L01: Introduction to Developmental Psychology

What is Developmental Psychology?

Perspective	Description
As a Method	Study phenomena during developmental windows to maximize variance
As Theoretical Commitment	Early experiences shape trajectories (not just accumulation)
As a Window	Into adult processes via child development
As a Tool	Apply developmental lens to any psychological domain
Multidisciplinary Hub	Integrates genetics, neuroscience, education, anthropology, philosophy

Exam Tip: Dev psych is "perhaps most flexible psychology discipline" - can approach through biological, social, cognitive, or clinical lens

Nature vs Nurture Dialectic

Position	Core Claim
Empiricism (Nurture)	Blank slate shaped entirely by experience
Rationalism (Nature)	Innate structures constrain development
Modern View	*FALSE DICHOTOMY* - dynamic interaction of both

Interactionist Examples

Domain	Nature	Nurture	Interaction
Language	Universal grammar	Environment triggers	Biological readiness + input
Intelligence	Hereditary baseline	Education, nutrition	Potential realized via scaffolding
Personality	Temperament	Parenting, peers	Goodness-of-fit model
Executive Function	PFC maturation	Practice, stress	Neural readiness + experience

Learning Outcomes (LOs)

LO	Skill Required
LO1	**Deep understanding:** Explain how theories support/undermine each other (not just describe)
LO2	**Methods:** Recognize conclusions are prisoners of their methods
LO3	**Communication:** Clear explanation (Pilates instructor, not bad food critic)
LO4	**Application:** Bridge lab findings to real-world (education, policy, clinical)

Critical: Essay emphasis on critical synthesis across frameworks - NOT research report format

Rate of Change Principle

Domain	Peak Change Period	Research Implication
Height	0-3 years, puberty	Study during growth spurts
Vocabulary	0-6 years	Explosive early acquisition
Executive Function	4-5 years (sharp slope)	Max variance in 1-year span

Key Principle: Study phenomena during rapid change for maximum observable variance
Example: Compare 4-5yo (steep EF slope) vs 25-30yo (flat) - former shows more developmental insight

Developmental Appropriateness

- **12-month-old:** CANNOT have malicious intent (no Theory of Mind until ~4 years)
- **Food throwing:** Not deliberate annoyance - lack cognitive architecture to model others' mental states
- **Implication:** Attributing adult motives to young children = fundamental misunderstanding

Tutorial Quiz System (Flipped Learning)

Timeline	Action
Monday (week before)	Readings released on Canvas
Friday	Quiz question released
Weekend	Read & compose response (~200 words)
Monday 8am	Submit to Canvas assignment box
Tutorial	Discussion (NO reading during session)

Scoring Rubric

Score	Criteria
0	No response OR didn't read material
1	Read + generally understood
2	Thoughtfully considered + reflected

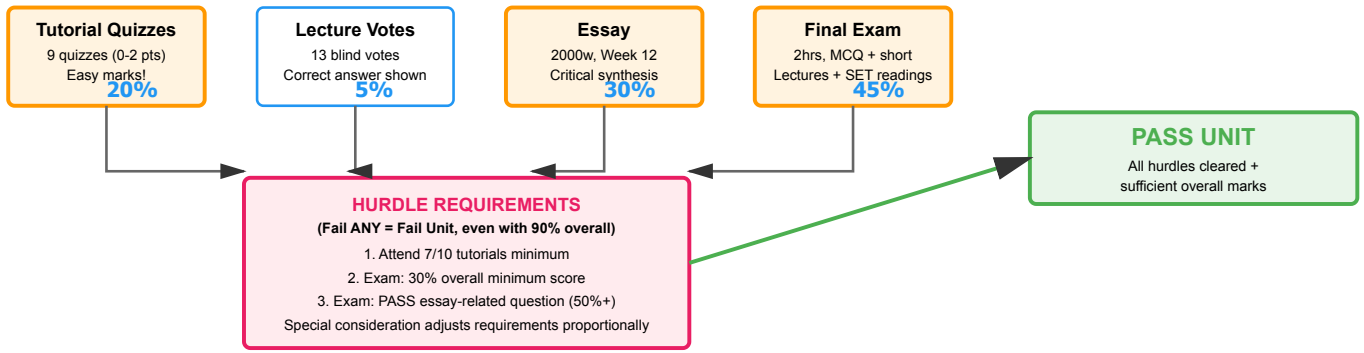
Easy 20%: Do readings weekly + thoughtful reflection = full marks. Total 18 possible points (9 quizzes × 2)

AI Usage Policy

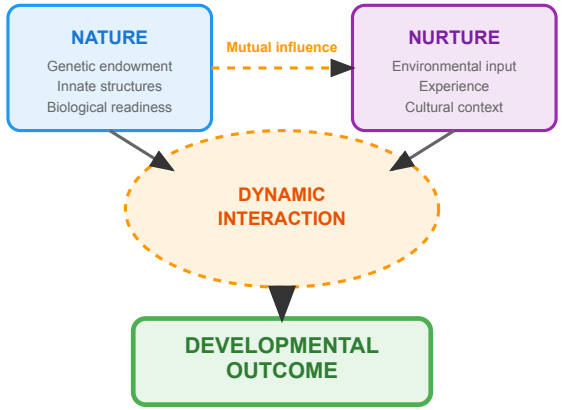
Use Case	Allowed?	Declare?
Literature search	YES	Yes
Outline/skeleton	YES	Yes
Concept exploration	YES ("Google on steroids")	Yes
Writing paragraphs	NO	-
Citations	Risky (fabricates sources)	Yes if used

Essay-Exam Link: If AI wrote essay, you CAN'T pass exam question (lack deep understanding). This is intentional anti-AI mechanism.
Detection: University uses MULTIPLE undisclosed methods - don't trust "AI-beating" tools

Assessment Architecture Flowchart



Nature-Nurture Interaction Model



Key: NOT binary choice - question is HOW genes & environment interact dynamically across time

Assessment Summary Table

Component	Weight	Hurdle?	Key Success Factor
Tutorial quizzes	20%	Attend 7/10	Pre-read + thoughtful reflection
Lecture votes	5%	No	Physical attendance + blind vote
Essay	30%	Pass exam Q	Critical synthesis across frameworks
Final exam	45%	30% min + pass essay Q	Answer THE question asked
3916 only	Exam 40% + 5% research	Same	Research participation component

Communication Excellence Standards

DON'T Be	DO Be
Bad food critic "Iridescent effervescence..." = flowery jargon when you don't understand	**Good Pilates instructor** Clear, precise guidance so reader understands without strain

- **Deep understanding:** Explain in simple words (hard!), not jargon (easy!)
- **Exam strategy:** Read question → Answer THAT question, not everything you know
- **Quality sources:** Peer-reviewed journals > popular media/magazines
- **Media literacy:** Lots of rubbish in parenting/child development media - be critical

Lecture & Tutorial Schedule

Weeks	Lecturer	Focus
1-6	Moul	Social-cognitive & moral development
7	Guest	Juvenile criminal law
8-13	Goldwater	Cognitive development

Tutorial Notes

- **Week 1:** NO tutorial
- **Week 6 (Tutorial 5):** 3916 ONLY
- **Week 9:** NO tutorial (post mid-semester break)
- **Week 13 (Tutorial 11):** 3016 ONLY

Essay Requirements

Aspect	Detail
Topic released	Week 3
Optional outline feedback	Submit by Friday Week 8
Due date	Week 12
Length	2000 words max (±5%)
Content sources	Lecture/tutorial material + supplementary refs OK
Late penalty	5% per calendar day (not worth it!)
Purpose	Critical thinking, argument construction, synthesis

Final Exam Details

Component	Details
Format	MCQ + short answer, in-person, 2 hours
Content tested	Lectures + SET readings (required, not recommended)
Tutorial content	Supplementary only - can enhance answers, not directly tested
Required vs Recommended	Required = content we want you to know (exam-able) Recommended = deepen understanding if interested
Essay question	Related to your essay topic - MUST PASS (50%+ hurdle)
Overall hurdle	30% minimum total exam score

CRITICAL EXAM TIP: Read the question carefully. Answer THAT specific question, not "everything I know about this topic"

Course Philosophy & Principles

- **Deep thinking over absorption:** Critical synthesis required, not passive learning
- **Essay over research report:** Argue across frameworks, not just describe methods
- **Continuous engagement:** Multiple touchpoints prevent cramming (20% quizzes + 5% lectures = 25% easy marks)
- **Hurdle system rationale:** Can't compensate for fundamental gaps with isolated excellence
- **Traditional knowledge sharing:** Questions during lecture encouraged (story-form learning)
- **Early childhood significance:** Changes 0-6 years MORE influential than 30-36 years
- **Edge of knowledge:** Some topics have no single answer yet - think critically & creatively

Career Pathways

Path	Developmental Psychology Relevance
Honours/PhD	Research in any developmental domain
Clinical psychology	Child/adolescent intervention & assessment
Education	Curriculum design, teaching methods, learning sciences
Social work	Child welfare, family support systems
Forensics	Juvenile justice, capacity assessment, witness reliability
Policy development	Evidence-based child/family policy, educational reform
Parenting	Understanding your own children's development

Common Pitfalls to Avoid

- **Exam pitfall:** Writing everything you know instead of answering the specific question
- **Essay pitfall:** Using AI to write essay → can't pass exam question (lack deep understanding)
- **Quiz pitfall:** Not reading before submitting = 0 points (easy 20% lost!)
- **Attendance pitfall:** Missing 4+ tutorials = fail unit even with high marks (hurdle!)
- **Reading confusion:** Required readings ARE exam-able; recommended are optional enrichment
- **AI citation risk:** Frequently fabricates sources - verify ALL citations independently
- **Communication pitfall:** Using flowery jargon when unclear (shows you DON'T understand)
- **Developmental attribution error:** Attributing adult motives/intentions to young children
- **Special consideration:** If granted for 5+ quizzes, alternative assessment replaces quizzes (harder!)

Key Quotes & Exam-Worthy Phrases

- "**Perhaps most flexible psychology discipline**" - multidisciplinary integration
- "**Early experiences shape trajectories**" - not just accumulation
- "**Study phenomena during rapid change**" - maximizes observable variance
- "**False dichotomy**" - nature vs nurture = dynamic interaction, not binary choice
- "**Essay-exam linkage = anti-plagiarism mechanism**" - authentic understanding tested
- "**Conclusions are prisoners of their methods**" - research design limits what you can claim
- "**Developmental appropriateness**" - must match expectations to child's cognitive stage
- "**Goodness-of-fit**" - temperament-environment interaction in personality development

Exam Day Strategy Checklist

Step	Action	Rationale
1. Read question FULLY	Identify what is actually being asked (not topic area)	Common mistake: writing everything you know vs answering specific question
2. Essay question FIRST	Tackle essay-related question early when fresh	HURDLE requirement - must pass this question to pass unit
3. Simple language	Explain clearly (Pilates instructor), avoid jargon unless necessary	Shows deep understanding; jargon often masks confusion
4. Use framework language	Reference theories, studies, concepts from lectures/readings	Demonstrates LO1: deep understanding of theoretical foundations
5. Link methods to conclusions	Note how research design constrains interpretations	Demonstrates LO2: methodological literacy
6. Time allocation	Proportion time to marks available	Don't over-invest in low-mark questions

Special Considerations

- **Quizzes:** If SC for <5 quizzes → percentage based on completed quizzes
- **Quizzes:** If SC for 5+ quizzes → alternative essay assessment (harder!)
- **Tutorials:** Need to attend 7/10 unless SC granted
- **Essay:** Extensions available via SC process
- **Exam:** Apply through official channels BEFORE exam if possible

Support Resources

- **Student Wellbeing:** Counseling, mental health support
- **Safer Communities:** Harassment, violence, bullying support
- **Welcome Hub:** Not just for new students - resources available anytime
- **Scam awareness:** Young adults most targeted - verify before giving info/money

L02: Nature vs Nurture - The Genetics-Environment Debate

Philosophical Positions

Position	Nature (Nativism)	Nurture (Empiricism)
Core Claim	Innate qualities present from birth; naturally unfold	Blank slate (tabula rasa); shaped by experience
Key Figures	Chomsky, Plato (rationalism)	Watson, Locke (behaviourism)
Language Example	Universal grammar module; kids learn syntax without teaching	Learned via environmental reinforcement
Development	Minimal environmental cues needed	Personal experiences create outcomes
Extreme Quote	"You are what you're born as" (inflexible)	"Give me a dozen infants, I'll make them anything" (Watson, 1930s)

Reality: FALSE DICHOTOMY - Both operate jointly. "Nature vs Nurture" debate is 50 years out of date.

Heritability: Core Formula

$$P = G + E$$

Phenotype = Genetic effects + Environmental effects

Term	Meaning
Phenotype (P)	Observable/measurable trait variation in population (e.g., height range 130cm-210cm)
Genetic effects (G)	Variance in phenotype caused by genetic differences
Environmental effects (E)	Variance in phenotype caused by environmental differences
Heritability (h^2)	$h^2 = \frac{V_G}{V_P}$ = Proportion of variance due to genetics

CRITICAL: Heritability ≠ Inherited
Heritability = population variance ratio (changes with environment)
Inherited = passing genes parent→offspring

Chomsky's Poverty of Stimulus

Component	Explanation
Argument	Natural language grammar is unlearnable given limited data available to children
Evidence	Kids acquire spoken language + grammar WITHOUT explicit teaching; but need intensive training for reading/writing
Conclusion	Innate linguistic capacity: genetically inherited neurological module for universal syntax
Module Function	Born with universal grammar understanding; fine-tuned by native language exposure
Example	Kids say "I brung my jumper" (overgeneralize rules) - demonstrates innate rule application, not imitation

- **Implication:** Certain abilities (language syntax) are natively present, not learned
- **Contrast:** Reading/writing = not innate, requires explicit training
- **Link to L03:** Theory of mind also related to syntax processing

Heritability Mechanics

Factor	Effect on h^2	Mechanism
↑ Genetic variance	h^2 increases	Outbreeding (tall family marries short family) → more genetic variation in offspring
↓ Environmental variance	h^2 increases	Optimize environment (good nutrition for all) → genetic differences become more apparent
↑ Environmental variance	h^2 decreases	Poor nutrition in some groups → environment masks genetic potential

Height Example:
Same genes: Good nutrition = 184cm | Malnutrition = 168cm (16cm difference)
h^2 = 85% (wealthy, good nutrition) vs h^2 = 40% (poverty, variable nutrition)
Same genes, different heritability due to environment

- **Paediatrician height formula:** (Father height + Mother height) / 2, ± adjustment for sex
- **Critical period:** Height window closes ~age 18; early malnutrition = permanent stunting
- **Cancer/illness effect:** Body prioritizes health over growth → temporary growth plateau

Measuring Genetics: SNPs

Term	Definition
SNP	Single Nucleotide Polymorphism (pronounced "snip")
What it is	One location on DNA with 2 possible amino acid variants
Notation	Common variant = A (big), Rare variant = a (small)
Genotypes	AA (homozygous dominant), Aa (heterozygous), aa (homozygous recessive)

Association Study Method:

1. Recruit 2 groups: Cases (with trait/disorder) vs Controls (without), matched on age/SES/education
2. Extract DNA (cheek swab, saliva, blood)
3. Scan for SNP frequency at specific genomic locations
4. Statistical comparison: If SNP frequency significantly different between groups → "associated"

CRITICAL: Association ≠ Causation
SNP may not cause disorder directly - may just "tag" nearby functional gene region

GWAS: Genome-Wide Association Scan

Component	Details
What it is	Scan hundreds of thousands of SNPs simultaneously in massive samples
Method	"Fishing trip" - no a priori hypothesis; use statistical power via huge N
Advantage	Discover unexpected genetic regions associated with traits
Problem 1	Random SNPs pop up with unclear functional relevance
Problem 2	May identify non-coding DNA regions (unknown function)
Solution	Hypothesis-driven molecular genetics: target known neurotransmitter systems (e.g., dopamine for ADHD)

Rob Plomin (1993): "Gene identified for dementia → opens door to investigate effects earlier in life, comorbid disorders, G×E interactions"
Finding one functional gene unlocks many research pathways

