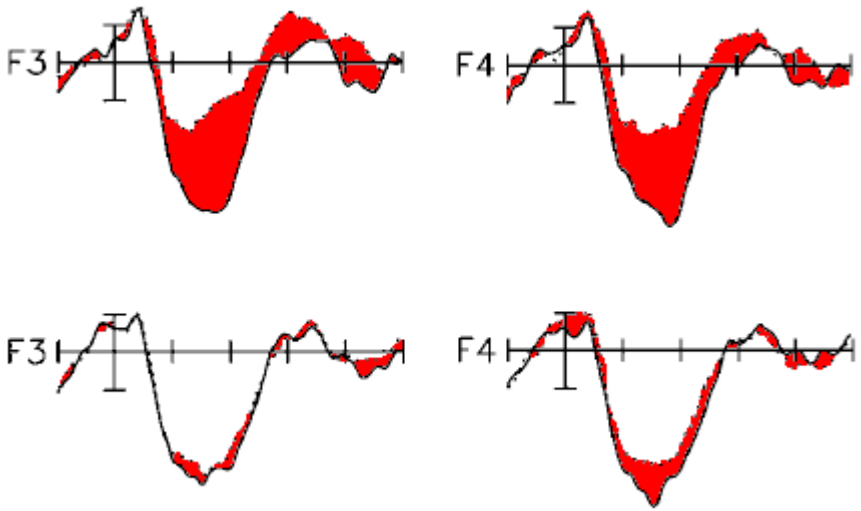
SOURCE: Tomalski et al., 2013.

FUNCTIONAL LEVEL: EEG/ERP

FAMILY INCOME, MATERNAL EDUCATION

Changes in topographic maps of different frequencies in resting state (6 to 9 mo)

ERP changes during tasks of selective attention and inhibitory control (3 to 8 yo)



SOURCE: Stevens et al., 2014.

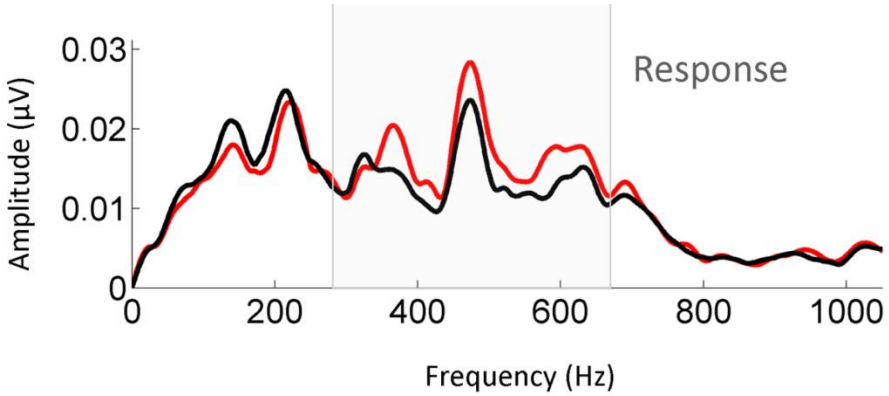
FUNCTIONAL LEVEL: EEG/ERP

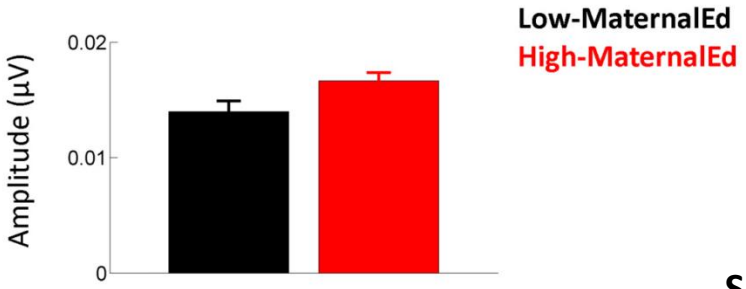
MATERNAL EDUCATION

Changes in topographic maps of different frequencies in resting state (6 to 9 mo)

ERP changes during tasks of selective attention and inhibitory control (3 to 8 yo)

Changes in auditory brainstem responses to the speech stimulus (14 to 15 yo)



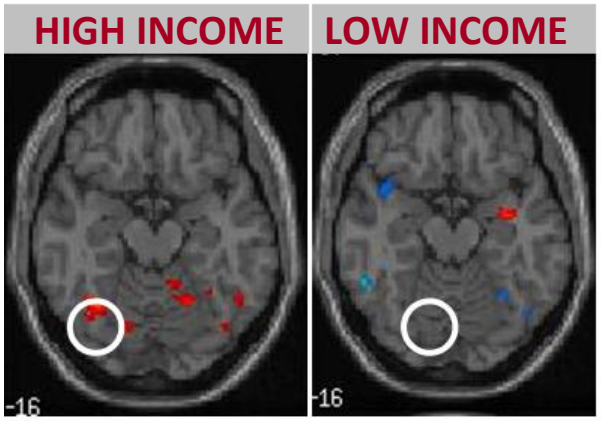


SOURCE: Skoe et al., 2014.

FUNCTIONAL LEVEL: fMRI

FAMILY INCOME, MATERNAL EDUCATION, PARENTAL OCCUPATION

Changes in the activation of occipito-temporal networks in task demanding phonological processesing (5 to 6 yo)



FUSIFORM GYRUS

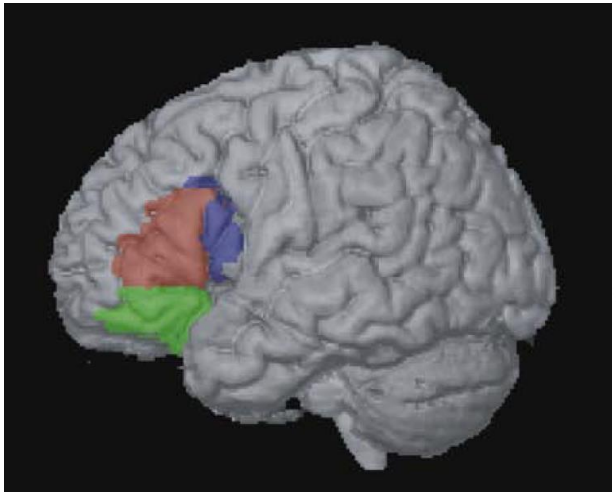
SOURCE: Noble et al., 2006.

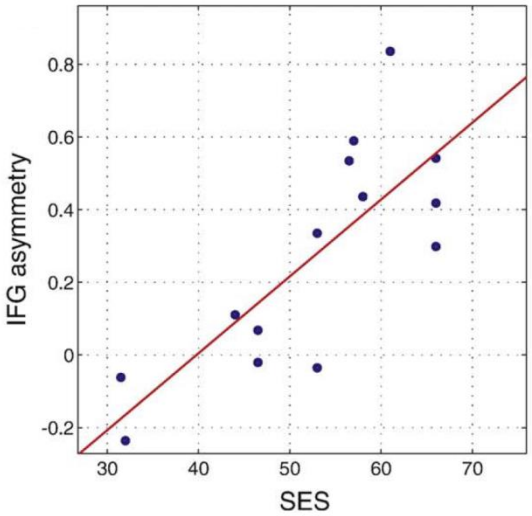
FUNCTIONAL LEVEL: fMRI

FAMILY INCOME, MATERNAL EDUCATION, PARENTAL OCCUPATION

Changes in the activation of occipito-temporal networks in task demanding phonological processesing (5 to 6 yo)

Changes in the assymetry of inferior frontal gyrus in tasks demanding discrimination of rhymes between monosyllabic words and non-words (5 yo)





SOURCE: Raizada et al., 2008.

FUNCTIONAL LEVEL: fMRI

FAMILY INCOME, MATERNAL EDUCATION, PARENTAL OCCUPATION

Changes in the activation of occipito-temporal networks in task demanding phonological processesing (5 to 6 yo)

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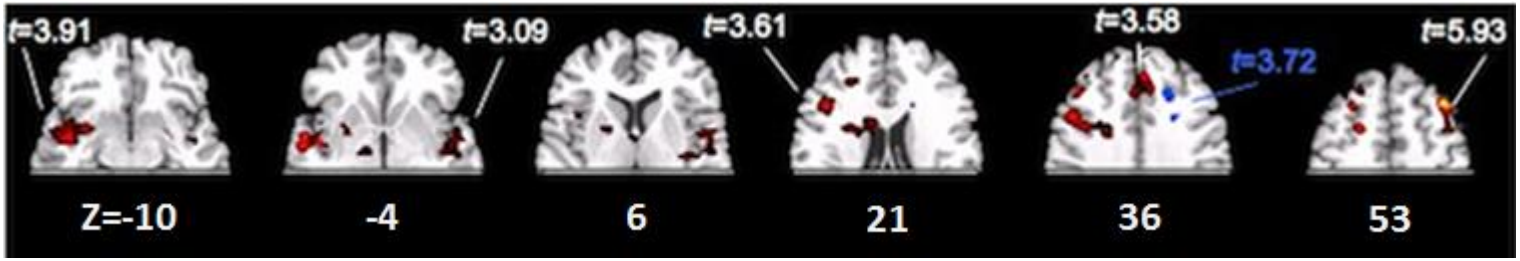
Changes in the activation of prefrontal networks in a task of associative learning (8 to 12 yo)

DIFFERENCES BY SES IN LEARNING CONTRAST



SOURCE: Sheridan et al., 2012.