Measuring Environment: Methods

Method	Pros	Cons
Direct observation	Real-time, in-context data	Expensive, observer effects, reactivity bias
Self-report (8+ yrs)	Quick, easy, scalable	Subjective, response bias, poor inter-rater correlation
Parent/teacher reports	Practical for children, multiple perspectives	Subjective, low correlation (parent vs teacher reports often disagree)
Clinical interview	Depth, nuanced understanding	Interviewer bias, time-consuming, not scalable
Public/social records	Objective, easy access (varies by country)	Limited to recorded data, lacks context

Environment Types: Physical (garden, stairs), Internal (diet, inflammation), Social (living arrangements), Family (parenting), Emotional (stress, support)

SES Brain Study (Martha Farah)

Finding	Details
Research Question	Why do poor children perform worse on IQ tests and in school?
Method	Brain scans of hundreds of children from wide SES range
Key Finding 1	NO brain architecture differences at birth between rich and poor
Key Finding 2	By age 12: Physical differences emerge - poverty → smaller hippocampus, thinner prefrontal cortex
Hippocampus	Learning, memory, stress regulation - slower growth in poverty
Prefrontal cortex	Memory coordination, perception, motor control - thinner in poverty
Mechanism	Lack of cognitive stimulation (reading, conversation, interesting places) + poverty stress

CRITICAL IMPLICATION: Biological differences ≠ genetic causes
Environment changes brain structure (same genes at birth, different brains by age 12)

- **NAPLAN results:** ~33% of rural/poor kids "developing or lower" vs ~10% in cities
- **Not genetic:** Environmental deprivation causes biological change

Key Distinctions (Exam Traps)

Term	Definition
Heritability	Proportion of variance in POPULATION due to genetic differences
Inherited	Passing genes from parent to offspring (DNA transmission)
Genotype	Genetic makeup at specific locus (AA, Aa, aa)
Phenotype	Observable/measurable trait (height, IQ, aggression)
Reaction range	Genetically possible range; environment determines position within range
G×E interaction	Genetic effect depends on environment (e.g., MAOA×maltreatment)

Myth 1: Genetic Determinism - "Genes Dictate Outcomes"

Trait	Heritability	Do genes dictate?	Evidence
Eye colour	~98%	Approximately YES (minimal environmental modulation)	Mostly genetic; some environmental influence on shade
Height	80-90%	**NO** - Genes set potential, nutrition required	Malnutrition → stunting despite tall genes; critical period closes age 18
IQ	~50%	**NO** - Education, cognitive stimulation critical	SES brain study: same genes, different IQ based on cognitive enrichment
Aggression	~40%	**NO** - MAOA-L gene requires maltreatment to elevate violence	MAOA-L + no maltreatment = low violence; + maltreatment = elevated violence
Down syndrome	100% (mutation)	**NO** - Even clear genetic cause shows massive phenotypic variation	Extra chromosome 21 → wide range of disability/ability, medical complications

Implications of genetic determinism:
- Social mobility: "Low IQ genes" → don't pursue doctor career (fatalism)
- Designer babies: If genes dictate, temptation to "select" traits
- Free will: Predestination vs agency debate

Reality: Genes set REACTION RANGE (what's possible), not outcome

Myth 2: Tabula Rasa Blame

Issue	Genetic Determinism	Environmental Determinism
Blame target	"Bad genes" (rotten apple)	Failing families, schools, communities
Responsibility	Individual not responsible (genes dictate)	Society fully responsible (must fix environment)
Intervention	Futile (can't change genes)	Necessary (perfect environment = perfect citizens)
Watson's claim	"Give me a dozen infants, I'll make them anything regardless of talents/abilities/race" (pure empiricism)	

Attribution Bias:
Positive traits → genetic ("I'm naturally smart")
Negative traits → environmental ("Not my fault")
Parent diagnosis preference: ADHD over ODD (same h^2~40%) because ADHD seen as "more biological" → less parenting blame

Myth 3: Warrior Gene (MAOA)

Component	Details
Gene	MAOA (monoamine oxidase activator) - regulates monoamine neurotransmitters
Variants	High activity (MAOA-H) vs Low activity (MAOA-L)
Finding	High proportion of violent offenders have MAOA-L variant
CRITICAL LOGIC ERROR	**Majority of people WITH MAOA-L do NOT commit violent crime**
G×E interaction	MAOA-L + no maltreatment = low violence MAOA-L + maltreatment = elevated violence
Legal use	MAOA genetic testing used to reduce prison sentence (criminal "less responsible")
Ethical problem	Criminal responsibility tied to genetic profile - massive societal implication

Psychopath vs Sociopath Myth:
"Psychopath = born (genetic), Sociopath = made (environment)"
BOTH FALSE: Environment and genes equally important for both

Myth 4: "All Traits Heritable → h^2 Irrelevant"

Heritability	Interpretation	Clinical Implication
10% heritable	Small genetic contribution	Environmental interventions primary treatment
30% heritable	Moderate genetic contribution	Combined approach: environment + biological awareness
80% heritable	Large genetic contribution	Investigate neurobiology; environmental interventions may be insufficient alone

Conduct Disorder Example (Treatment Resistance):
Low CU traits: h^2 = 30% → Good treatment response (parenting interventions work)
High CU traits: h^2 = 81% → Poor treatment response (different mechanism, needs biological understanding)
Implication: Can't treat all patients the same; h^2 guides mechanism investigation

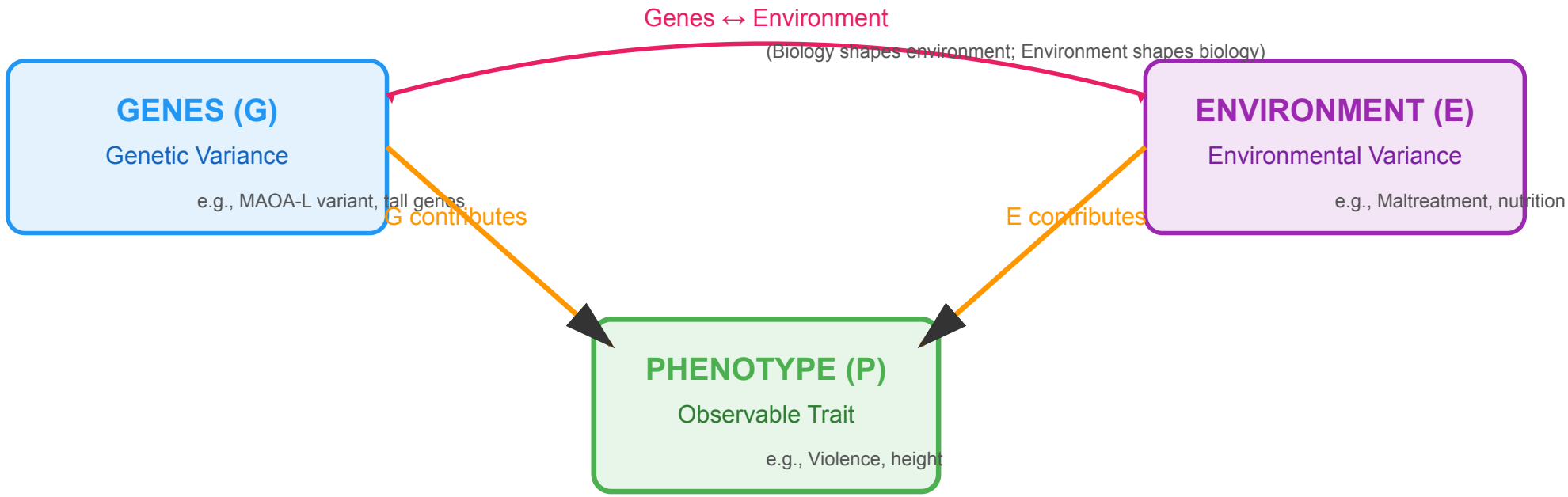
- **ADHD mechanism:** h^2~70% → dopamine system investigation → medication targets
- **Anxiety/Depression:** h^2~40% → serotonin system (why SSRIs work for some)
- **Variation in h^2 matters for treatment planning**

Myth 5: Public Misinterpretation & Genetic Literacy

Misinterpretation	Problem	Real-World Impact
"Fat genes"	Locus of control - "Nothing I can do" (fatalism)	People with genetic risk factor may stop trying to manage weight
"Brain different from birth"	Misconception that brain differences = unchangeable	14yr ADHD boy: "My brain doesn't work properly, can't be different" → why try? → self-fulfilling prophecy
"Designer babies"	If genes dictate, temptation to genetically "select" traits	Ethical concerns: eugenics, genetic discrimination, loss of diversity
"Low IQ genes"	Social mobility threatened by genetic fatalism	Students don't pursue higher education/careers if told genes limit potential
"Genes load gun, environment pulls trigger"	Too simplistic - implies one-way directionality	Ignores: environment can load gun, genes can pull trigger; bidirectional G↔E

Solutions:
1. **Education:** Psychologists must understand genetic findings properly (G×E interactions, not determinism)
2. **Communication:** Media must convey genetic findings accurately (not sensationalize)
3. **Early intervention:** Not just reducing environmental risk - also optimizing gene expression windows (critical periods)

Gene-Environment Interaction Model



G×E Examples:

Bidirectional Influence:
Genes → Environment: Genetic predispositions shape environment selection (shy kids avoid parties, extroverted kids seek stimulation)
Environment → Biology: SES study - poverty environment causes physical brain changes (hippocampus, PFC)
Extreme environments override genes: Severe malnutrition, trauma, enrichment can override genetic propensities

Common Exam Traps & Pitfalls

- **Heritability = Inherited:** NO - Completely different concepts (population variance vs gene transmission)
- **High h² = Unchangeable:** NO - Means current environment optimized; change environment → change phenotype
- **Gene association = Causation:** NO - SNP may just tag nearby region, not functional itself
- **Nativism vs Empiricism dichotomy:** FALSE - Both operate jointly, "vs" debate is outdated
- **MAOA-L → Violence:** NO - Most carriers non-violent; requires maltreatment (G×E interaction)
- **Biological difference = Genetic cause:** NO - Environment changes brain (SES brain study proof)
- **All traits heritable → irrelevant:** NO - Magnitude variation clinically meaningful (10% vs 80%)
- **"Genes load gun, E pulls trigger":** Too simplistic - Bidirectional; can be reversed
- **Poverty of stimulus = no input needed:** NO - Still need language exposure, just not explicit grammar teaching
- **Heritability constant across populations:** NO - Changes with environmental variance (h² height: 85% wealthy, 40% poor)
- **Age is environmental factor:** NO - Age is chronological/biological, not environmental (in-lecture quiz question)
- **Hormonal conditions in utero:** YES environmental (biological environment for developing foetus)

Critical Studies & Examples

Study/Concept	Key Finding/Quote
Chomsky Poverty of Stimulus	Kids learn syntax without teaching → innate universal grammar module
Watson (1930s)	"Give me dozen healthy infants, I'll make them anything regardless of talents/race" (pure empiricism)
SES Brain Study (Farah)	Same brains at birth; by age 12: poverty → smaller hippocampus/thinner PFC (environmental effect)
MAOA Warrior Gene	Used to reduce prison sentence; flawed logic (most MAOA-L carriers non-violent)
Conduct Disorder CU Traits	Low CU h²=30% (good treatment response); High CU h²=81% (poor response, different mechanism)
Height Siblings Example	Same genes: good nutrition 184cm vs malnutrition 168cm (16cm environmental difference)
Rob Plomin (1993)	"Gene for dementia → investigate earlier life effects, comorbid disorders, G×E" (one gene unlocks pathways)
Down Syndrome	Clear genetic mutation (chromosome 21) yet massive phenotypic variation (genes don't dictate everything)

Formula Quick Reference

Formula	Interpretation
$P = G + E$	Phenotype variance = Genetic variance + Environmental variance
$h^2 = \frac{V_G}{V_P}$	Heritability = Proportion of phenotypic variance due to genetic variance
$h^2 = \frac{V_G}{V_G + V_E}$	Heritability as ratio (increases if V_E decreases OR V_G increases)

Remember: h² is population-specific and context-dependent (not fixed universal value)

Core Takeaways

- **Debate is OVER:** "Nature vs Nurture" is false dichotomy; both operate jointly
- **Heritability ≠ Genetic determinism:** High h² doesn't mean unchangeable
- **Environment changes biology:** SES brain study proves environmental effects on brain structure
- **Genes set reaction range:** What's possible, not what happens (requires environmental input)
- **G×E interactions critical:** Genetic effects depend on environment (MAOA×maltreatment)
- **Variation in h² matters:** 10% vs 80% guides treatment approach (environmental vs biological focus)
- **Public literacy crucial:** Misinterpretation → fatalism, loss of agency, genetic discrimination
- **Poverty of stimulus:** Language syntax innate (not taught); reading/writing not innate (requires teaching)
- **Association ≠ Causation:** SNPs may tag functional regions, not cause directly
- **Critical periods matter:** Height window closes ~18; early intervention optimizes gene expression

In-Lecture Quiz Reminder

Question: Which is NOT a source of environmental variation?
A) Income of child's family
B) Hormonal conditions in utero
C) Relationship between mother and child
D) Age of the child ✓ (CORRECT)
E) Child's diet

Trap: B seems biological → but it's environmental FOR the developing foetus
Key: Age is chronological/biological factor, not environmental variation source

L03: Behaviour Genetics I: Twin Studies & Heritability

Core Terminology

Term	Definition
Heritability (h^2)	Proportion of *variation* in a trait in a *population* due to genetic differences. NOT individual determination.
Phenotype	Observable trait = Genetic effects (G) + Environmental effects (E)
Monozygotic (MZ)	Identical twins; share 100% genes, 100% common environment
Dizygotic (DZ)	Fraternal twins; share 50% genes (like siblings), 100% common environment
Common Environment (C)	Events affecting both twins in the *same way* (e.g., family SES, neighborhood, school)
Unique Environment (E)	Events affecting one twin only, OR both twins *differently* (includes measurement error)
Additive Genetic Effects (A)	Genetic variance assuming effects sum linearly (1 risk allele = +R; 2 alleles = +2R)
Dominant Genetic (D)	Non-additive effects from dominance/epistasis (gene-gene interactions)
Narrow-sense h^2	Heritability from additive effects only (A)
Broad-sense H^2	Total genetic variance (A + D)

Twin Studies: Logic

- **Naturalistic experiment:** Twins occur naturally; no manipulation required
- **Key comparison:** MZ correlation vs DZ correlation on same trait
- **Power source:** MZ share 100% genes; DZ share 50% genes; both share common environment
- **If trait highly heritable:** MZ correlation >> DZ correlation
- **If environment important:** MZ and DZ correlations both high and similar

Critical Insight: Heritability estimates are POPULATION-SPECIFIC and CONTEXT-DEPENDENT. Cannot generalize across populations or apply to individuals.

Core ACE/PACE Equations

Component	Formula	Notes
Phenotype Variance	$V_P = V_G + V_E$	Total variance = Genetic + Environmental
ACE Decomposition	$1 = h^2 + c^2 + e^2$	A (additive) + C (common env) + E (unique env)
MZ Correlation	$r_{MZ} = h^2 + c^2$	100% genes + common environment shared
DZ Correlation	$r_{DZ} = \frac{1}{2}h^2 + c^2$	50% genes + common environment shared
Falconer's Formula	$h^2 = 2(r_{MZ} - r_{DZ})$	Estimate heritability from twin correlations
Common Environment	$c^2 = 2r_{DZ} - r_{MZ}$	Or: $c^2 = r_{MZ} - h^2$
Unique Environment	$e^2 = 1 - r_{MZ}$	Includes measurement error

When Falconer's Formula Fails ($h^2 > 1$)

Problem: If $h^2 > 1.0$, the simple ACE model is violated
Causes:

- **Dominant genetic effects (D):** MZ share 100% of D; DZ share only 25% of D
- **Assortative mating:** Non-random partner selection inflates genetic similarity
- **Equal environments assumption violated:** MZ treated more similarly than DZ

Solution: Use ADE model (Additive + Dominant + unique Environment)

Model Selection Decision Tree

Condition	Model	Interpretation
$r_{DZ} \approx \frac{1}{2}r_{MZ}$	**AE**	Additive genes + unique environment; no common environment
$r_{DZ} > \frac{1}{2}r_{MZ}$	**ACE**	Common environment substantial; use full ACE model
$r_{DZ} < \frac{1}{2}r_{MZ}$	**ADE**	Non-additive genetic effects (dominance/epistasis) present
$h^2 > 1.0$	**ADE**	Falconer's formula fails; fit dominance model

Worked Example: Childhood Anxiety

Given: $r_{MZ} = 0.70$, $r_{DZ} = 0.50$

Step 1: Check r_{DZ} vs $\frac{1}{2}r_{MZ}$
$\frac{1}{2}(0.70) = 0.35$; $r_{DZ} = 0.50 > 0.35$ → Use ACE model

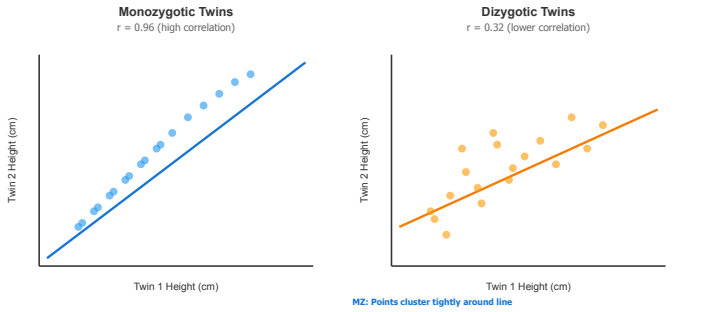
Step 2: Calculate $h^2 = 2(r_{MZ} - r_{DZ}) = 2(0.70 - 0.50) = 0.40$

Step 3: Calculate $c^2 = r_{MZ} - h^2 = 0.70 - 0.40 = 0.30$

Step 4: Calculate $e^2 = 1 - r_{MZ} = 1 - 0.70 = 0.30$

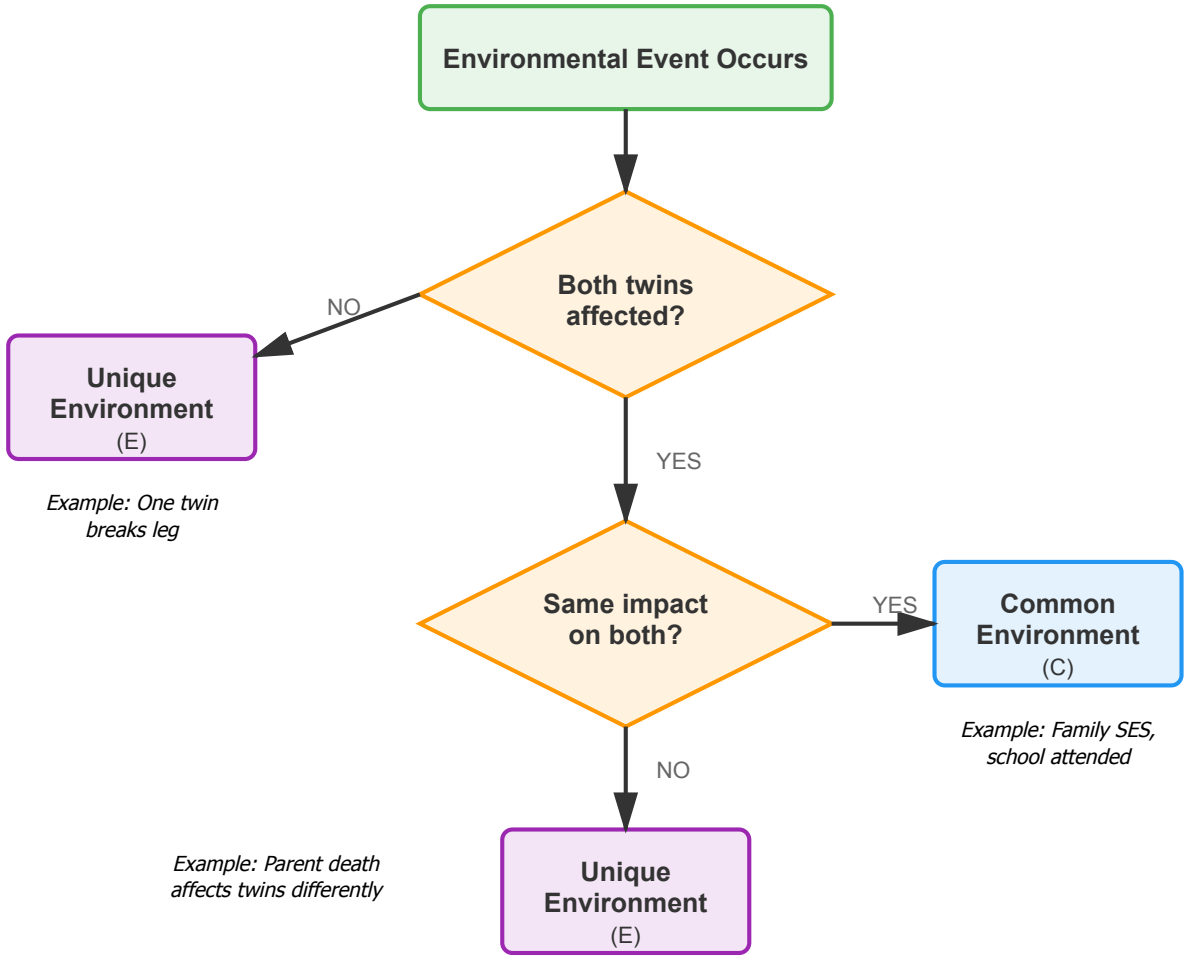
Result: 40% genetic, 30% common environment, 30% unique environment

Correlation vs Variation in Twin Data



Correlation: How closely points cluster around regression line (tighter = higher r)
Variation: How points distribute over the range (MZ twins create extreme pairs together)

Common vs Unique Environment Decision Flowchart



Child Psychopathology: ACE Components

Domain	a² (Genetic)	c² (Common Env)	d² (Dominant)	e² (Unique Env)
Conduct Problems	0.50	0.14	0.00	0.36
ODD Problems	0.48	0.16	0.00	0.36
Depression	0.42	0.16	0.00	0.42
Anxiety	0.48	0.12	0.00	0.40
ADHD Problems	0.26	0.00	0.44	0.30

Key Findings

- **~50% heritability** for most disorders (except ADHD: 70% total genetic with dominance)
- **10-16% common environment** - NOT negligible (challenges "twin wisdom")
- **25-42% unique environment** (includes measurement error)
- **ADHD unique:** Strong dominant genetic effects ($d^2 = 0.44$); zero shared environment

Clinical Implication: Common environment (parenting, family factors) accounts for 10-16% variance in most child psychopathology → Family interventions justified even with high heritability

Shared Environment & Parenting

Evidence-Based Associations

Parenting Pattern	Child Outcome	Mechanism (C or E?)
Overprotection, overcontrol	Increased anxiety	Can be C (family style) or E (differential response to each twin)
Hostility, anger, poor boundaries	Externalizing problems (conduct/ODD)	Often C (shared family climate)
Poverty, low SES	All psychopathology domains	C (shared economic environment)
Bullying (school-based)	Depression, anxiety	E (unique to individual twin)

Age Matters: Common environment (C) effects are stronger in childhood when twins spend more time at home. As adolescence progresses, unique environment (E) increases as peers and individual experiences become more important.

Assumptions of Twin Studies

1. **Equal Environments Assumption (EEA):** MZ and DZ twins experience equally similar environments
   - Often violated: MZ treated more identically (appearance, identity)
   - Can inflate heritability estimates
2. **Random Mating:** No assortative mating (partners chosen randomly)
   - Reality: Non-random (height, personality, ethnicity, religion)
   - Increases DZ genetic similarity beyond 50%
3. **Additive Genetic Effects:** Gene effects sum linearly
   - Often violated by dominance, epistasis (gene-gene interactions)
   - Use ADE model when h² > 1.0
4. **Twin Representativeness:** Twins reflect general population
   - IVF trends: Twins may be from more affluent families
   - Heritability estimates population-specific
5. **No Gene-Environment Interaction:** Genes and environment act independently
   - Reality: Gene-environment correlation (rGE) common
   - Can inflate heritability estimates

Common Exam Mistakes to Avoid

WRONG: "60% heritability means 60% of your personality is inherited from parents"
RIGHT: "60% of *population variance* in personality is due to genetic differences"

WRONG: "High heritability means environment doesn't matter"
RIGHT: "High heritability means genetic *differences* explain variance; environment still shapes trait development"

WRONG: "Heritability estimates generalize across populations"
RIGHT: "Heritability is population-specific and context-dependent"

WRONG: "High heritability means interventions won't work"
RIGHT: "High heritability indicates genetic risk; interventions target environmental pathways (C and E)"

Calculation Quick Reference

Step-by-Step ACE Calculation

1. **Compare r_{DZ} to $\frac{1}{2}r_{MZ}$**
   - If $r_{DZ} > \frac{1}{2}r_{MZ}$: Use ACE (common env present)
   - If $r_{DZ} \approx \frac{1}{2}r_{MZ}$: Use AE (no common env)
   - If $r_{DZ} < \frac{1}{2}r_{MZ}$: Use ADE (dominance)
2. **Calculate h²:** $h^2 = 2(r_{MZ} - r_{DZ})$
3. **Calculate c²:** $c^2 = r_{MZ} - h^2$ OR $c^2 = 2r_{DZ} - r_{MZ}$
4. **Calculate e²:** $e^2 = 1 - r_{MZ}$
5. **Verify:** $h^2 + c^2 + e^2 = 1.0$
6. **If h² > 1.0:** Model fails; use ADE instead

Memory Aid: The 50% Rule

~50% of variance in complex human traits (personality, intelligence, psychopathology) is genetic
~10-15% common environment (C)
~35-40% unique environment (E)
Exception: ADHD has 70% total genetic ($a^2 + d^2$) with strong dominance

Critical Concepts Checklist

Concept	Key Distinction
Heritability	Population variance, NOT individual trait determination
MZ vs DZ	100% vs 50% genes; both 100% common environment
C vs E	C = same impact on both twins; E = one twin OR different impact
Narrow vs Broad h²	h² (additive only) vs H² (additive + dominance)
ACE vs ADE	ACE if r_DZ > 0.5*r_MZ; ADE if r_DZ < 0.5*r_MZ
Correlation vs Variation	Correlation = clustering; Variation = spread over range
Falconer's Formula	h² = 2(r_MZ - r_DZ); assumes additive effects only

The Measurement Problem

Turkheimer's Parallel: "There's an interesting parallel between the search for individual genes and the failed attempt to specify the nonshared environment in measured environmental variables."

Why Is Nonshared Environment (E) So Hard to Measure?

- **Definition problem:** E includes events affecting one twin OR both twins *differently*
- **Cannot pre-specify:** What question would you ask? "What unique thing happened to you that didn't affect your twin the same way?"
- **Measurement error inflates E:** $e^2 = 1 - r_{MZ}$ includes unreliability
- **Subjective experience:** Same event (parent death) may affect twins completely differently based on temperament, attachment, developmental stage

Similarly: Why Can't We Find "The Genes" for High Heritability Traits?

- **Polygenicity:** Hundreds/thousands of small-effect variants
- **Epistasis:** Gene-gene interactions (non-additive)
- **Gene-environment correlation:** Genes and environment not independent
- **Missing heritability:** Twin studies show 50% h², but GWAS explains <10%

The Paradox: Twin studies tell us genetic and environmental variance are important, but we struggle to identify *specific genes* or *specific environmental variables* responsible. We know variance components exist, but not their mechanistic content.

L04: Behaviour Genetics II - Interactions & Epigenetics

Missing Heritability Problem

Aspect	Details
Definition	Gap between twin study heritability and GWAS findings
Twin studies	~50% heritability for most psychological traits
GWAS findings	Only 2-3% variance explained by identified variants
The gap	47 percentage points unaccounted for
Replication issue	Gene-disorder associations rarely replicate (~20 years ago)
Key formula	$h^2 = 2(r_{MZ} - r_{DZ})$

Potential Explanations

Category	Explanation
Wrong genes	Not looking at correct genes or incomplete gene sets
Gene functionality	Genes don't do what we think; receptors vary by region (e.g., serotonin in gut vs brain)
Gene networks	Missing parts of system; need whole network, not isolated genes
Protein issues	Proteins don't function as expected (e.g., oxytocin doesn't cross blood-brain barrier)
Sample problems	Phenotype imprecise, ethnicity not tracked, age range too broad
Interactions	Gene-gene (epistasis), gene-environment effects not captured
Epigenetics	Methylation and other regulatory mechanisms not measured

Heritability Calculation Example

Scenario: Aggressive behavior study

- MZ correlation (r_{MZ}) = 0.65
- DZ correlation (r_{DZ}) = 0.35

$h^2 = 2(r_{MZ} - r_{DZ})$

$h^2 = 2(0.65 - 0.35)$

$h^2 = 2(0.30) =$ **0.60 or 60%**

Interpretation:

- 60% of variance is heritable
- If GWAS finds 4% variance explained
- Missing heritability = 60% - 4% = **56%**

Why Replication Failed

- **Underpowered:** N < 200 typical
- **Publication bias:** Positive findings published preferentially
- **No correction:** Multiple testing without alpha adjustment
- **Winner's curse:** Inflated effect sizes in initial findings

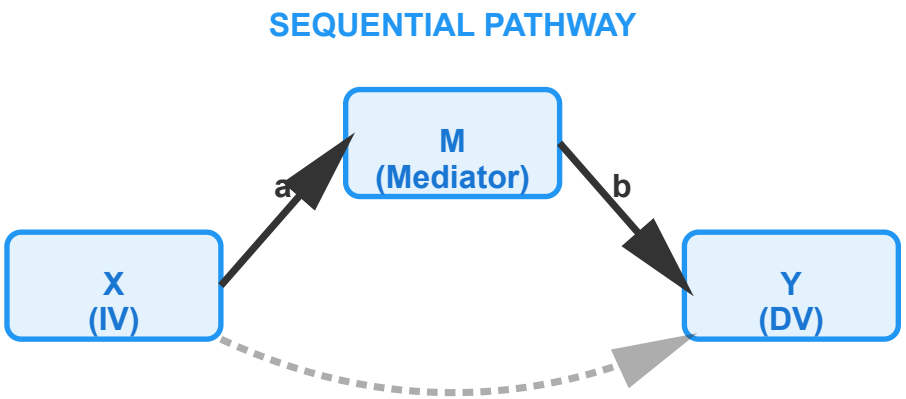
Mediation vs Moderation: Critical Distinctions

Aspect	Mediation	Moderation
Key Question	HOW / WHY?	WHEN / FOR WHOM?
Function	Specifies **mechanism** (transmits effect)	Specifies **boundary condition** (changes strength/direction)
Relationship	Mediator is in the **causal pathway**	Moderator is **external to pathway**
Structure	X → M → Y (sequential chain)	X × Z → Y (interaction term)
Effect type	Indirect effect through pathway	Interaction effect (strength varies by Z)
Genetic example	Serotonin 1B gene → neurotransmission efficiency → callous-unemotional traits	NR3C1 gene × intervention → externalizing disorder
Non-genetic example	Homework → practice papers → exam performance (practice explains why homework helps)	Negative social contacts × drinking to cope → home drinking (effect only for high copers)
Statistical test	Test indirect effect (a×b path)	Test interaction term (X×Z coefficient)
Without it	Know THAT relationship exists, not WHY	Miss subgroup differences; average obscures pattern

Coffee Example (from lecture)

Statement	Type
"Coffee makes you more efficient because it makes neurons fire faster"	**Mediation** (explains HOW)
"1-3 cups increases efficiency; 4+ cups decreases efficiency"	**Moderation** (dose moderates effect direction)
"Coffee makes neurons fire faster, which is why 4+ cups frazzles neurons"	Mixed (mediation + moderation)

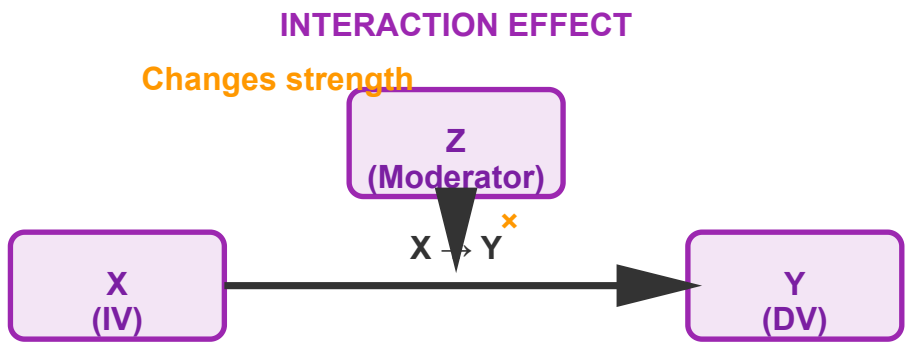
Mediation: HOW/WHY (Mechanism)



e: Serotonin gene →
nission → callous traits

c' (direct effect, reduced)