FUNCTIONAL LEVEL: fMRI

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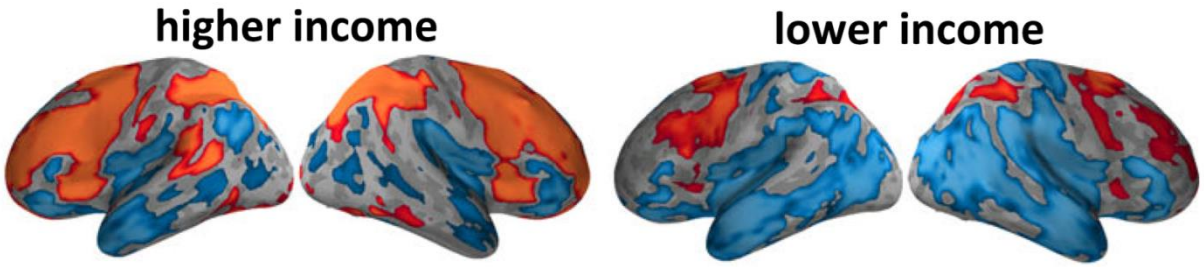
Changes in the activation of prefrontal networks in a task of associative learning (8 to 12 yo)

Changes in the activation of prefrontal, parietal and other region in a working memory task in correlation with mathematics scores (14 yo)



SOURCE: Finn et al., 2016.

FUNCTIONAL LEVEL: fMRI

FAMILY INCOME, MATERNAL EDUCATION, PARENTAL OCCUPATION

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Changes in the activation of prefrontal, parietal and other region in a working memory task in correlation with mathematics scores (14 yo)

History of childhood poverty (9 yo) was associated in adulthood to: (a) increments in amygdala and prefrontal reactivity, and (b) less connectivity between these networks to threatening faces

SOURCE: Javanbakht et al., 2015.

SUMMARY OF EVIDENCE

Poverty and SES are associated to a diverse set of NS structural and functional outcomesboth in quantity and quality terms

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The most sensitive systems seem to be those related to executuve functions, language, learning and stress regulation

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The most sensitive systems seem to be those related to executuve functions, language, learning and stress regulation

The evidence is mostly associative

Partly, the psychological meaning of this evidence must still be elucidated

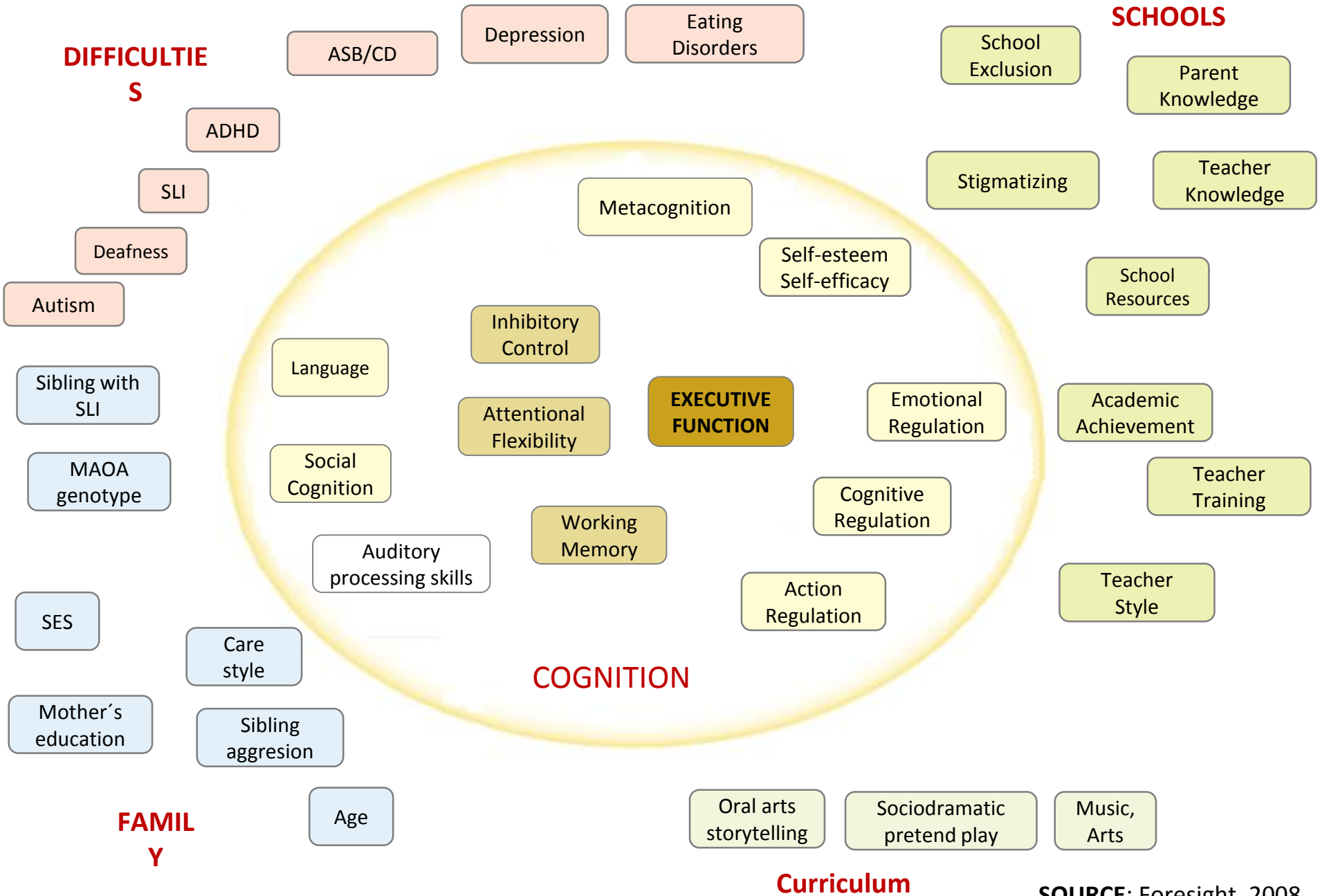
It is also necessary to elucidate the global value of this evidence (cultural variability)

OVERVIEW

What is the evidence of the associations between poverty and NS?

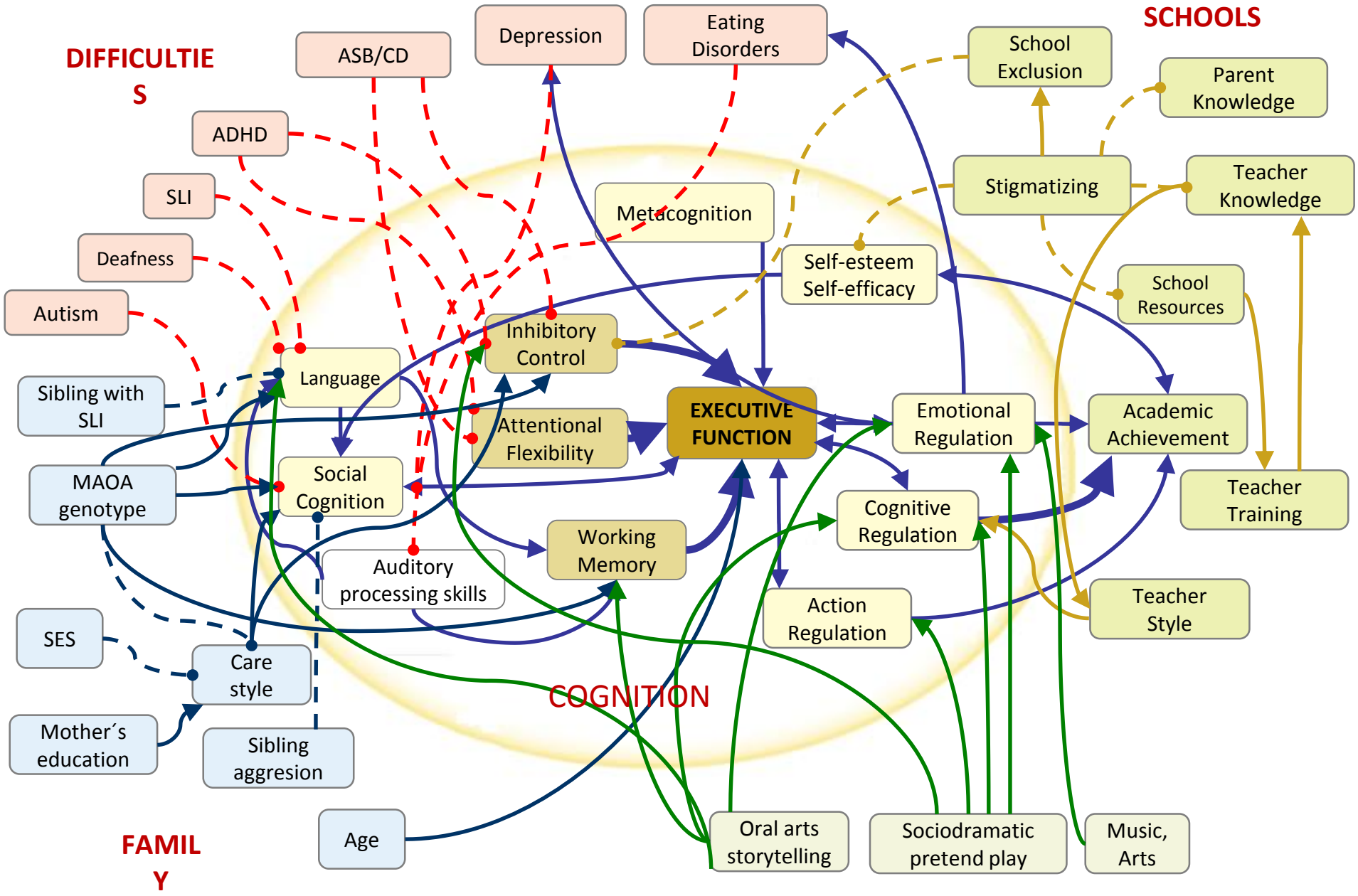
What are the hypothetical mechanisms that underlie these associations?