Moderation: WHEN/FOR WHOM (Boundary)



e: Intervention effect
ON genotype (GG vs A)

Gene × Environment (GxE) Interaction

Component	Details
Definition	Genotype changes relationship between environmental IV and DV (moderation)
Type	Moderation: genotype moderates environmental effect
Key insight	Not everyone responds same to environment
Example	Child abuse → adult psychopathology (but not for everyone)
Importance	Must consider genetics + environment simultaneously
Note	Different from rGE (gene-environment correlation)

Differential Susceptibility Model

Aspect	Details
Core claim	Environment has different effects depending on genetic susceptibility
High susceptibility	Negative env → very poor outcomes; Positive env → very good outcomes
Low susceptibility	Stable across environments (resilient to both negative and positive)
Pattern type	Crossover interaction (lines cross)
NOT diathesis-stress	DS = "for better and for worse"; Diathesis = "for worse only"
Mechanism	Genetic variants in stress response systems (e.g., glucocorticoid receptor)

Orchid vs Dandelion Children

Feature	Orchid (High Susceptibility)	Dandelion (Low Susceptibility)
Genetics	Carry susceptibility allele (e.g., A in NR3C1)	Don't carry allele (e.g., GG genotype)
Negative env	Very poor outcomes (wither)	Resilient (grow anyway)
Positive env	Very good outcomes (blossom)	Average outcomes (don't excel)
Responsiveness	Highly responsive to environment quality	Stable regardless of environment
Plant analogy	Orchids: picky conditions, beautiful when thrive	Dandelions: grow anywhere, even concrete
Not inherently	Worse - just responsive	Better - just stable

Fast Track Study: Design

Component	Details
Design	Randomized controlled trial (RCT)
Sample	High-risk first graders (age ~7)
High risk defined	Low SES + high crime environment (criminogenic)
Follow-up	Tracked to age 25
Gene	NR3C1 (glucocorticoid receptor gene; social stress response)
Variants	GG (common) vs A carrier (A allele = rare susceptibility)
Intervention	Intensive support: education, social services, everything
Control	Waitlisted (no intervention)
Outcome	% with externalizing disorder at age 25

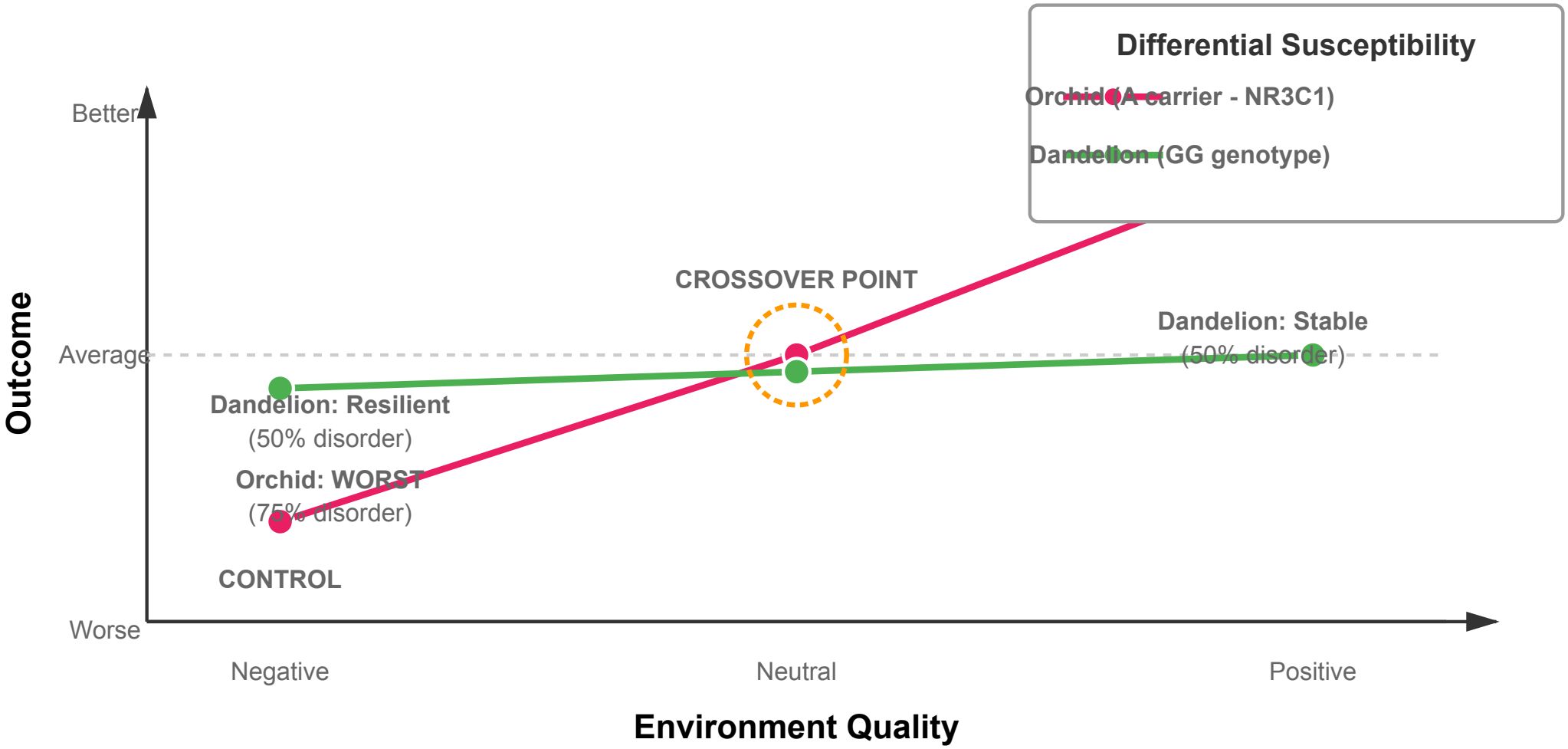
Fast Track Study: Results

Genotype	Control	Intervention	Effect
GG (Dandelion)	50%	50%	**NO EFFECT**
A carrier (Orchid)	75%	18%	**HUGE EFFECT**

Critical Interpretations

- **Main effect would be modest:** Without genotype split, intervention shows small overall effect (obscures true pattern)
- **Orchid pattern:** A carriers do WORST without intervention (75%), BEST with intervention (18%)
- **Dandelion pattern:** GG stable at 50% regardless of intervention (resilient but don't benefit)
- **Differential susceptibility confirmed:** Same genetic variant predicts both vulnerability AND plasticity
- **Ethical implication:** Could genotype to target interventions, but problematic (who gets resources?)
- **Statistical implication:** Interaction effect; moderation, not mediation

Differential Susceptibility: Orchid vs Dandelion Pattern (Crossover Interaction)



Key Pattern: Orchid children (high susceptibility) show crossover interaction: worst outcomes in negative environments, BEST outcomes in positive environments. Dandelion children (low susceptibility) show stable outcomes across environments. This is moderation (genotype moderates environmental effect), NOT mediation.

Epigenetics: Core Concepts

Component	Details
Definition	Functionally relevant changes to genome WITHOUT nucleotide sequence change
Alternative def	Dynamic alterations to transcriptional potential of cell
Key principle	Changes gene EXPRESSION, not gene SEQUENCE
Heritability	Can be passed to offspring (mitotically stable)
Main mechanism	DNA methylation (most studied)
Other mechanisms	Histone modification, chromatin remodeling
Core analogy	DNA = library. Does NOTHING unless READ (transcribed)
Function in GxE	Molecular mechanism for gene-environment interaction

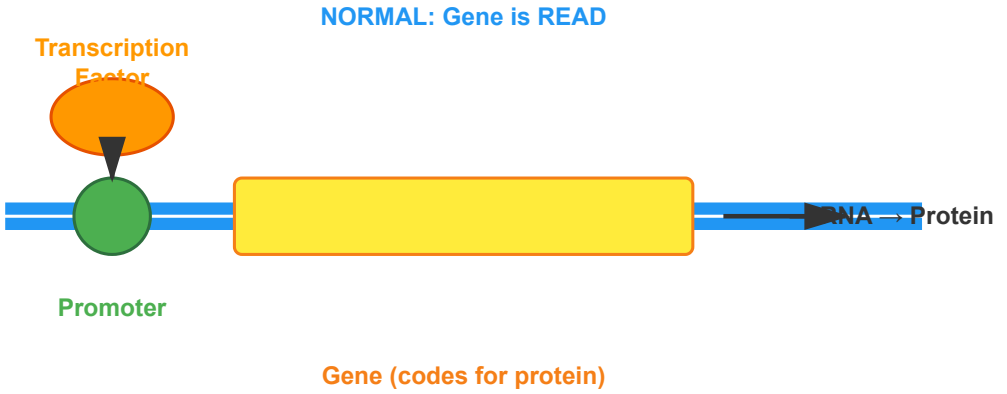
DNA Methylation Mechanism

Component	Function
DNA as library	Books on shelf do nothing unless READ
Gene	Specific sequence coding for protein (between promoter regions)
Promoter region	DNA location where transcription factor binds to start reading
Transcription	Reading process: factor binds → reads gene → creates RNA → protein
Methyl group	Small chemical unit (CH_3) that binds to DNA (usually cytosine)
Effect of methylation	Makes it HARDER for transcription factor to bind/read gene
More methylation	Gene read LESS → less protein produced → reduced function
Less methylation	Gene read MORE → more protein produced → increased function
Bug-on-stick analogy	Bug walks along stick, eats it, spits out protein; methyl = obstacles

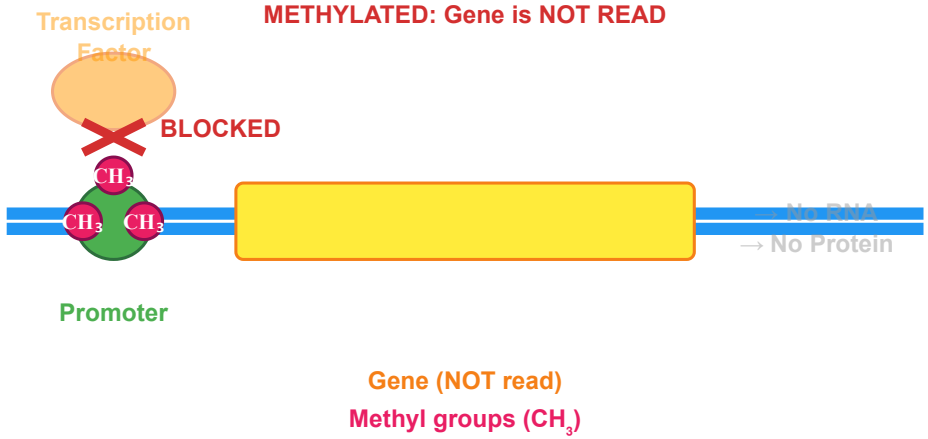
Methylation: Causes & Features

Aspect	Details
Environmental causes	Stress, diet, extreme conditions, trauma
Quebec ice storm	In utero exposure → methylation changes in T cells → altered immunity/insulin signaling
Variability	Differs by tissue, body region, brain region
Measurement	Usually overall methylation (not gene-specific)
Reversibility	Sometimes dynamic (can speed up, slow down, reverse); not always
Direction (typical)	More methylation generally = reduced expression (often "bad")
Direction (nuance)	Depends on gene/location; sometimes less methylation is problematic
Structural effects	3D DNA structure: methylation far from gene can affect it via charges
Genotypic effects	Some genes influence methylation rates of other genes (genetic control of epigenetics)
Critical periods?	Possible mechanism for developmental critical periods (Piaget)

DNA Transcription Process (Normal)



DNA Methylation Blocking Transcription



Key Definitions

Term	Definition
Genotype	What genes say (DNA sequence: A, G, C, T)
Phenotype	Observable trait/behavior measured
Transcription	Reading DNA to create RNA/protein
Promoter region	Where transcription factor binds to start reading
Susceptibility allele	Gene variant making individual responsive to environment
GxE	Gene × Environment interaction (genotype moderates env effect)
rGE	Gene-environment correlation (genes influence env exposure)
Epistasis	Gene-gene interaction (one gene influences another's effect)
GWAS	Genome-wide association study (scan millions of SNPs)

Exam-Critical Points

- **Missing heritability:** Twin = 50%, GWAS = 2-3%, gap = 47%
- **Heritability formula:** $h^2 = 2(r_{MZ} - r_{DZ})$
- **Mediation = mechanism:** HOW/WHY (X → M → Y)
- **Moderation = boundary:** WHEN/FOR WHOM (X × Z → Y)
- **GxE = moderation:** Genotype moderates environmental effect
- **Differential susceptibility:** Same allele → bad (negative env) OR good (positive env)
- **Orchid children:** Highly susceptible (carry A allele in NR3C1)
- **Dandelion children:** Stable across environments (GG genotype)
- **Fast Track orchids:** 75% control vs 18% intervention
- **Fast Track dandelions:** 50% both conditions (no effect)
- **Epigenetics:** Changes EXPRESSION without changing SEQUENCE
- **Methylation:** CH_3 groups block transcription → less protein
- **DNA function:** Does NOTHING unless READ (transcribed)
- **Crossover interaction:** Lines cross (differential susceptibility pattern)

Common Exam Confusions

Confusion	Clarification
Mediation vs moderation	Mediation = WHY it works (mechanism); Moderation = WHEN it works (condition)
Orchid = bad genes?	NO. Orchid = responsive (bad in negative env, GOOD in positive env)
Epigenetics = mutation?	NO. Methylation doesn't change DNA sequence (just accessibility)
More methylation = better?	Usually WORSE (less expression), but depends on gene/location
GxE = rGE?	NO. GxE = genes change response TO env; rGE = genes influence env exposure
DNA creates protein directly?	NO. DNA → transcription → RNA → translation → protein (must be READ)
Differential susceptibility = diathesis-stress?	NO. DS = for better AND worse; Diathesis-stress = for worse only
Fast Track: intervention works for all?	NO. Only for orchids (A carriers); no effect for dandelions (GG)

Sample Issues & Solutions

Issue	Example	Solution
Phenotypic heterogeneity	Impulsivity from ADHD, TBI, antisocial PD, substance use (different causes)	Define precise phenotype; separate by etiology
Ethnicity stratification	A allele 20% in Caucasian, 80% in Masai (different base rates)	Track ethnicity; control for population stratification
Age range issues	Hearing loss from ear infections (temporary) vs biological (permanent) both at age 2	Narrow age range; longitudinal follow-up
Protein misattribution	Oxytocin nasal drip measured as brain release (doesn't cross blood-brain barrier)	Verify protein function in target tissue; pharmacokinetics

Gene-Environment Correlation (rGE)

Type	Mechanism	Example
Passive rGE	Parents provide genes + correlated environment	Musical parents → genes for musicality + instruments at home
Evocative rGE	Child's genes evoke reactions from others	Irritable temperament → harsh parenting
Active rGE	Child seeks environments matching genetic predispositions	Extraverted child joins many clubs

Key: rGE means genes influence environments experienced (not just responses to environment). Different from GxE (moderation).