MULTIPLE POTENTIAL MEDIATORS AND MODERATORS



SOURCE: Foresight, 2008.

MULTIPLE POTENTIAL MEDIATORS AND MODERATORS



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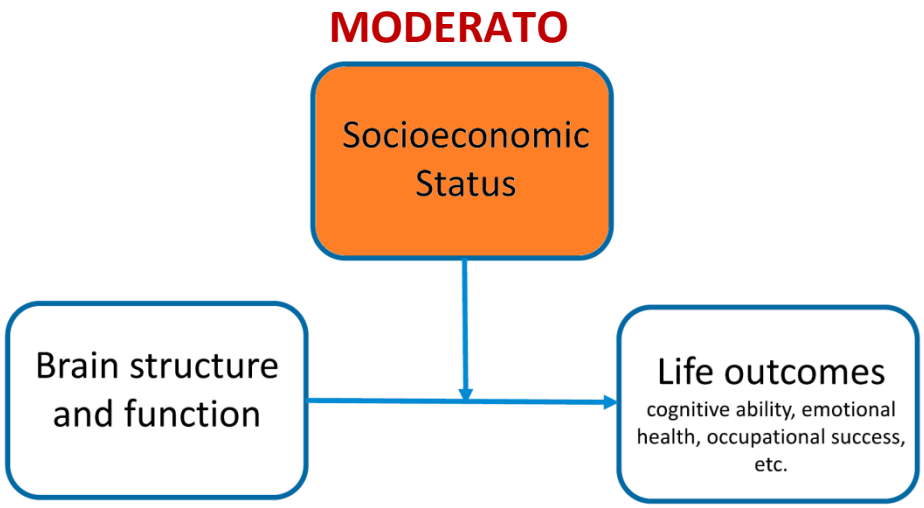
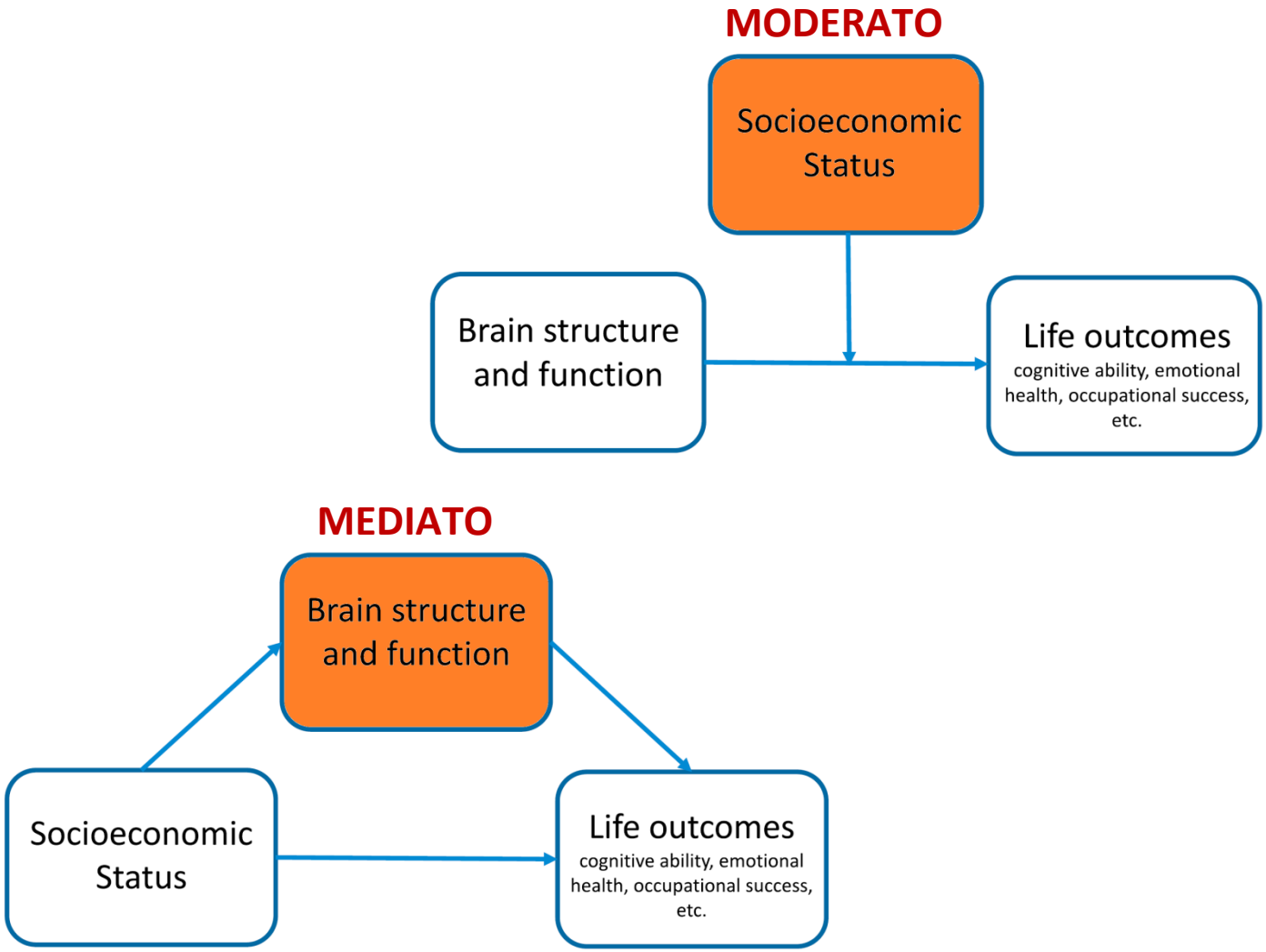
MODERATION/MEDIATION: NEUROSCIENTIFIC PERSPECTIVE



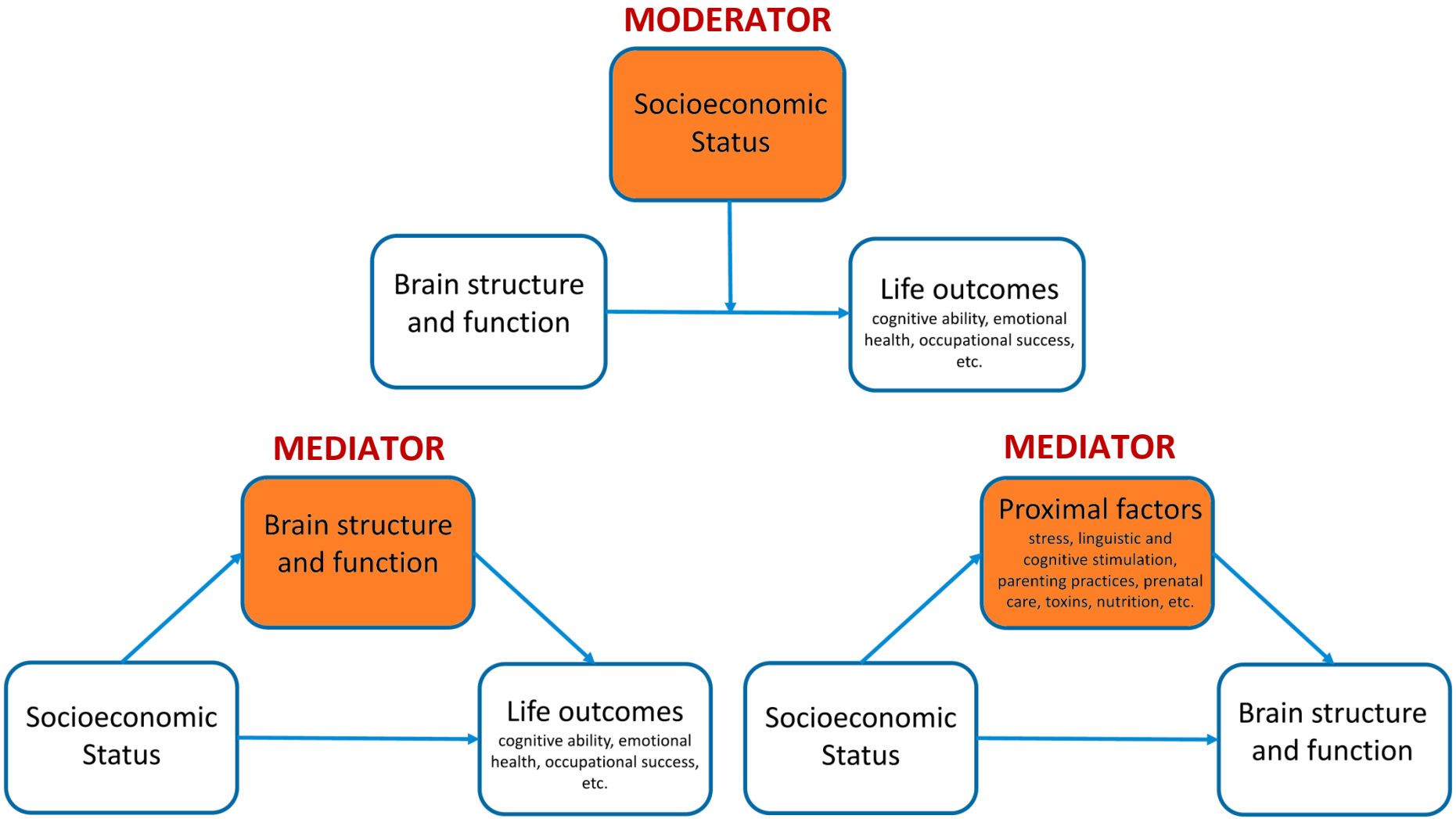
SOURCE: Farah, 2017.

MODERATION/MEDIATION: NEUROSCIENTIFIC PERSPECTIVE



SOURCE: Farah, 2017.

MODERATION/MEDIATION: NEUROSCIENTIFIC PERSPECTIVE



SOURCE: Farah, 2017.

SUMMARY OF EVIDENCE (MEDIATION/MODERATION)

Mediators and moderators involve several individual and contextual factors at different levels of organization

- Early linguistic environment and stressors
- Structural and epigenetic changes

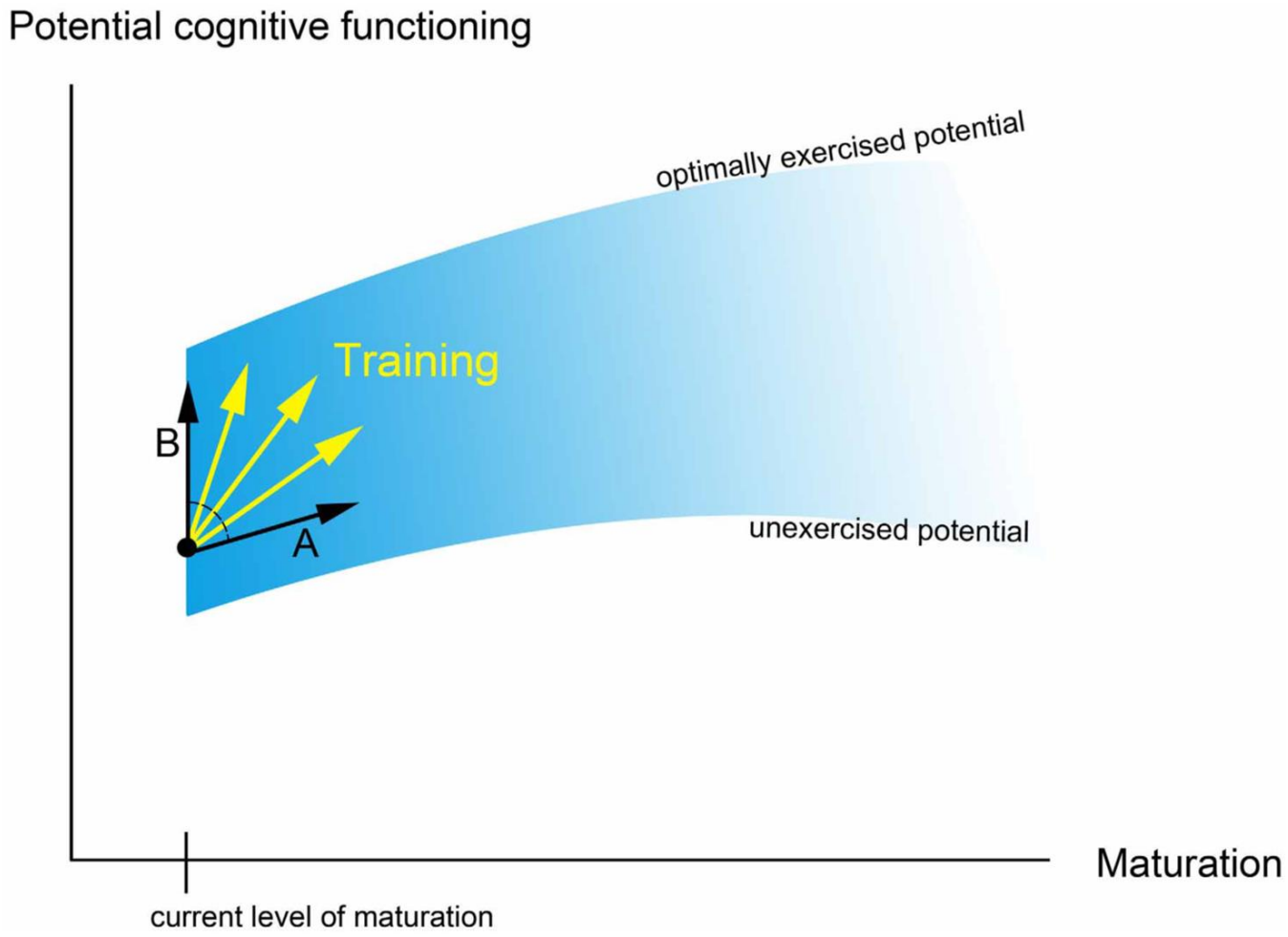
OVERVIEW

What is the evidence of the associations between poverty and NS?

What are the hypothetical mechanisms that underlie these associations?

What is the degree of change of these associations (interventions)?

NEUROSCIENTIFIC INTERVENTIONS: RATIONALE



SOURCE: Jolles & Crone, 2012.

INTERVENTIONS INVOLVING NEURAL MEASURES

Design	Controlled randomized
Sample	n=141 Low-SES 3-5 yo
Intervention	Parenting activites Attentional training 8 weeks

SOURCE: Neville et al., 2013.

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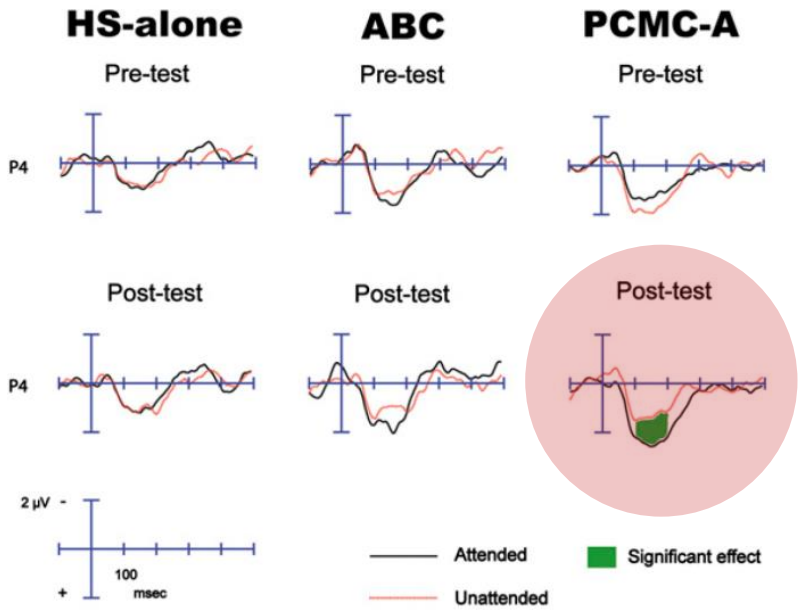

Cognitive and behavioral gains
+ Attentional ERP effect

SOURCE: Neville et al., 2013.

INTERVENTIONS INVOLVING NEURAL MEASURES

Design	Controlled randomized
Sample	n=65 Diverse-SES 6-9 yo
Intervention	Reading training 6 weeks

SOURCE: Romeo et al., 2017.

INTERVENTIONS INVOLVING NEURAL MEASURES

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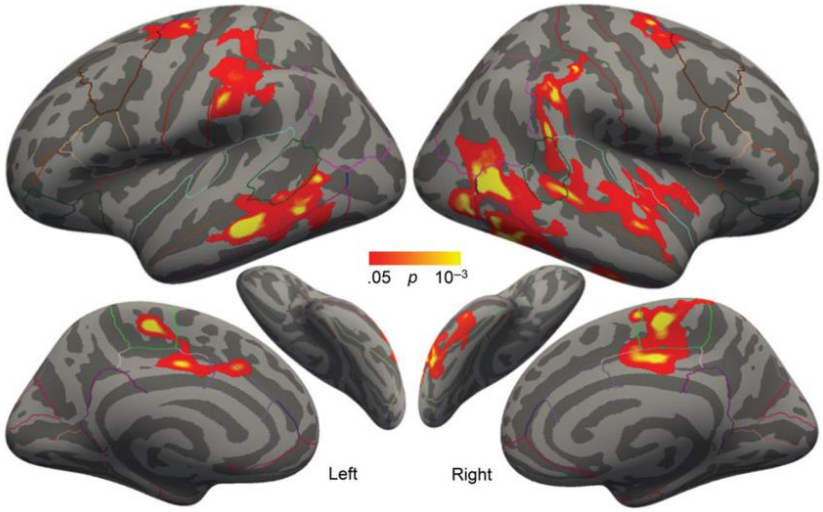

Reading gains
+ Increase thickening in OT/TP
(low-SES + RD)

SOURCE: Romeo et al., 2017.