Theoretical Framework: Nature-Nurture Integration

- **Nature-nurture debate is OVER:** They interact at every level
- **Epigenetics = molecular GxE:** Environment changes gene expression via methylation
- **Upside-down triangle:** Behavior (top) ← Cognition/Emotion ← Brain function ← Protein ← Gene expression ← DNA
- **Environment at every level:** Influences all layers from DNA methylation to behavior
- **Critical periods:** Possibly explained by methylation windows (Piaget's insight?)
- **Reversibility:** Some epigenetic changes dynamic (hope for intervention)
- **Quebec ice storm:** In utero stress → methylation changes → lifelong immune/metabolic effects
- **Importance:** Understanding mechanisms enables targeted interventions (but raises ethical issues)

Lecture Examples & Applications

Concept	Example from Lecture	Lesson
Protein function location	Serotonin receptors function differently in gut vs brain (friend's frustration with gut-brain research)	Can't assume same gene/protein does same thing across tissues
Pharmacokinetics failure	Oxytocin intranasal doesn't cross blood-brain barrier; saliva measures = nasal drip, not brain release	Publication bias for "love drug"; verify protein reaches target
Phenotype precision	Ear infections → hearing loss (temporary) vs biological hearing loss (permanent); both look similar at age 2	Phenotypic heterogeneity dilutes genetic associations
Ear infections → behavior	Consistent ear infections → child behavior problems (pain, can't hear, can't articulate)	Outside-the-box thinking; simple physical issues can mimic psychological disorders
Coffee moderation	1-3 cups → efficiency ↑; 4+ cups → efficiency ↓ (dose moderates direction)	Moderation changes strength/direction of effect
Orchid care	Class poll: successfully grown orchid? Orchids picky, need specific conditions	Metaphor for differential susceptibility: thrive with right environment, wither otherwise
Dandelions everywhere	Grow in concrete cracks; lecturer has carrots growing in concrete (weird)	Metaphor for resilience: stable across environments
DNA as library	Books on shelf do nothing unless READ; DNA does nothing unless transcribed	Gene expression (reading) matters more than just having genes
Bug on stick	Bug walks along stick, eats it, spits out protein; methyl groups = obstacles	Methylation blocks transcription mechanistically
Quebec ice storm (1998)	Pregnant women exposed to extreme cold; children show methylation differences in immunity/insulin genes	In utero environment can cause lifelong epigenetic changes

L05: Social Cognition I - Comparative Developmental Foundations

THE DEVELOPMENTAL PARADOX: Infants understand OTHERS' goal-directed intentions at 6-9mo (mummy-ball paradigm) BUT fail mirror self-recognition until age 2 (50% pass Rouge test). Social cognition develops NON-LINEARLY through parallel pathways, NOT sequential building blocks (A→B→C). Challenges intuitive assumption that self-awareness must precede other-awareness.

Mirror Self-Recognition: Rouge Test

Age	Pass Rate	Developmental Marker
18mo	~25%	Emerging recognition
24mo	**50%**	Touch marked face (not mirror)
36mo	~90%	Reliable self-recognition

Great Ape Comparison

- **Chimpanzees:** 75% pass by adolescence
- **Orangutans:** 60% pass (variable performance)
- **Gorillas:** 30% pass (higher if human-reared in enriched environments)
- **Bonobos:** Similar to chimps (~75%)

Cognitive Architecture Required

- Visual detection → proprioceptive body schema mapping (cross-modal representation)
- Frontal lobe maturation + language emergence ("me/you" conceptual anchors)
- Self-other differentiation: creates conceptual space for "others have independent minds"

Rouge Test Methodology & Controls

Phase	Procedure	Purpose
Baseline	Count face-touching frequency (e.g., 3 touches/min)	Establish normal touching rate
Marking	Apply rouge to face while cleaning (tactilely undetectable)	Visual but not proprioceptive cue
Test	Present mirror, observe response	Measure mark-directed touching
Scoring	Mark-directed > baseline = PASS	Confirm genuine recognition

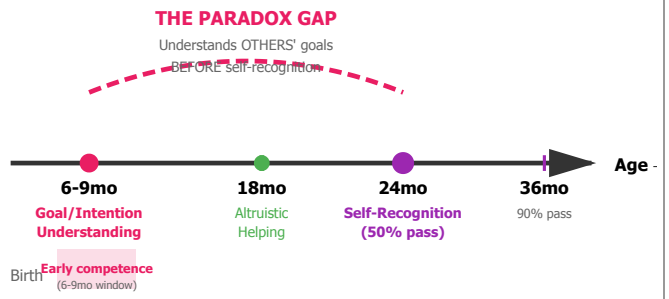
False Positive Prevention

- **Mark-specificity ratio:** If baseline = 3/min, post-mark = 8/min, mark-directed = 6/min → Ratio = 6/(8-3) = 1.2 (exceeds 1.0 threshold)
- Must touch marked area specifically (not random face exploration)
- Rouge chosen for visual salience but tactile imperceptibility

Mirror-Inexperienced Progression

- Initial: Treat mirror as conspecific (attacking/socializing)
- Exploration: Investigate mirror properties
- Contingency testing: Test correspondence between self and image
- Recognition: Self-directed behavior when viewing reflection

Developmental Timeline: The Paradox Visualized



Affective Empathy: Contagious Yawning

Stimulus Type	Chimp Yawn Rate	Interpretation
Familiar human	+3.0/session	Strong in-group contagion
Unfamiliar human	+1.5/session	Cross-species but reduced
In-group chimp	+3.1/session	Conspecific affiliation
Out-group chimp	+0.3/session	**Threat suppresses**
Gelada baboon	+0.2/session	No contagion (threat species)

Selectivity Index Calculation

Formula: (Familiar - Baseline) / (Gelada - Baseline)
Example: (4.0 - 1.0) / (1.2 - 1.0) = 3.0/0.2 = **15.0**
15-fold stronger contagion for affiliative vs neutral → confirms social modulation, not automatic mimicry

Key Findings

- **Social mechanism:** Requires perceived safety/affiliation
- **Threat override:** Evolutionary wariness blocks empathic resonance (gelada baboon = natural predator threat)
- **Cross-species possible:** Semi-free ranging chimps + positive human experience = contagion maintained

Affective vs Cognitive Empathy: Critical Distinction

Type	Mechanism	Response Pattern	Example
Affective	Emotional contagion Automatic mirroring Mirror neurons	SAME emotion as target	Crying when others cry Anxious face when presenter nervous Yawning when others yawn
Cognitive	Perspective-taking Understanding needs Deliberate response selection	APPROPRIATE (may differ from target)	Encouraging smile to nervous presenter Retrieving dropped pen Providing requested object

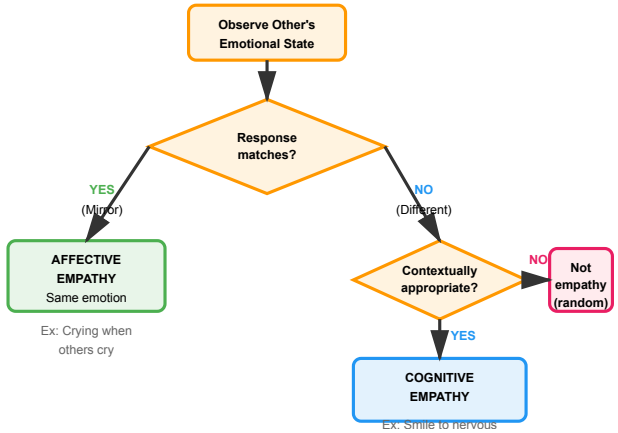
Contagion Properties

- **Automatic:** No understanding of cause/context required
- **Stranger-capable:** Works with unfamiliar individuals (within safety boundaries)
- **Internal state change:** Feeling tired/anxious when others yawn, beyond motor copying
- **Mirror neuron role:** Fire for both performing and observing actions (embodied simulation hypothesis)

When Contagion Fails as Empathy

- No contextual modulation (yawning during distress = reflexive only)
- Threat context suppresses (out-group chimps, gelada baboons)
- May impede helpful responding (overwhelmed by mirrored distress)

Empathy Types: Decision Flowchart



Warneken Altruistic Helping Paradigm

Condition	18mo Humans	Adult Chimps	Interpretation
Reaching + No Reward	40-60%	40-60%	Altruistic helping
No Reaching + No Reward	5-20%	5-20%	Random manipulation baseline
Reaching + Reward	~50%	~50%	Similar to no-reward (not reward-driven)

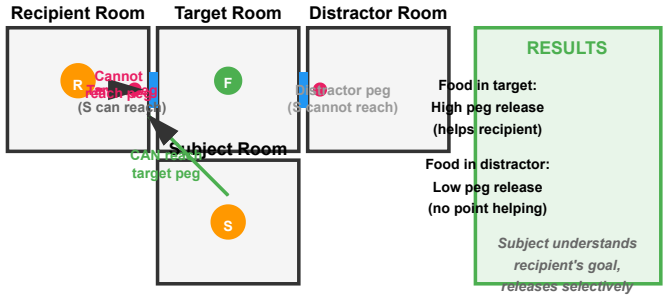
Altruistic Specificity Calculation

Formula: [P(help|reach,no-reward) - P(help|no-reach,no-reward)] / P(help|reach,reward)
Calculation: (0.45 - 0.08) / 0.50 = 0.37/0.50 = **0.74**
Interpretation: 74% of maximal helping is genuinely altruistic (not reward-driven), confirming prosocial motivation

Critical Controls

- **Reaching specificity:** 45% → 8% drop confirms intention-directed (not random object play)
- **No reward:** Helping persists without tangible reinforcement
- **Unfamiliar recipients:** Eliminates kinship/reciprocity/hierarchical bond explanations
- **Cross-species:** Chimps help humans (not just conspecifics)

Chimp Within-Species: Peg Release Paradigm



Key Design Features

- **4 rooms:** Subject, Recipient, Target (food), Distractor (empty)
- **Peg access:** Subject can reach target peg, recipient cannot
- **Control:** Food placement (target vs distractor) tests selectivity
- **Cost to subject:** Time/effort expenditure, no personal benefit

Validating Altruistic Intent: Decision Tree

Question	If NO	If YES
1. Contingent on reaching?	Random manipulation	Continue ↓
2. Persists without reward?	Learned behavior	Continue ↓
3. Occurs with strangers?	Reciprocal exchange	Continue ↓
4. Incurs cost to helper?	Convenience, not sacrifice	**TRUE ALTRUISM ✓**

Human Toddler Example (German Study)

- **Age:** 15-18 months
- **Scenario:** Experimenter drops pen while writing, reaches for it
- **No verbal instruction:** No "give me the pen" or "thank you" (intentionally withheld)
- **Result:** Toddlers retrieve and hand back pen spontaneously
- **Multiple channels:** Also respond to "oops!" (verbal distress signal + reaching)
- **Interpretation:** Multimodal need recognition (gesture + speech) = cognitive empathy

Common Error: Shyness Confound

- Not all non-helping = lack of altruism
- Shyness, stranger wariness can suppress helping despite capacity
- Multiple variables beyond cognitive understanding affect behavior

Mummy-Ball / Baby-Ball Paradigm

Phase	Experimental Group	Control Group
Habituation	Baby ball jumps OVER central barrier to mummy ball	Baby ball jumps (barrier on SIDE - no obstacle)
Action Interpretation	Jump = **INSTRUMENTAL** (goal-directed, necessary)	Jump = **RANDOM** (irrational, no purpose)
Test (barrier removed)	A: Old action (jump) - now IRRATIONAL B: New action (roll) - now RATIONAL	

Critical Results: 9-Month-Olds

- **Experimental group:** Look 42s at continued jumping (irrational familiar) vs 18s at rolling (rational novel)
- **Violation index:** (42-12)/(18-12) = 30/6 = **5.0-fold** stronger recovery for irrationality vs novelty
- **Control group:** No difference between old/new actions (neither rational/irrational in original habituation)
- **6-Month-Olds:** Far less effect - track goals but NOT efficiency yet

Interpretation: Teleological Reasoning

- 9mo infants encode actions as **means to ends** (teleologically), not just motor patterns
- Surprised by perceptually FAMILIAR but conceptually IRRATIONAL event
- **Rationality Principle:** Expect agents to take efficient paths given constraints
- Operates below mental state attribution (don't need to represent beliefs/desires)

Rationality Principle & Teleological Reasoning

Age	Capacity	Evidence
6 months	Track goals but NOT efficiency	Mummy-ball: no differential looking
9 months	Expect efficient goal pursuit	Mummy-ball: 5x longer looking at irrational
Definition	Actions should be efficient given constraints: shortest path, minimal effort, highest success probability within environmental/bodily limitations	

What Makes Action "Rational"?

- **Constraint recognition crucial:** Barrier present = jumping rational; barrier absent = jumping irrational for same goal
- **Occupied hands:** Using feet rational; free hands + foot-use signals foot-use requirement
- **Goal constant, path varies:** Getting to mummy ball = goal; jump vs roll = path selection based on constraints
- **Barrier position matters:** Central barrier necessitates jumping; lateral barrier makes jumping unnecessary

Teleological vs Mental State Reasoning

Type	Level	Developmental Timing
Teleological	"In order to" relationships Observable action efficiency	6-9 months
Mental States	Hidden beliefs/desires False belief understanding	~4 years (false belief)

Key Distinction: Teleological reasoning may support but doesn't require full theory of mind

Chimp Foot-Pressing: Rational Action Understanding

Condition	Demonstration	Chimp Response	Logic
A (Constrained)	Human presses button with FOOT (hands carrying bucket)	Press with **HANDS**	"Hands occupied → foot necessary due to constraint → button works with any effector → I'll use hands (easier)"
B (Unconstrained)	Human presses button with FOOT (hands free)	Press with **FOOT**	"Hands free but still used foot → foot-use must be REQUIRED by button mechanism → I'll use foot"

Critical Interpretation

- **Selective copying based on constraints:** Not blind imitation, not mental state attribution
- **Demonstrates:** Understanding action rationality WITHOUT representing beliefs/desires
- **Teleological reasoning sufficient:** Recognize efficiency relative to situational limitations
- **Foundation for later ToM:** May scaffold mental state understanding, but operates independently

Exam Key: Chimps infer constraints (hands full) and goal-directedness (press button) to determine if action = necessary due to constraint OR required by mechanism. This is teleological reasoning, NOT theory of mind.

Habituation Paradigm: Interpretation Challenges

Challenge	Solution
Perceptual novelty vs conceptual surprise	Control: identical perceptual change without rationality violation shows no looking increase
Fatigue, side preferences	Counterbalance which action shown first; experimental + control groups
Stimulus salience confound	"Surprising" event must be perceptually FAMILIAR (same motion path seen before)
Gold standard criterion	Conceptual surprise to perceptually familiar events (longer looking at OLD irrational action vs NEW rational action)

Why This Matters

- If infants just preferred novelty: would look longer at NEW action (rolling)
- Actually look longer at OLD action (jumping) when it becomes irrational
- Dissociation proves encoding teleologically, not motorically

Critical Decision Points Across Paradigms

Self-Recognition

- **Threshold:** Mark-specificity ratio > 1.0 prevents over-interpretation
- **Debate:** Spontaneous mark-touching vs explicit self-reference required?
- **False positives:** Must exceed baseline + general increase from marking sensation

Empathy Classification

- **Response appropriateness,** not just presence, distinguishes affective from cognitive
- **Common error:** Emotional synchrony ≠ understanding (conflation trap)
- **Context crucial:** Suppression for threat (gelada, out-group) confirms social mechanism

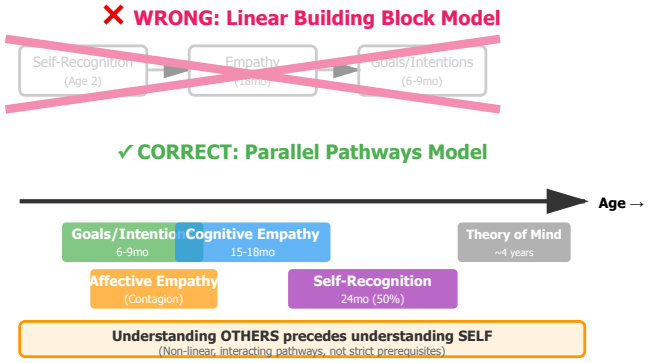
Altruism Validation

- **4-part decision tree:** Contingency, reward-independence, stranger-generalization, cost
- **Reaching drop:** 45% → 8% confirms intention-directed (not random object exploration)
- **Within-species control:** Peg release paradigm eliminates human-chimp relationship confound

Teleological Reasoning

- **Control group essential:** Distinguishes perceptual from conceptual surprise
- **Counterbalancing:** Which test action shown first (old vs new) to prevent order effects
- **Age comparison:** 6mo vs 9mo pinpoints developmental emergence window

Building Blocks Model: LINEAR (WRONG) vs PARALLEL (CORRECT)



Age Milestones: CRITICAL FOR EXAM

Age	Capacity	Evidence/Paradigm
6mo	Goal tracking (NOT efficiency)	Mummy-ball: no differential looking
6-9mo	Teleological reasoning emerges	Developmental window for rationality principle
9mo	Expect efficient goal pursuit	Mummy-ball: 5x longer looking at irrational
15-18mo	Altruistic helping (cognitive empathy)	Warneken: 40-60% retrieve without reward
24mo	**Mirror self-recognition (50%)**	Rouge test: mark-directed touching
36mo	Reliable self-recognition (90%)	Rouge test: nearly universal pass

THE PARADOX: 6-9mo understand others' goals → 18mo help altruistically → 24mo recognize self. Opposite of intuitive building block sequence!