SUMMARY OF DEGREE OF MODIFICATION

It is possible to modify the neural resources of children from low-SES homes through different intervention strategies

Changes are not the same for all participants (individual variability)

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It is possible to modify the neural resources of children from low-SES homes through different intervention strategies

Changes are not the same for all participants (individual variability)

These changes have been verified at different ages during the first decade of life

This potentiality of change questions the attribution of immutability of the impact of poverty on brain structures associated with self-regulation, reading and learning skills

FUTURE DIRECTIONS

Neuroscientific evidence is of value and still preliminary to inform policy

Psychological meanings of findings

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- Psychological meanings of findings
- Need to specify neuroscientific contributions
  - Mechanisms, timing of interventions, specificity of different adversities

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- Transcend the «inform policy» mindset
  - Participation of scientists: design, implementation, evaluation
  - Ethical and stereotypes issues

FUTURE DIRECTIONS

Neuroscientific evidence is of value and still preliminary to inform policy

- Psychological meanings of findings
- Need to specify neuroscientific contributions
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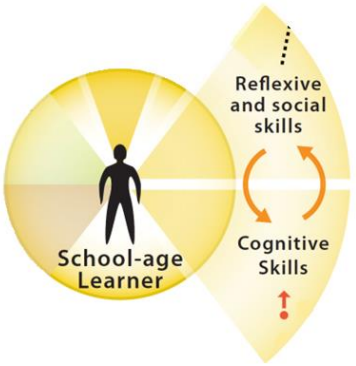
Design of experiments: *among* disciplines (transdisciplinary mindset)

- Ecology of learning

ECOLOGY OF HYPOTHETICAL MEDIATORS AND MODERATORS

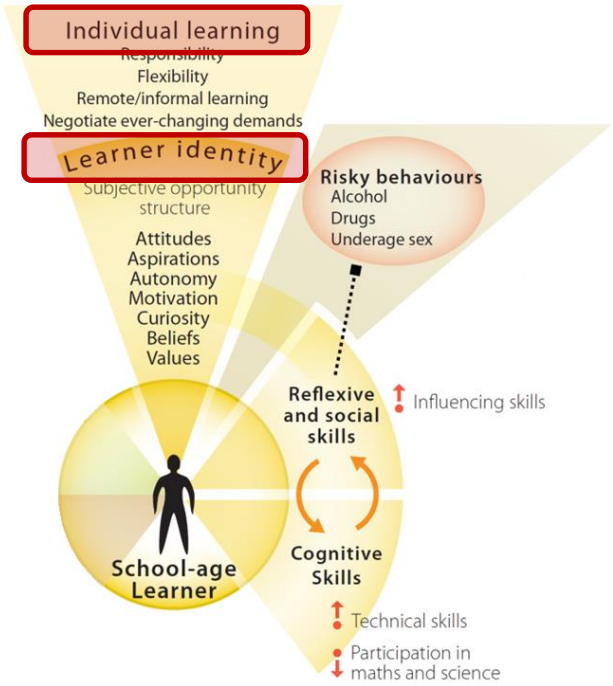
SCIENCE OF LEARNING PERSPECTIVE



SOURCE: Foresight, 2008.

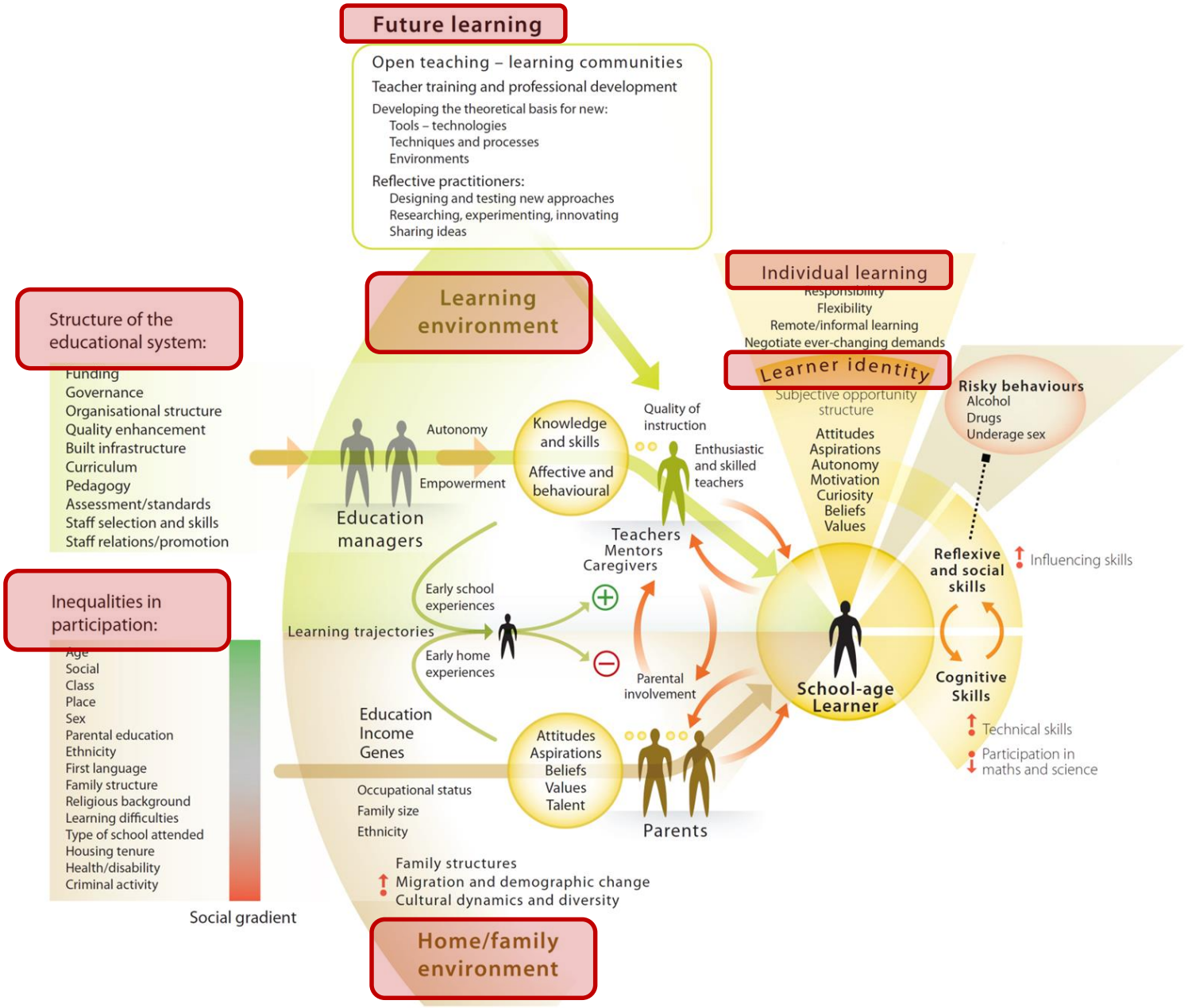
MULTIPLE MEDIATORS AND MODERATORS

SCIENCE OF LEARNING PERSPECTIVE



SOURCE: Foresight, 2008.

MULTIPLE MEDIATORS AND MODERATORS: SCIENCE OF LEARNING PERSPECTIVE



SOURCE: Foresight, 2008.

FUTURE DIRECTIONS

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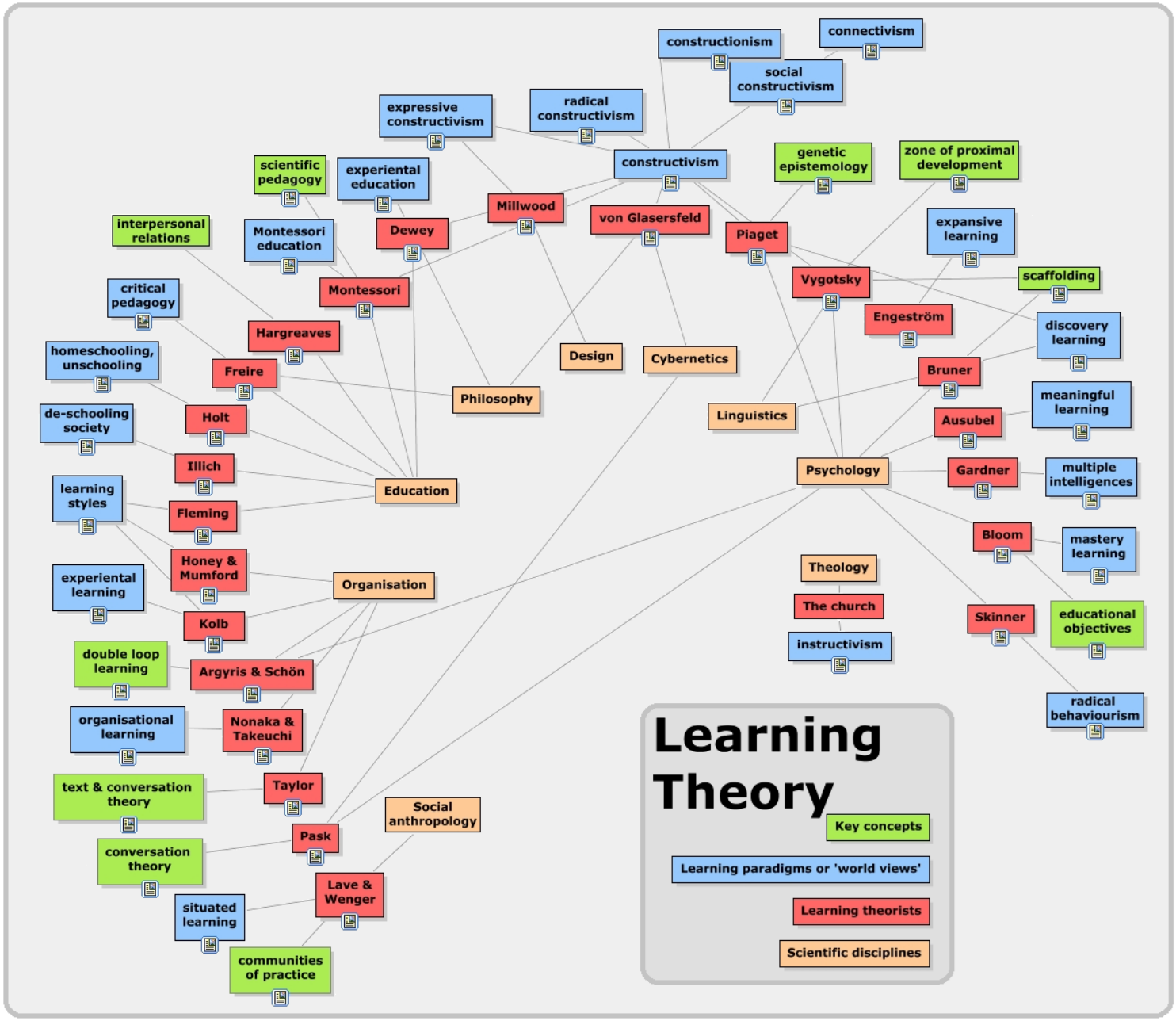
Design of experiments: *among* disciplines (transdisciplinary mindset)

- Ecology of learning
- Multiple learning theories

MULTIPLICIYT OF LEARNING THEORIES



SOURCE: HoTEL, 2013.