Human vs Great Ape Comparison

Capacity	Humans	Great Apes
Self-Recognition	50% at 24mo, 90% at 36mo	Chimps 75%, Orangs 60%, Gorillas 30% (adolescence)
Contagious Yawning	Yes, in-group specific	Yes, in-group specific (identical pattern)
Altruistic Helping	18mo: 40-60%	Adults: 40-60% (cross-species & within)
Rationality Understanding	9mo: yes (mummy-ball)	Adults: yes (foot-pressing selective copying)
Key Difference	**Protracted development** 6mo → 9mo → 18mo → 24mo progression	**Adult-like immediately** Capacities present without developmental trajectory

Shared Evolutionary Foundation

- Affective empathy (contagion) + cognitive empathy (helping) = shared with great apes
- Teleological reasoning (rationality principle) = shared
- Self-recognition = shared (though variable by species)
- **Human uniqueness:** Extended developmental trajectory, not capacities themselves

Common Exam Confusions: AVOID THESE

Confusion	Correction
Social cognition = linear A→B→C	**WRONG.** Parallel pathways, non-linear development. Goals at 9mo, self-recognition at 24mo.
Affective = Cognitive empathy	**WRONG.** Affective = mirror emotion. Cognitive = appropriate response (may differ).
Helping = trained behavior	**WRONG.** Persists without reward, with strangers, incurs cost. Genuinely altruistic.
Teleological = Theory of Mind	**WRONG.** Teleological = efficiency understanding. ToM = mental states (beliefs/desires).
Contagion = automatic for all	**WRONG.** Requires safety/affiliation. Threat suppresses (gelada, out-group chimps).
Looking time = novelty preference	**WRONG.** Longer looking at FAMILIAR irrational vs NOVEL rational = expectation violation.
Chimps lack prosocial behavior	**WRONG.** 40-60% helping rate, cross-species & within-species, without reward.
Self-recognition = prerequisite	**WRONG.** Intention understanding (9mo) precedes self-recognition (24mo) by 15 months!

Key Calculations & Formulas

Mark-Specificity Ratio (Rouge Test)

$$\text{Ratio} = \frac{\text{Mark-directed touches}}{\text{Post-mark total} - \text{Baseline}}$$

Example: Baseline = 3/min, Post-mark = 8/min, Mark-directed = 6/min

$$\text{Ratio} = \frac{6}{8-3} = \frac{6}{5} = 1.2$$

Pass criterion: Ratio > 1.0

Contagion Selectivity Index

$$\text{Selectivity} = \frac{\text{Familiar} - \text{Baseline}}{\text{Neutral} - \text{Baseline}}$$

Example: Familiar = 4.0, Baseline = 1.0, Gelada = 1.2

$$\text{Selectivity} = \frac{4.0-1.0}{1.2-1.0} = \frac{3.0}{0.2} = 15.0$$

Interpretation: 15-fold stronger contagion for affiliative stimuli

Altruistic Specificity

$$\text{Altruism} = \frac{P(\text{help}|\text{reach, no-reward}) - P(\text{help}|\text{no-reach, no-reward})}{P(\text{help}|\text{reach, reward})}$$

Example: 0.45 - 0.08 / 0.50 = 0.37/0.50 = 0.74
Interpretation: 74% of maximal helping is altruistic (not reward-driven)

Violation Index (Habituation)

$$\text{Violation} = \frac{\text{Looking}_{\text{irrational}} - \text{Looking}_{\text{habituated}}}{\text{Looking}_{\text{novel}} - \text{Looking}_{\text{habituated}}}$$

Example: Irrational = 42s, Habituated = 12s, Novel = 18s

$$\text{Violation} = \frac{42-12}{18-12} = \frac{30}{6} = 5.0$$

Interpretation: 5-fold stronger recovery for expectation violation

Quick Reference: Study Summaries (APA Format)

Study	Participants	Method	Key Finding	Citation Template
Rouge Test	Humans: 18-36mo Great apes: adolescent	Mark face, present mirror, measure mark-directed touching	50% pass at 24mo (humans) 75% chimps, 60% orangs, 30% gorillas	"Mirror self-recognition emerges at 24 months in 50% of children (Rouge test)"
Contagious Yawning	Semi-free ranging chimpanzees	Video presentation: familiar/unfamiliar humans, in/out-group chimps, gelada baboons	In-group contagion (+3.0/session), out-group suppression (+0.3/session)	"Contagious yawning shows in-group specificity, suppressed by threat (gelada baboons)"
Warneken Helping	18mo humans, adult chimps	Reaching vs no-reaching, reward vs no-reward (2x2 design)	40-60% help when reaching, 5-20% when not (no reward needed)	"Altruistic helping at 18 months: 40-60% retrieve without reward when experimenter reaches"
Mummy-Ball	6mo & 9mo infants	Habituation: jump over barrier. Test: jump (irrational) vs roll (rational) after barrier removal	9mo: 5x longer looking at irrational familiar vs rational novel. 6mo: no effect	"9-month-olds demonstrate teleological reasoning: expect efficient goal pursuit (mummy-ball paradigm)"
Chimp Foot-Pressing	Adult chimpanzees	Observe human press button with foot (hands full vs free), then imitate	Hands full → chimps use hands. Hands free → chimps use foot (selective copying)	"Chimpanzees understand action rationality: selective copying based on constraint presence"

L06: Social Cognition II: From Triadic Interactions to False Belief Understanding

This lecture traces the developmental progression from **dyadic sociality** (infant-caregiver face-to-face interaction) to **metarepresentational capacity** (tracking others' false beliefs), revealing how infants construct a cognitive framework for understanding others as information-bearing agents. Three transformative shifts occur: (1) emergence of **triadic interactions** (9-15 months) incorporating external referents through joint attention and declarative pointing, (2) development of **social referencing** using others' emotional appraisals to resolve uncertainty, and (3) capacity to track **perception-knowledge correspondences** where infants understand others know what they've seen. The central paradox: 15-month-olds show **implicit false belief understanding** via looking time (Onishi & Baillargeon) yet fail explicit tasks until age 4, while chimpanzees track uninformed competitors successfully but fail with misinformed ones, suggesting either metarepresentational limitations or cognitive load constraints.

Developmental Timeline: Social Cognition Milestones

Age	Capacity Emerges	Key Evidence
0-6 months	Dyadic interaction only; no evidence of understanding others as minded agents	"Dance of communication" - stimulus-response without external referents
9-15 months	Triadic interactions: joint attention, gaze following, declarative pointing	Carpenter et al. (1998): 13 months = majority pass all three components
12 months	Social referencing: using others' emotional appraisals to guide behavior	Visual cliff: 74% cross with joy, 0% with fear (Sorce et al., 1985)
12-14 months	Perception-knowledge tracking: understanding seeing leads to knowing	Selective pointing to inform: M=1.27 when adult missed event vs M=0.53 when witnessed
15 months	Implicit false belief understanding (looking time measures)	Onishi & Baillargeon watermelon task: longer looking at belief-inconsistent searches
18-24 months	Mirror self-recognition	Rouge test - recognize own reflection
4 years	Explicit false belief understanding	Sally-Anne task: correctly predict search based on false belief

Joint Attention Development Metrics (Carpenter et al.)

Age	Mean Episode Duration	Fold Increase
9 months	4.2 seconds	Baseline
12 months	11.3 seconds	2.7x increase
15 months	18.6 seconds	4.4x increase from 9mo

Measurement criteria: (1) infant looks at toy ≥2 seconds, (2) shifts gaze to caregiver within 3 seconds, (3) returns to toy within 3 seconds while caregiver maintains attention. If caregiver not engaged = object exploration, NOT joint attention.

Core Concepts & Definitions

Term	Definition
Dyadic Interaction	Face-to-face infant-caregiver exchange (0-6 months) without external referents; caregiver treated as stimulus, not minded agent
Triadic Interaction	Infant-caregiver-object triangulation (9-15 months); incorporating external referents into social exchanges via joint attention, gaze following, pointing
Joint Attention	Coordinated attention between infant, adult, and object with gaze alternation; NOT incidental co-attention or parallel looking
Gaze Following	Infant follows adult's line of sight to locate referent; demonstrates understanding that looking is referential and informative
Declarative Pointing	Pointing to share interest (not request); includes checking looks to adult; distinguishes from imperative pointing (requesting)
Social Referencing	Using others' emotional appraisals to resolve uncertainty about ambiguous situations; requires signal decoding, referential specificity, communicative appreciation
Perception-Knowledge Link	Understanding that seeing leads to knowing; tracking what others have/haven't witnessed to update their knowledge states
Uninformed State	Agent lacks information (didn't see event); requires tracking presence/absence during events
Misinformed State	Agent holds incorrect belief conflicting with reality (saw initial state, missed change); requires dual representation of reality + false belief
Implicit False Belief	Expectation violation via looking time (15 months); measures automatic prediction without deliberate reasoning
Explicit False Belief	Verbal prediction/explanation (4 years); requires deliberate reasoning and inhibitory control to override reality

Critical Distinctions (Common Exam Confusions)

Easily Confused Pair	Key Difference
Joint Attention vs. Parallel Looking	Joint = gaze alternation + coordinated engagement; Parallel = both looking at same thing without coordination
Declarative vs. Imperative Pointing	Declarative = sharing interest (checking looks); Imperative = requesting object (no checking looks)
Uninformed vs. Misinformed	Uninformed = binary (didn't see); Misinformed = dual representation (saw X, doesn't know Y)
Informing vs. Sharing	Informing = epistemic (updating knowledge gaps); Sharing = affiliative (social bonding when positive affect)
Implicit vs. Explicit ToM	Implicit = automatic expectation (15mo, looking time); Explicit = deliberate prediction (4yr, verbal response)

Landmark Study: Visual Cliff (Sorce et al., 1985)

Design:

12-month-olds on plexiglass surface with apparent drop-off (visual cliff); uncertainty resolved by mother's emotional expression

Results:

Emotion Displayed	% Crossed	Interpretation
Joy/Happiness	74%	Safety signal; encouragement to explore
Fear	0%	Warning about environmental threat
Anger	11%	Generalized negative valence (though inappropriate emotion)
Interest/Neutral	73%	Default to exploration when no prohibition

Social Referencing Prerequisites:

- **Signal Decoding:** Discriminate facial expressions as affective meanings
- **Referential Specificity:** Map emotion to correct environmental referent (cliff, not background)
- **Communicative Appreciation:** Understand information can be transmitted between agents

Landmark Study: Perception-Knowledge (Liszkowski et al., 2007)

Design:

Puppet appears on screen; experimenter either attends event (sees it) or attends screen (misses it); measure infant pointing behavior

Results (Mean Points Per Condition):

Condition	Neutral Affect	Positive Affect	Interpretation
Adult ATTENDED event	0.53	0.85	Baseline (adult knows)
Adult MISSED event	1.27	1.65	Informing + Sharing
Referent ABSENT (adult missed)	1.72	-	Informing persists without perceptual support

Key Finding: 2.4x increase in pointing when adult uninformed (1.27 vs 0.53); positive affect amplifies both informing AND sharing (1.95x overall increase)

Landmark Study: Implicit False Belief (Onishi & Baillargeon, 2005)

Design:

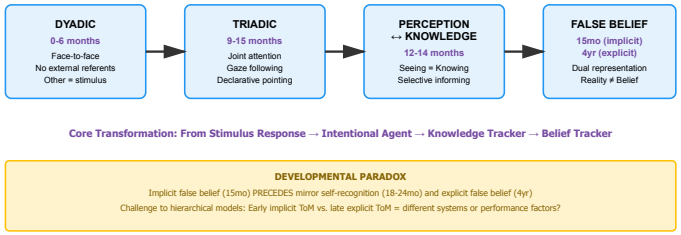
15-month-olds watch actor hide watermelon in green box; watermelon either stays (true belief) or moves to yellow box with/without actor seeing (false belief); measure looking time when actor searches

Results (Mean Looking Times):

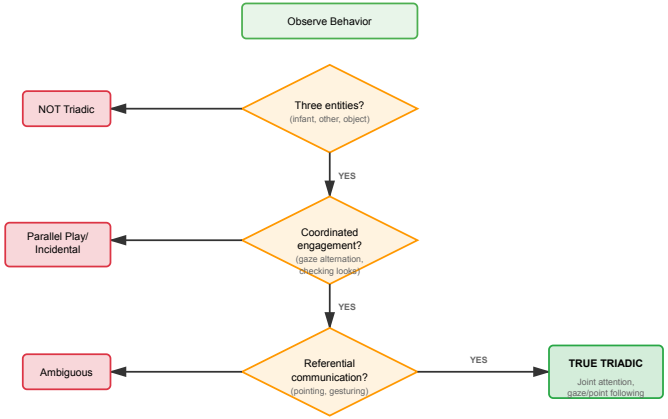
Condition	Search Green	Search Yellow	Violation?
True Belief (saw move to yellow)	27.0s ✓	10.5s	Violates if searches wrong location
False Belief (didn't see move)	11.5s	20.0s ✓	Violates if searches reality-based (should search original)

Critical Interpretation: Longer looking when actor searches YELLOW in false belief condition (20.0s vs 11.5s) = infants expect actor to search where she last saw it (green), NOT where it actually is. Demonstrates implicit tracking of actor's outdated belief.

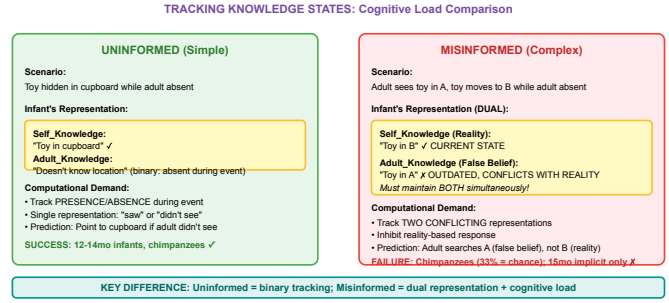
Developmental Progression: Dyadic to Metarepresentational



Triadic Interaction Decision Flowchart



Uninformed vs. Misinformed: Computational Demands



🦍 Chimpanzee Food Competition Studies (Brauer et al., 2007)

Condition	Visibility Setup	Subordinate Retrieval %	Interpretation
Hidden1	Food inside bucket, visible only to subordinate	42%	Understands dominant lacks knowledge about unseen objects
Visible1	Food on top, visible to both	27%	Avoids competition when dominant knows location
Hidden-Visible Choice	One hidden (sub only), one visible (both)	54% chose hidden vs 26% visible	**Strategic exploitation of knowledge asymmetry**
False Belief	Both see A; subordinate sees move to B	33% (chance performance)	**FAILURE: Cannot track/exploit false beliefs**

Critical Interpretation:

- **SUCCESS with uninformed:** Chimps track "saw/didn't see" binary states
- **FAILURE with misinformed:** Cannot maintain dual representations (reality + outdated belief)
- **Cognitive load hypothesis:** Tracking two objects' histories + two knowledge states + dominance dynamics exceeds capacity
- **Alternative:** Fundamental metarepresentational limit (can't represent beliefs about beliefs)

🧠 Human Infants vs. Chimpanzees: Theory of Mind Comparison

Capacity	Human Infants	Chimpanzees	Key Difference
Goals & Intentions	✓ 6mo (mummy-baby ball)	✓ Adult chimps	Equivalent capacity
Mirror Self-Recognition	✓ 18-24mo (rouge test)	✓ Adult chimps	Equivalent capacity
Empathy	✓ Basic forms early	✓ Prosocial behavior	Comparable
Perception-Knowledge	✓ 12-14mo (selective informing)	✓ Food competition	Equivalent: both track seeing→knowing
Uninformed States	✓ 12-14mo (point when adult absent)	✓ Hidden food retrieval	Equivalent capacity
False Belief (Misinformed)	✓ 15mo implicit; 4yr explicit	✗ Chance performance	**DIVERGENCE: Humans develop metarepresentation**

⚡ Quick Reference: Paradigm Design Features

Paradigm	Measure	Critical Control
Triadic Interaction	Gaze alternation frequency; pointing with checking looks	Distinguish coordinated vs. incidental co-attention
Social Referencing	% crossing visual cliff by emotion condition	Genuine uncertainty (plexiglass safe but appears dangerous)
Selective Informing	Pointing frequency when adult attended vs. missed event	Adult witnessed event = baseline (no informing needed)
Food Competition	Subordinate retrieval rate by visibility condition	Visible food = baseline (dominant knows, avoid competition)
Implicit False Belief	Looking time at belief-consistent vs. inconsistent searches	True belief conditions verify expectation formation

📋 Exam Checklist: Common Misinterpretations

- ❌ **Don't confuse:** Parallel play (both doing same activity) ≠ Triadic interaction (coordinated engagement)
- ❌ **Don't confuse:** Reaching for toy ≠ Declarative pointing (need checking looks + sharing intent)
- ❌ **Don't confuse:** Social referencing ≠ Emotional contagion (requires referential mapping to situation)
- ❌ **Don't confuse:** Uninformed (binary: didn't see) ≠ Misinformed (dual: saw X, doesn't know Y)
- ❌ **Don't confuse:** Implicit ToM (automatic expectation, 15mo) ≠ Explicit ToM (deliberate prediction, 4yr)
- ✓ **Key insight:** Triadic capacity (9-15mo) emerges BEFORE self-recognition (18-24mo) but AFTER dyadic sociality (0-6mo)
- ✓ **Key insight:** Positive affect amplifies BOTH informing AND sharing (Liszkowski: 1.65 vs 1.27 points)
- ✓ **Key insight:** Implicit false belief (15mo) precedes explicit by 2.5 years = performance factors or different systems?
- ✓ **Key insight:** Chimps succeed with uninformed but fail with misinformed = cognitive load, not metarepresentation absence

🎯 High-Yield Numerical Facts

Finding	Value	Source
Joint attention duration increase (9mo→15mo)	4.2s → 18.6s (4.4x)	Carpenter et al., 1998
Visual cliff crossing with joy vs. fear	74% vs. 0%	Sorce et al., 1985
Pointing when adult missed vs. attended	M=1.27 vs. M=0.53 (2.4x)	Liszkowski et al., 2007
Positive affect amplification of pointing	M=1.65 vs. M=1.27 (1.3x)	Liszkowski et al., 2007
Chimp hidden vs. visible food retrieval	42% vs. 27%	Brauer et al., 2007
Chimp false belief performance	33% (chance level)	Brauer et al., 2007
False belief looking: yellow vs. green search	20.0s vs. 11.5s (1.7x)	Onishi & Baillargeon, 2005
Age gap: implicit vs. explicit false belief	15mo vs. 4yr (2.5 years)	Multiple studies

Theoretical Implications & Exam Arguments

1. Implicit-Explicit Dissociation (False Belief Paradox)

- **Evidence:** 15mo implicit (looking time) vs. 4yr explicit (verbal prediction) = 2.5-year gap
- **Theory A - Two Systems:** Early implicit ToM for rapid social prediction + late explicit ToM for deliberate reasoning
- **Theory B - Performance Factors:** Continuous competence masked by inhibitory control, working memory, verbal demands
- **Critical test:** Does infant implicit performance predict preschool explicit performance? (Individual differences approach)

2. Chimpanzee Limitations: Cognitive Load vs. Metarepresentation

- **Cognitive Load Hypothesis:** Tracking 2 objects × 2 knowledge states + dominance dynamics exceeds capacity
- **Metarepresentation Limit:** Fundamental inability to represent beliefs about beliefs
- **Evidence for load:** Success with uninformed (binary) but failure with misinformed (dual representation)
- **Counter-evidence:** Humans show implicit false belief at 15mo despite similar cognitive constraints

3. Triadic Interaction Before Self-Recognition

- **Puzzle:** Joint attention (12-13mo) emerges before mirror self-recognition (18-24mo)
- **Implication:** Understanding others as agents precedes explicit self-awareness
- **Challenges:** Traditional hierarchies assuming self-other differentiation required first

L07: Social Cognition III - Advanced Theory of Mind & Two-Pathway Hypothesis

Lecture Backbone: This lecture resolves the apparent paradox of theory of mind (ToM) development by demonstrating that false belief understanding emerges through two distinct pathways—**implicit (automatic, eye-gaze based, 9 months, phylogenetically ancient)** and **explicit (cognitive, verbally mediated, 4 years, human-unique)**. The central thesis challenges the single-mechanism view of ToM: **shared intentionality transforms individual cognition into collaborative frameworks**, with belief-desire psychology emerging around age 4 as children acquire the capacity to hold both "true state" and "represented state" simultaneously in working memory. **Critical insight:** ToM deficit in autism is pathway-specific, not absolute—explicit ToM can be learned through compensatory top-down processing even when bottom-up implicit system is impaired.

Shared Intentionality (Tomasello)

Individual Act	+ Shared Frame →	Collaborative Act
Gaze following (directional tracking)	Mutual knowledge of shared attention	**Joint attention** ("we are attending together")
Group activity (parallel individual goals)	We-mode representation	**Collaboration** (role differentiation + shared goal)
Social learning (passive observation)	Common ground framework	**Instructed learning** (shared teaching frame)

Key: Human cognition differs not by brain size but by collaborative capacity. Chimps lack "we are doing X together" representation—only "I am doing X near others." **Example:** Hide-and-seek pointing: 14-month infants infer hidden object from point; chimps see "bucket, so what?" Missing shared attentional frame.

Three Critical Distinctions

Distinction	Simpler	Complex
1. Ignorance vs Belief	**Ignorance:** Track info access only ("doesn't know X")	**False Belief:** Dual representation ("thinks X when Y true")
2. Coordination vs Collaboration	**Coordination:** Parallel goals (chimps pick berries)	**Collaboration:** Role differentiation (shake tree, hold bucket)
3. Implicit vs Explicit ToM	**Implicit:** Automatic eye gaze (9mo, apes)	**Explicit:** Conscious reasoning (4yr, verbal)

Common Error: Equating "doesn't know X" with "believes not-X"—these require different cognitive demands. Ignorance = absence of knowledge (single representation). False belief = contradictory mental content (dual representation + inhibition).

Belief-Desire Psychology

Age ~3: Desire Psychologist	Age ~4+: Belief-Desire Psychologist
Subjective desires only	Desires + beliefs as internal representations
Can't separate represented state from real state	Hold dual: "true state" AND "other's belief"
"Biscuit loop": persists asking despite "none left" (reality doesn't constrain desire)	Inhibits reality bias to report false belief

Behavior Formula: Action = Desire × Belief

- **Same desire + different beliefs → different actions** (both want apple: Person A believes fridge → goes to fridge; Person B believes cupboard → goes to cupboard)
- **Same beliefs + different desires → different actions** (both know apple in fridge: Person A wants it → gets it; Person B doesn't want it → ignores it)
- **Beliefs trump desires:** If you don't believe X is possible, desire for X won't generate action

False Belief Understanding: Cognitive Architecture

Sally-Anne Task Structure

Phase	Protagonist	Subject (Child)	Cognitive Load
T1: Shared knowledge	Sees apple in basket	Sees apple in basket	1 representation: [basket=apple]
T2: Protagonist absent	—	Sees apple→banana switch	Update: [basket=banana]
T3: Test (returns)	Believes: apple in basket	Knows: banana in basket	**DUAL:** [reality=banana] + [Sally's belief=apple] + inhibit "banana" response

Pass age 4: Prefrontal development enables dual representation + inhibitory control. Question: "What does Sally think is in the basket?" → Answer: "Apple" (correct).
Fail before 4: Reality bias dominates → answer "banana" (reality, not Sally's false belief). Cannot maintain metarepresentation (representing someone's representation of reality).

Why Age 4 Specifically?

- Prefrontal cortex maturation (executive control)
- Working memory capacity for dual representations
- Language development ("thinks that" structures)
- Inhibitory control to suppress reality bias

ASD & ToM: The Paradox

Explicit Success Despite Implicit Failure

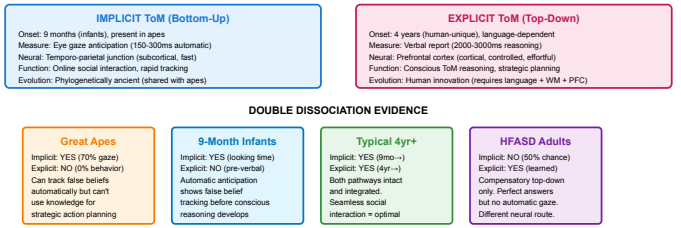
Study	Sample	Key Finding
Baron-Cohen 1985	Autism (CA 11yr, VMA 5yr) vs Down (CA 10yr, VMA 5yr) vs Typical (CA 4yr)	Autism: 20% pass Sally-Anne. Down+Typical: ~85% pass. Initial "no ToM" conclusion.
Scheeren 2013	n=194 HFASD vs TD (matched IQ)	**NO differences** in 2nd-order false belief, faux pas, sarcasm by adolescence. **Delay, not deficit.**
Senju 2009	HFASD adults (IQ 115, perfect explicit ToM)	Eye-tracking: **50% chance level** (fail implicit). Same answer via different neural route (prefrontal effort vs automatic TPJ).

Developmental Trajectories

- **Typical:** Implicit (9mo) → Explicit (4yr) [Both pathways intact]
- **ASD:** No implicit → Explicit (10-14yr via compensatory learning) [Top-down only]
- **Apes:** Implicit (yes) → Explicit (never) [Ancient system only]

Clinical Implication: High performance on structured ToM tasks doesn't indicate typical social processing. Real-world social interaction relies heavily on automatic implicit ToM (150-300ms), explaining why high-functioning individuals still experience social challenges despite understanding ToM concepts intellectually (2000-3000ms conscious reasoning too slow).

Two-Pathway Hypothesis: Visual Model



Core Insight: Pathways are dissociable and can operate independently. Real-world social function requires IMPLICIT (automatic, fast). Explicit knowledge provides understanding but ≠ natural social ease.

Comparative Cognition: What Apes Reveal

Capacity	Apes	Human 9mo	Human 4yr+	Interpretation
Mirror self-recognition	YES	18mo	YES	Self-awareness shared
Goal understanding	YES	12mo	YES	Intention reading shared
Gaze following	YES	6mo	YES	Directional tracking shared
Ignorance tracking	**YES**	14mo	YES	Info access monitoring shared
Implicit false belief	**YES (70%)**	**YES (9mo)**	YES	**Ancient implicit system**
Explicit false belief	**NO (0%)**	NO	**YES (4yr)**	**Human innovation (language + WM + PFC)**
Shared intentionality	NO	14mo	YES	Collaborative framework human-unique

2017 Eye-Tracking Study (Krupenye et al.)

Apes anticipate false-belief reach location with eye gaze (implicit works) but cannot use this knowledge for strategic behavior planning (explicit missing).
Cognitive bottleneck: Implicit processing → ??? → behavioral planning. This link missing in apes, present in humans age 4+.

Cross-Population Synthesis

Population	Implicit ToM	Explicit ToM	Real-World Social	Theoretical Insight
Typical 9mo	YES	NO	Smooth dyadic	Implicit precedes explicit developmentally
Typical 4yr+	YES	YES	Seamless	Parallel integration = optimal function
Great Apes	YES	NO	Limited dyadic	Implicit ancient; explicit human-unique
HFASD	NO	YES (delayed)	Struggles despite knowledge	Explicit cannot replace implicit function
Down syndrome	Intact (presumed)	YES (VMA 2-3yr)	Preserved	ToM partially independent of general IQ

Double Dissociation Proof: Apes (implicit+/explicit-) mirror image HFASD (implicit-/explicit+) → pathways are independent systems, not single developmental continuum.

Processing Timeline Comparison

- **Implicit pathway (150-300ms):** Automatic gaze shift to expected reach location; no conscious awareness; present in infants, apes, typical adults; absent in autism
- **Explicit pathway (2000-3000ms):** Conscious reasoning ("They think it's still there"); verbal report possible; develops age 4+; preserved in high-functioning autism
- **Real-world implication:** Natural conversation operates on implicit timeline; explicit processing too slow for fluid social interaction

Exam Quick Reference: Age Milestones

Age	Milestone	Measure	Significance
6mo	Gaze following	Directional tracking	Precursor to joint attention
9mo	Implicit false belief	Looking time/eye gaze	Ancient automatic system online
12-14mo	Joint attention, shared intentionality	Pointing comprehension in shared frame	Collaborative capacity emerges
18mo	Mirror self-recognition	Rouge test	Self-awareness established
~3yr	Desire psychologist	Subjective wants, reality bias	"Biscuit loop" persists despite "none"
~4yr	Belief-desire psychologist	Explicit false belief pass	Dual representation + inhibition online
10-14yr (HFASD)	Delayed explicit false belief pass	Compensatory top-down learning	Alternative route to explicit ToM

Common Exam Errors to Avoid

Error	Why It's Wrong	Correct Understanding
Assuming explicit task success = intact ToM overall	Misses implicit deficit; conflates pathways	Must assess both pathways separately (eye-tracking + verbal)
Equating ignorance with false belief	Different cognitive demands	Ignorance = info access (single rep); False belief = contradictory content (dual rep + inhibition)
Equating coordination with collaboration	Parallel ≠ shared framework	Coordination = parallel goals; Collaboration = we-mode + role differentiation
Concluding ASD = "no ToM"	Ignores developmental trajectory + pathway specificity	Delay + pathway-specific (implicit deficit, explicit can be learned)
Thinking language alone explains ToM	Down syndrome: low VMA (2-3yr), still pass ToM	Language helps but isn't sufficient; conceptual relationship unclear
Assuming apes lack ToM entirely	Ignores implicit measures	Apes have implicit ToM (70% gaze) but lack explicit (0% strategic behavior)

High-Yield Contrasts for Exam

Concept A vs Concept B	Key Distinguishing Feature
Gaze following vs Joint attention	Mutual knowledge of shared focus ("we both know we're looking at X together")
Ignorance vs False belief	Information access monitoring vs representing contradictory mental content
Coordination vs Collaboration	Parallel individual goals vs role differentiation within we-mode representation
Desire psychology vs Belief-desire psychology	Subjective wants only vs representational states (can separate true from represented)
Implicit ToM vs Explicit ToM	Automatic/fast (150-300ms) vs controlled/slow (2000-3000ms); bottom-up vs top-down
True belief vs False belief	False belief requires inhibiting reality bias + dual representation maintenance

Memory Aid: The Two-Pathway Dissociation

Apes have IMPLICIT but not EXPLICIT (can track but can't use strategically)
HFASD have EXPLICIT but not IMPLICIT (can reason but can't track automatically)
Typical humans have BOTH (seamless integration from age 4+)
9-month infants have IMPLICIT only (pre-verbal automatic tracking)

Key Studies: Must-Know Details

Baron-Cohen (1985) - Original ASD Study

- **Sample:** Autism (CA 11yr, VMA 5yr) vs Down (CA 10yr, VMA 5yr) vs Typical (CA 4yr)
- **Task:** Sally-Anne false belief (verbal report)
- **Result:** Autism 20% pass; Down + Typical ~85% pass
- **Initial conclusion:** ASD = no ToM (later revised)
- **Critical detail:** 4 autistic children did pass—sparked developmental trajectory research

Scheeren (2013) - Large-Scale HFASD Study

- **Sample:** n=194 high-functioning ASD vs TD (matched IQ)
- **Tasks:** 2nd-order false belief, faux pas, sarcasm, display rules
- **Result:** NO significant differences in adolescence
- **Conclusion:** Delay, not deficit; converges by age 10-14

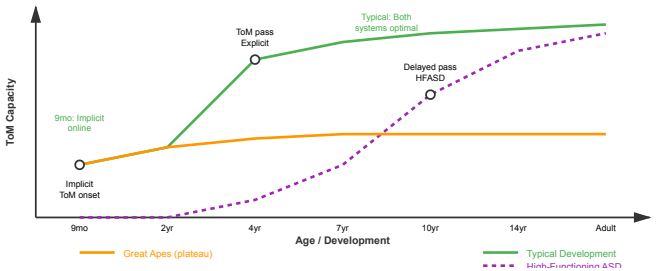
Senju (2009) - Implicit/Explicit Dissociation

- **Sample:** HFASD adults (IQ 115) vs neurotypical controls
- **Explicit task:** Strange stories, verbal ToM → No differences (perfect performance)
- **Implicit task:** Eye-tracking anticipatory gaze → HFASD at 50% chance level (fail)
- **Neural difference:** Typical = automatic TPJ activation; ASD = effortful prefrontal activation
- **Insight:** Same behavioral output via different neural routes

Krupenye et al. (2017) - Ape Implicit ToM

- **Sample:** Great apes (chimpanzees, bonobos, orangutans)
- **Method:** Eye-tracking during false belief scenarios
- **Result:** 70% anticipatory looking to false-belief location
- **Conclusion:** Implicit system present in apes; explicit system human-unique

Developmental Trajectory Visualization



Key Insights: (1) Typical development: implicit emerges first (9mo), explicit follows (4yr). (2) HFASD: delayed but eventual convergence via compensatory route. (3) Apes: implicit system functional but explicit never develops—evolutionary constraint.