FUTURE DIRECTIONS

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Design of experiments: *among* disciplines (transdisciplinary mindset)

- Ecology of learning
- Multiple learning theories
  - Application of common integrative conceptual frameworks

FUTURE DIRECTIONS: Integrative frameworks

Table 1. Proposed layered abstraction framework for the learning sciences

Layer	Developmental phase	Layer name	Relevant discipline	Function
V	Populations	Sociocultural	Education, social sciences	Individuals interact with other organisms, in ecological, sociocultural contexts in which information is processed and transmitted
				This communication leads to group wide behavioural patterns, cultural norms and larger societal value sets (e.g. what should be included in curriculum?)
V	Organisms	Individual	Cognitive & behavioural psychology	The complete complement of biological, psychological and emotional systems embodied in an individual person. Communication between individuals generates larger sets of behaviour which are typically measurable and conscious
III	Organs	Cerebral	Systems, cognitive and behavioural neurosciences	Groups of neurons form connections with other neurons and non-neuronal cells to form larger networks. Patterns of network activity and excitability allow for the transmission and processing of information within and between specific organs in the body. This communication leads to specialised, occasionally unmeasurable and largely subconscious proto-behavioural patterns
I	Cells	Cellular	Biology/pure neuroscience	Unspecialised cells can individually store, encode, process and transmit information by use of proto-neurotransmitters which float freely in the cytoplasm. Specialised neurons capable of storing, processing and transmitting information
I	Matter	Physical	Physics	Information obtained from the external environment can be encoded, stored in, and occasionally transmitted between atoms, particles and complex molecules. Examples include machine learning (supervised and unsupervised) in computing devices

SOURCE: Donoghue and Harvath, 2016.

FUTURE DIRECTIONS

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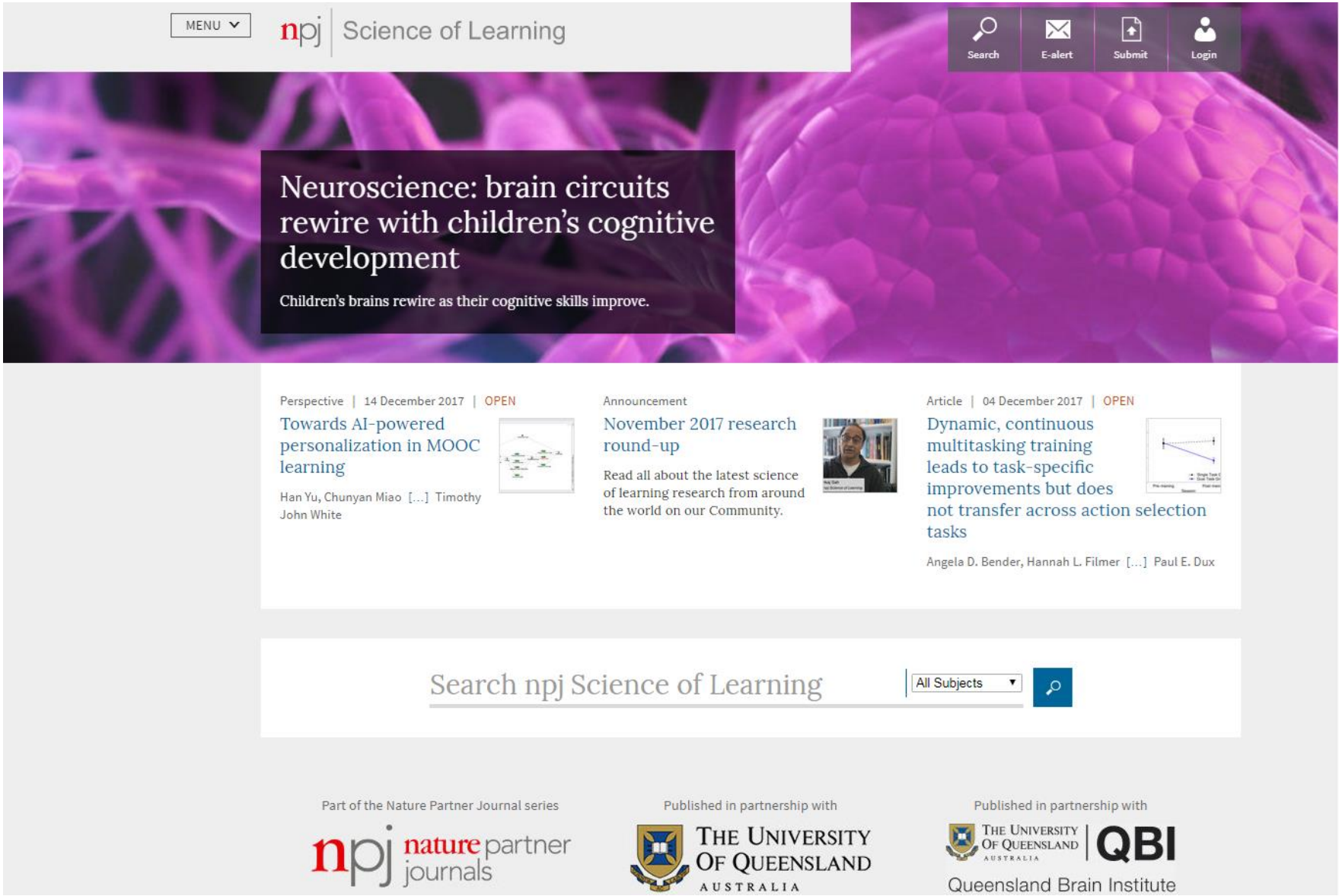
Design of experiments: *among* disciplines (transdisciplinary mindset)

- Ecology of learning
- Multiple learning theories
  - Application of common integrative conceptual frameworks
  - Networking

FUTURE DIRECTIONS: Networking



FUTURE DIRECTIONS

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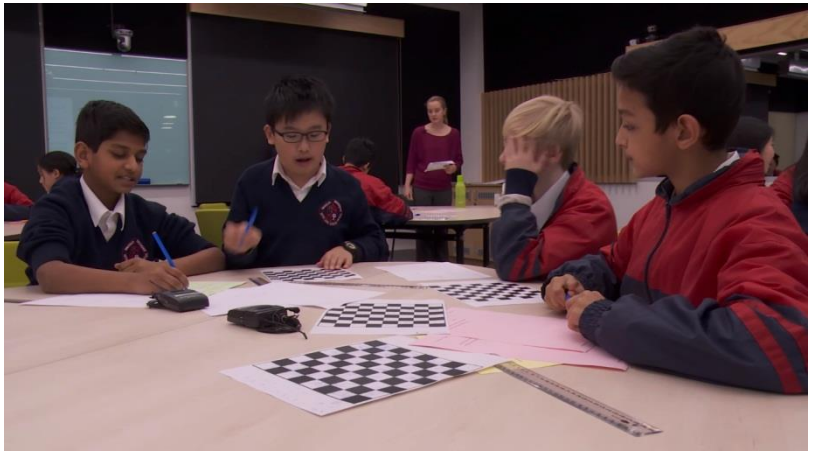
Design of experiments: *among* disciplines (transdisciplinary mindset)

- Ecology of learning
- Multiple learning theories
  - Application of common integrative conceptual frameworks
  - Networking
- Innovation

FUTURE DIRECTIONS: Infrastructure for ecological approaches

Science of Learning Research Classroom, University of Melbourne

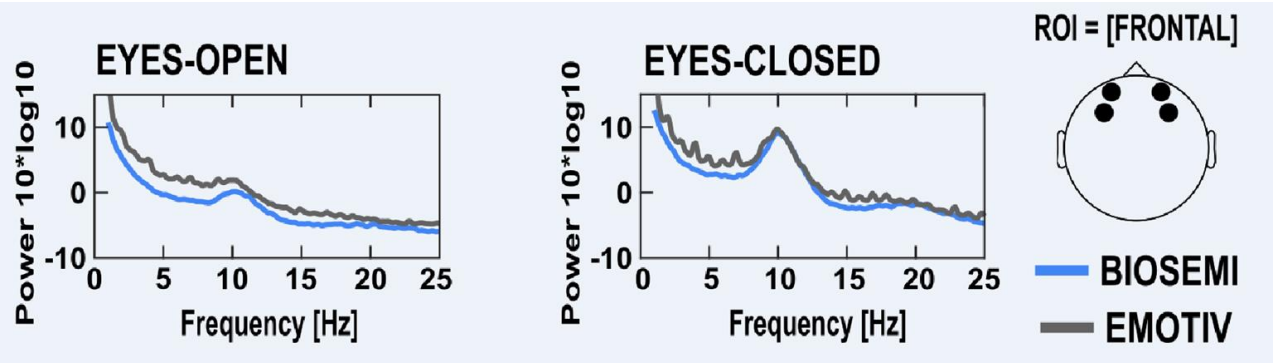


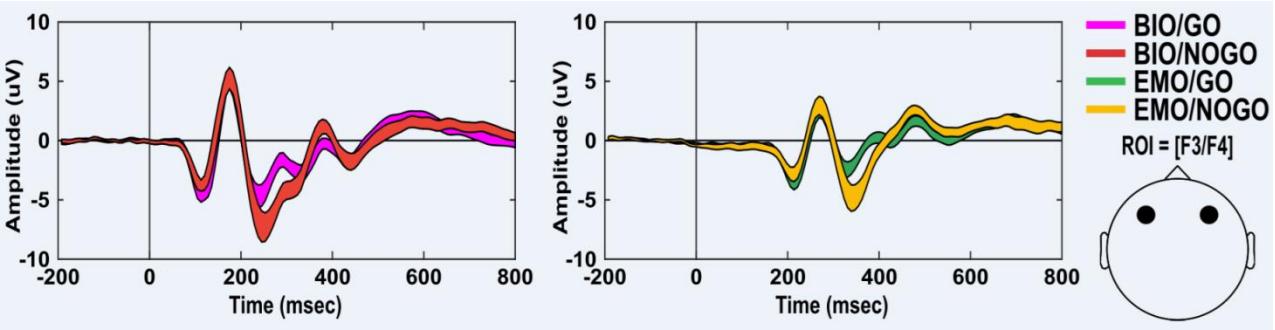
Child Development Center, Oregon State University

FUTURE DIRECTIONS: Validation of EEG portable methods

SOURCE: Pietto et al., in preparation.

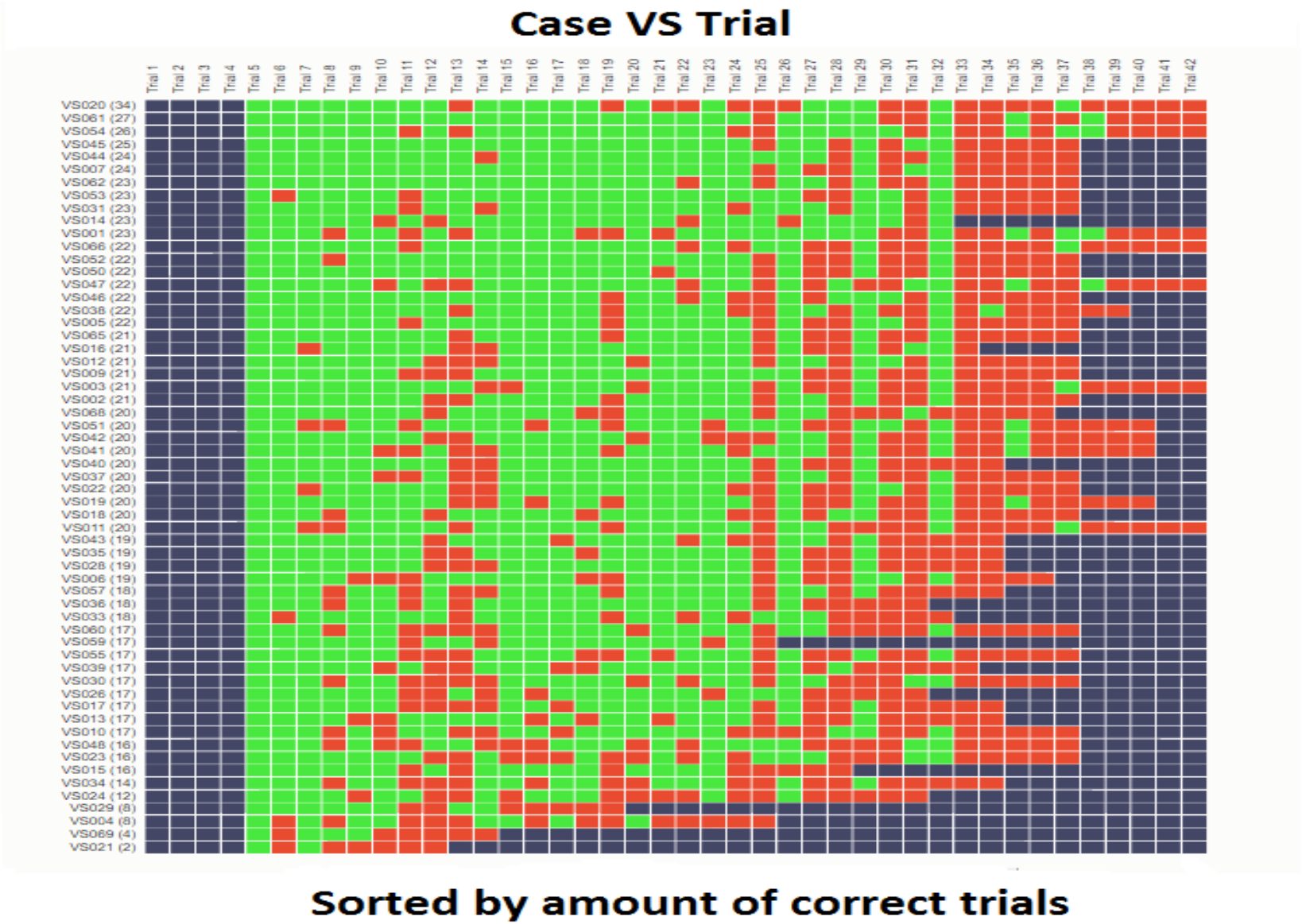
FUTURE DIRECTIONS: Validation of EEG portable methods





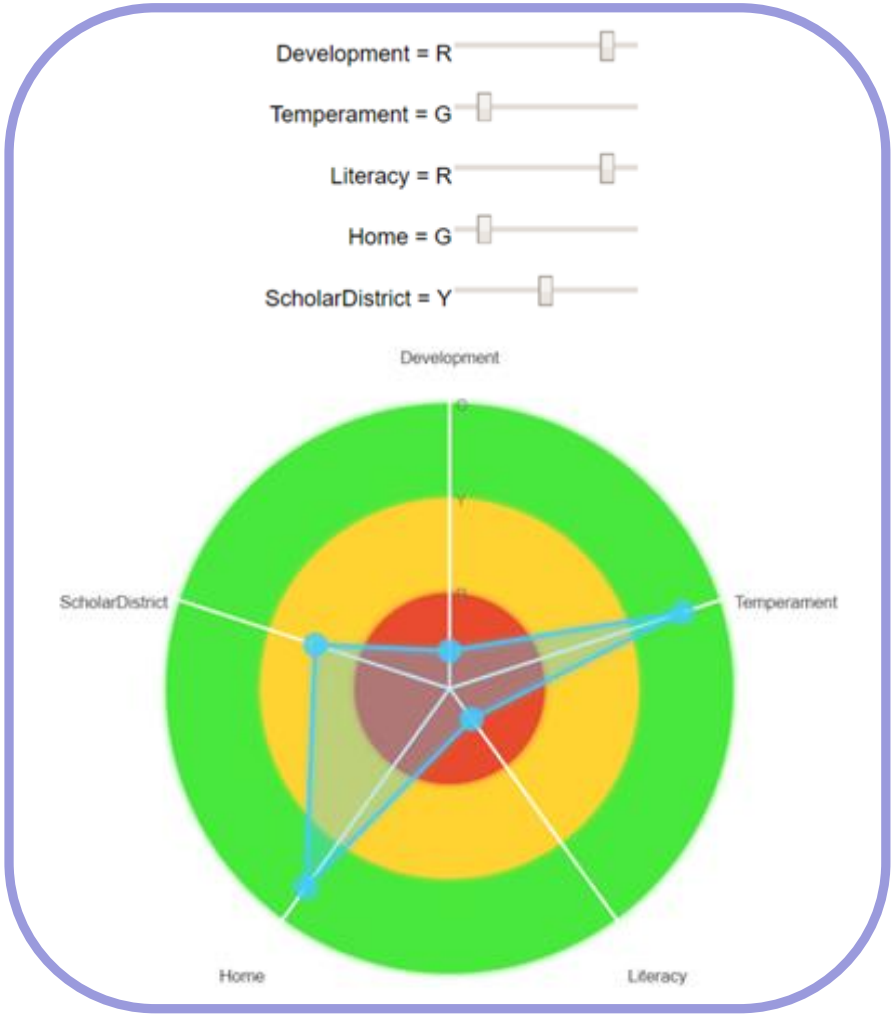
SOURCE: Pietto et al., in preparation.

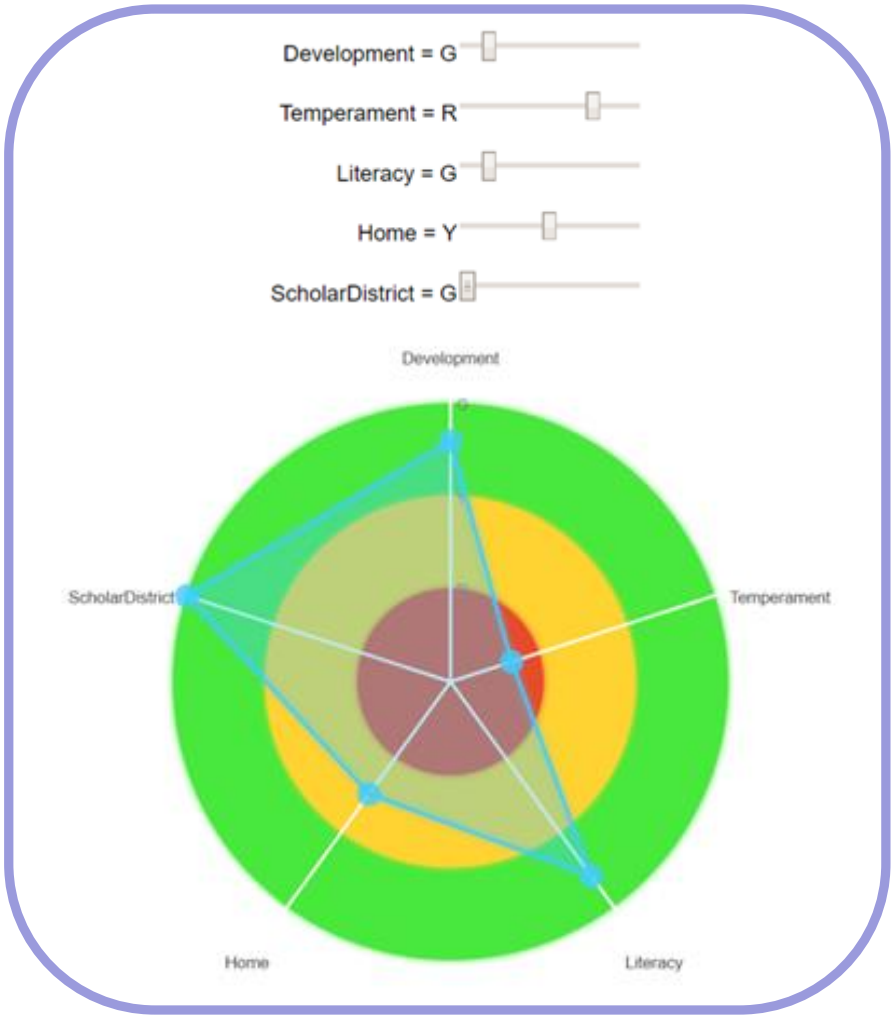
FUTURE DIRECTIONS: Individualdity in the design of interventions



SOURCE: Giovannetti et al., in preparation.

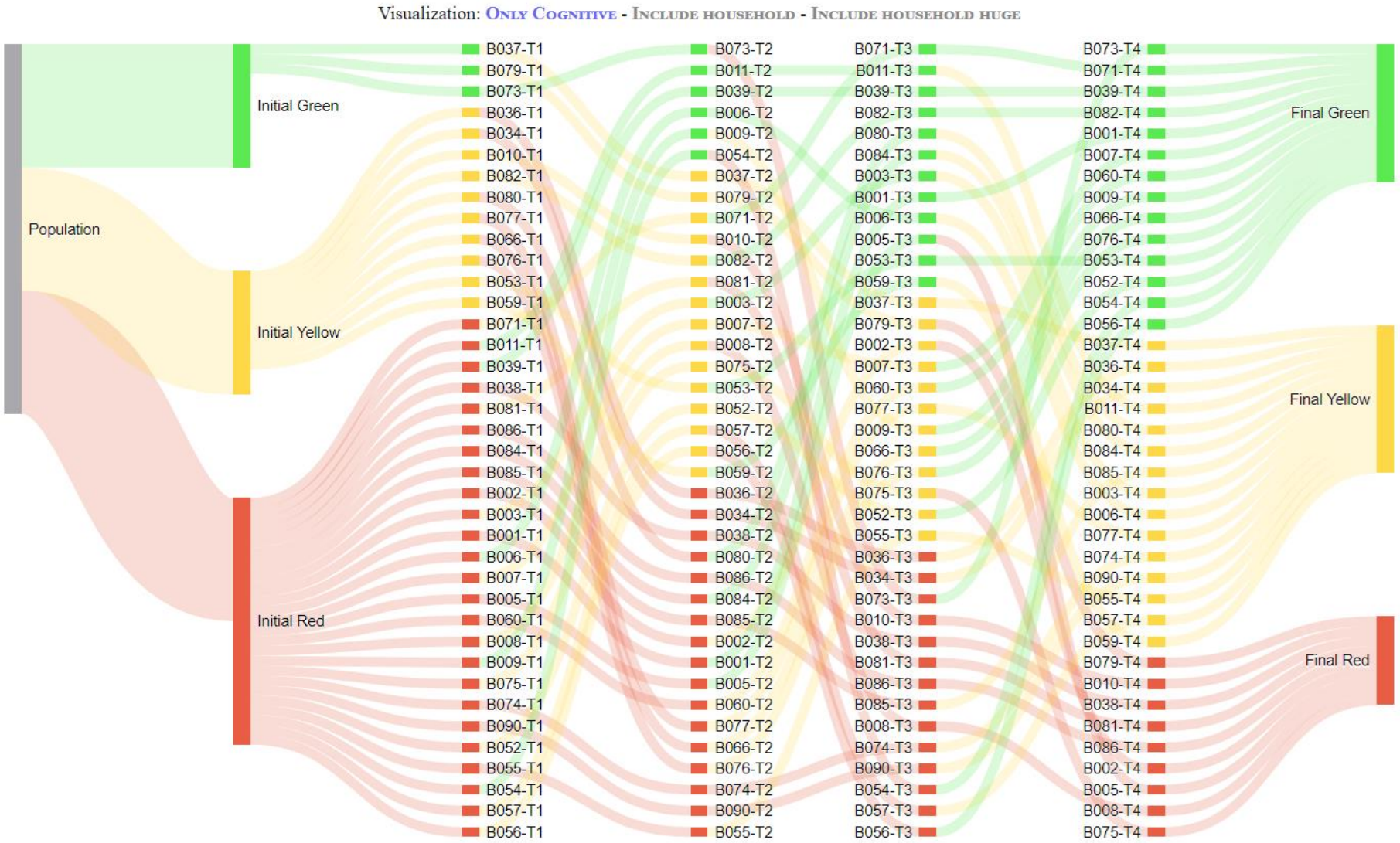
FUTURE DIRECTIONS: Algorithms for policy decision making





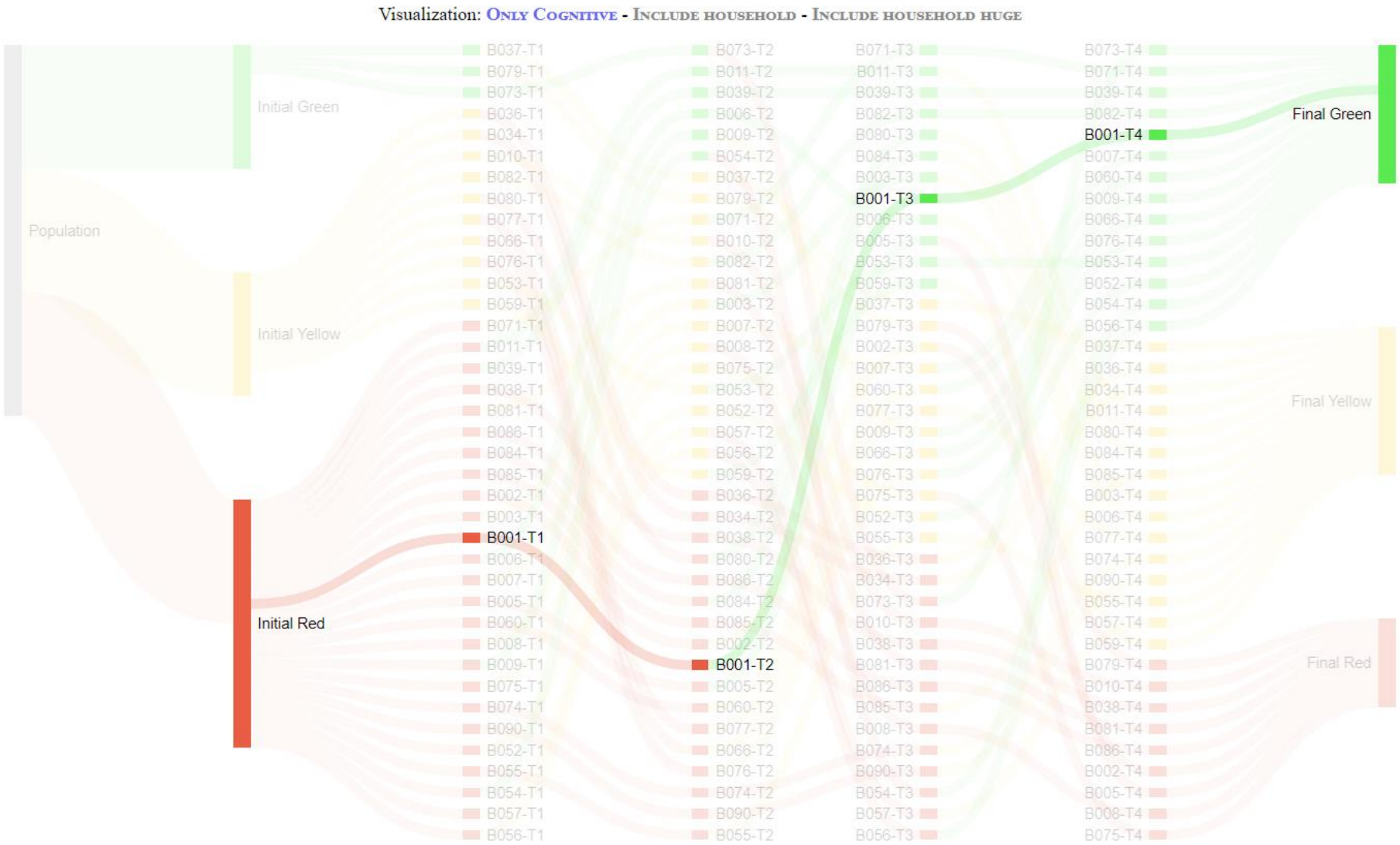
SOURCE: Lopez-Rosenfeld et al., 2017.

FUTURE DIRECTIONS: Algorithms for policy decision making



SOURCE: Lopez-Rosenfeld et al., 2017.

FUTURE DIRECTIONS: Algorithms for policy decision making (individuality)



SOURCE: Lopez-Rosenfeld et al., 2017.

Thank you for your attention

"We have learned that the boundaries between academic disciplines offer important opportunities for progress"

Michael I. Posner, 2016