Neurocognitive Systems Summary

Feature	Implicit System	Explicit System
Neural substrate	Temporo-parietal junction (TPJ), subcortical	Prefrontal cortex (PFC), cortical
Processing speed	Fast (150-300ms)	Slow (2000-3000ms)
Consciousness	Automatic, no awareness	Controlled, conscious
Measurement	Eye-tracking, looking time, anticipatory gaze	Verbal report, behavioral choice, reasoning tasks
Developmental onset	9 months (pre-verbal)	4 years (language-dependent)
Evolution	Phylogenetically ancient (shared with apes)	Human innovation (language + culture-driven)
Cognitive load	Low (no executive demands)	High (working memory + inhibition)
Training/learning	Cannot be consciously trained	Can be taught through instruction
Function	Real-time online social interaction	Strategic planning, offline reasoning
ASD profile	Impaired (bottom-up deficit)	Intact/delayed (top-down compensation)
Ape profile	Functional (70% accuracy)	Absent (cannot translate to behavior)

L08: Moral Development I

Prerequisites: Self-Awareness

Age	Capability	Moral Significance
18 mo	Self-awareness (Rouge Test: 50% pass at age 2)	Moral agency emerges - "you" exists as responsible entity
2 yrs	Pride, shame, embarrassment (WITH audience)	Self-conscious emotions require external feedback
4-6 yrs	Emotions differentiated from basic (pride ≠ happiness)	Transition: beginning internalization
8 yrs	Self-appraisal WITHOUT audience	Internalized moral standards (autonomous conscience)

Key Principle: Without self-concept, no responsibility/accountability. External feedback → internalized conscience (age 2 to 8).

What Kohlberg Measures

Question Type	What It Is	What It Is NOT
Moral Reasoning	What people think SHOULD be done in hypothetical dilemmas	NOT what they would actually do
Method	Structured interviews with moral dilemmas (e.g., child drops roll in water - will mother give another?)	NOT behavioral observation
Cognitive Component	Reasoning, justification, "thinking side"	NOT feelings, emotions, or actual behavior

EXAM CRITICAL: Moral reasoning ≠ moral behavior. Same behavior (e.g., helping) can stem from Stage 2 (self-interest), Stage 3 (social approval), or Stage 6 (universal principles).

Two Theoretical Traditions

Tradition	Rationalist (Kohlberg)	Sentimentalist (Social Domain)
Question	What SHOULD be done?	Is it right or wrong?
Focus	Cognitive reasoning (thought)	Evaluative appraisal (intuition/emotion)
Development	Slow hierarchical stages (6 stages)	Early-emerging distinction (30 months)
Method	Hypothetical dilemmas, verbal justification	Harm perception, rule contingency judgments
Age Competence	Adolescence for conventional morality	30 months for moral-conventional distinction

- **Integration:** Neither predicts behavior alone; reasoning without emotion = empty principles; intuition without reasoning = can't handle complex dilemmas

Kohlberg's 6 Stages of Moral Reasoning

Level	Stage	Primary Question	Motivation Source	Example Reasoning	Typical Age
Pre-Conventional (Egocentric, external consequences)	**1. Punishment Avoidance**	Will I be punished?	Avoid punishment	"Drawing on wall is wrong because I got told off"	Early childhood
	2. Self-Interest	What's in it for me?	Personal benefit	"Do homework because I get to go to cinema"	Early-mid childhood
Conventional (External expectations, social/legal rules) *MOST ADULTS*	**3. Social Approval** ("Good girl/good boy")	What will others think?	Social expectations	"Help elderly person cross road - that's what good people do"	Adolescence+
	4. Law & Order	What do rules require?	Maintain social order	"Report friend's shoplifting despite social cost - upholding laws maintains order"	Adolescence+
Post-Conventional (Abstract principles, independent ethics) *10-15% ADULTS*	**5. Social Contract**	What benefits majority?	Democratic principles, changeable laws	"Stealing food for starving child justified - life preservation > property rights"	10-15% adults
	6. Universal Principles	What is ethically right?	Personal conscience, self-chosen ethics	"Bonhoeffer (pacifist pastor) tried to assassinate Hitler - stopping genocide > personal beliefs/laws"	Very rare (~1%)

EXAM TRAP: Everyone thinks they're Stage 5-6, but most adults are Stage 3-4. Very hard to know what motivates your own reasoning (social group vs independent principles).

Stage Reasoning: Scenario Analysis

Scenario	Stage 1-2	Stage 3-4	Stage 5-6
Drawing on wall	"I got told off"	"Damages property, disrespectful to parents"	N/A (minor issue)
Should do homework?	"Get to go to cinema"	"That's what students should do"	"Enhances learning, fulfills potential"
Help elderly person cross road	"Might get reward"	"Society expects it / right thing to do"	"Protecting vulnerable"
Friend shoplifts	"I'll get in trouble too"	"Must uphold laws to maintain social order"	"Property rights violated"
Steal food for starving child	Can't reason at this level	"Wrong: breaks law"	"Right: life preservation > property"
Man punches bus harasser	"Impress woman" (2)	"Meet social expectations" (3) / "Stop injustice" (4)	"Protect vulnerable" (6)

Key Insight: SAME BEHAVIOR can stem from DIFFERENT STAGES - cannot infer reasoning from behavior alone.

Theory of Mind Requirement

Stage	Requires ToM?	Reasoning
Stage 1-2 (Pre-conventional)	NO	Egocentric, focuses only on self (punishment, reward)
Stage 3 (Social Approval)	**YES**	Must understand what OTHERS think/expect ("good girl/boy")
Stage 4 (Law & Order)	**YES**	Must consider societal perspective, how others view behavior
Stage 5-6 (Post-conventional)	**YES**	Requires perspective-taking to weigh competing principles

CRITICAL CONNECTION: Theory of Mind emerges age 4-5, enabling transition from pre-conventional (egocentric) to conventional (social perspective) morality.

Kohlberg's Limitations: 7 Critical Flaws

Criticism	Details	Evidence	Exam Application
1. Reasoning ≠ Behavior	Same behavior → different stages. Same reasoning → different behaviors (personality, anxiety, group effects intervene)	Bus harasser example: punch could be Stage 2 (impress woman), 3 (expectations), or 6 (principles)	Cannot infer moral reasoning from behavior alone
2. Gender Bias (Gilligan 1982)	Male-only sample. Females → Stage 3 (care/relationships). Males → Stage 4 (justice/rules). Hierarchy ranks justice > care	Ethics of care (contextual, relational) vs ethics of justice (abstract, rule-based). Kohlberg ranks 4 > 3 = female reasoning appears "less developed"	Care vs justice are DIFFERENT orientations, not hierarchical levels
3. Not Hierarchical	People use multiple stages simultaneously, context-dependent (minor infraction → Stage 2; legal matter → Stage 4)	Longitudinal data shows overlapping stage percentages across ages, not clean progression	Development = gradual shift in reasoning repertoire, not discrete stages
4. Ecological Validity (Eisenberg)	Hypothetical dilemmas ≠ real moral pressure. People respond differently when actually facing dilemmas vs imagining them	Can't replicate real-world factors: social pressure, emotional stakes, time pressure	Lab findings may not generalize to real moral decisions
5. Cultural Bias	Collectivist cultures value Stage 3 (harmony/relationships) > Stage 4 (justice/law). Western hierarchy doesn't apply universally	Collectivist: prioritize group harmony (Stage 3). Individualist: prioritize abstract justice (Stage 4)	Hierarchy reflects Western individualist values, not universal moral sophistication
6. Articulation Limits	Kids <7 can't verbally explain reasoning (doesn't mean they lack it). Complex to give scenario + articulate justification	Video of 4-year-old explaining Christmas: incoherent but may understand more than can express	Data on young children may underestimate moral understanding
7. Stage 6 Too Rare	~1% reach it. Measurement may be inadequate (not sensitive enough to detect)	Very few people demonstrate Stage 6 reasoning in research	Question: Are people not using it, or are we not measuring it properly?

Gilligan (1982): Care vs Justice

Dimension	Ethics of Care (Stage 3)	Ethics of Justice (Stage 4)
Focus	Relationships, contextual response	Rules, fairness, abstract principles
Goal	Maintain relationships, minimize harm	Consistent rule application
Gender Pattern	More frequent in females (on average)	More frequent in males (on average)
Kohlberg Rank	Stage 3 (lower in hierarchy)	Stage 4 (higher in hierarchy)
Bias Issue	Female reasoning appears "less developed"	Male reasoning privileged as "higher"
Cultural Note	Collectivist cultures prioritize care	Individualist cultures prioritize justice

KEY INSIGHT: Care and justice are DIFFERENT moral orientations, not hierarchical levels. Kohlberg's hierarchy creates gender/cultural bias.

Context Dependency: Same Person, Different Stages

Scenario: Office Worker

Situation	Reasoning Stage	Justification
Taking office supplies home	Stage 2 (Self-Interest)	"Everyone does it, and I need pens"
Friend asks to lie about whereabouts	Stage 3 (Social Approval)	"A good friend would help"
Witnessing hit-and-run accident	Stage 4 (Law & Order)	"I must report this to maintain justice"

EXAM POINT: Same individual jumps between stages depending on context (severity, social factors, consequences). Development is NOT strict hierarchy.

Social Domain Theory: Moral vs Conventional Distinction

Criterion	Moral Transgressions	Conventional Transgressions
Definition	Cause harm, suffering, interpersonal tension (intrinsic to event)	Break social rules coordinating group behavior (no inherent harm, arbitrary)
Examples	Hitting, stealing, biting, not sharing, pushing	Not sitting on mat, not wearing clothes, not queuing, improper greetings, not saying grace
Wrong without rules?	**YES** - inherently wrong (harm to victim regardless of prohibition)	**NO** - only wrong if prohibited (rule-dependent)
Context-bound?	**NO** - wrong everywhere (home AND school)	**YES** - depends on setting (wrong at school, OK at home)
Authority-modifiable?	**NO** - remains wrong even if authority allows it	**YES** - OK if authority permits it
Seriousness	Very serious, more deserving of punishment	Less serious, mild response (encouragement)
Basis	Factors intrinsic to event (pain, unfairness, suffering)	External rules, social organization, coordination
Universality	Universal across cultures (harm always recognized)	Arbitrary, alterable by consensus (varies by culture)
Perception Source	Not contingent on presence of rule (harm is self-evident)	Contingent on social expectations and rules

EXAM CRITICAL: Moral = HARM-based (universal, unalterable). Conventional = COORDINATION-based (context-bound, modifiable). If convention causes harm, it shifts to moral domain.

Smetana (1981): Landmark Study

Component	Details
Participants	Ages 30-57 months (2.5 to 4.75 years)
Key Finding	**NO age differences** - Even 30-month-olds distinguish moral from conventional
Moral Judgments	More wrong without rules, more serious, deserving of punishment, wrong everywhere (home AND school)
Conventional Judgments	Only wrong if prohibited, less serious, context-specific (wrong at school, OK at home)
Implication	Moral understanding emerges MUCH earlier than Kohlberg suggests (30 mo vs adolescence)
Challenge to Kohlberg	30-month-olds = "pre-conventional" (egocentric) BUT already distinguish moral from conventional

How Children Learn the Distinction

- **Adult Response Quality:** Different intensity teaches domain distinction
- **Conventional (not sitting on mat):** Mild encouragement "Would you like to sit?" - let it go if child refuses
- **Moral (biting):** Immediate intervention, parent notification, addressed seriously, different quality/intensity

KEY POINT: By 30 months, children reliably distinguish harm (moral) from rule-breaking (conventional). This is innate/early-learned, NOT hierarchical development.

Harm Principle: Domain Shifting

Scenario	Domain	Reasoning
Not wearing clothes (general)	Conventional	Social rule, no inherent harm, arbitrary
Not wearing clothes (Arctic, forced)	**Moral**	**Causes harm** (hypothermia, not their choice)
Shaking hands (refusing)	Conventional	Awkward, but no harm
Not removing shoes (place of worship)	Conventional → **Moral**	May cause **emotional harm** if deeply offensive to others
Queuing vs cutting line	Conventional	Social coordination, no direct harm (may cause frustration, not harm)
Not putting toys away (preschool)	Conventional	Social rule for organization, no harm
Hitting another child	Moral	Causes pain (physical harm), wrong everywhere

RULE: If conventional transgression causes harm (physical, emotional, social) → shifts to moral domain. Context determines domain.

Development Paradox: Understanding ≠ Behavior

Age	Moral Understanding	Moral Behavior	Gap Explanation
30 mo	Distinguishes moral (hitting) from conventional (not sitting on mat)	Still violates both domains	Cannot articulate reasoning yet
2.5-3 yrs	Knows hitting is wrong everywhere	Still hits sibling when angry	Immature impulse control, emotional regulation
3-7 yrs	Stable moral-conventional distinction	Frequently violates both	Behavioral control lags understanding
8 yrs	Internalized standards (no audience needed for shame/pride)	Better compliance, but gaps remain	Social anxiety, group dynamics, personality intervene
Adolescence+	Sophisticated contextual application	Reasoning-behavior gap persists	Situational factors override reasoning

KEY PARADOX: Moral knowledge ≠ moral behavior. Understanding emerges early (30 mo); behavioral control requires years of development (impulse control + emotional regulation + internalization).

Why the Gap?

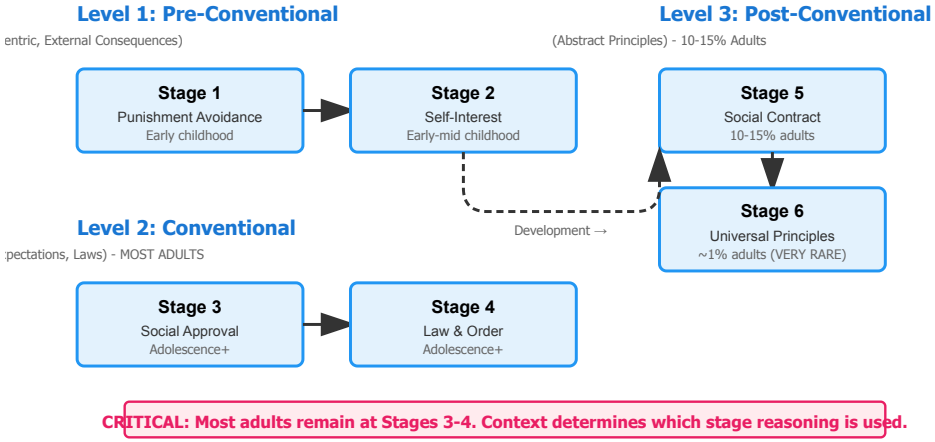
- **Immature impulse control:** Can't stop action even when knowing it's wrong
- **Emotional regulation:** Anger/frustration overrides knowledge
- **Internalization process:** External understanding → internal behavioral control (gradual across childhood)
- **Situational factors:** Group pressure, social anxiety, personality override reasoning

Integrated Developmental Timeline

Age	Kohlberg Stage	Social Domain	Key Milestone
18 mo	Pre-Stage 1	N/A	Self-awareness (Rouge Test) = moral agency emerges
2 yrs	Stage 1 emerging	N/A	Self-conscious emotions (pride, shame) WITH audience
30 mo	Stage 1	**Moral-conventional distinction**	Distinguish harm (moral) from rule-breaking (conventional)
3-7 yrs	Stage 1-2 (Pre-conventional)	Stable distinction maintained	Behavior lags understanding (impulse control immature)
8 yrs	Stage 2-3 transition	Sophisticated contextual application	Self-appraisal WITHOUT audience (internalized standards)
12-17 yrs	Stage 3-4 (Conventional)	Context-sensitive application	Theory of Mind enables perspective-taking (required for conventional morality)
18+ yrs	Stage 3-4 (most); 10-15% Stage 5; ~1% Stage 6	Maintained from childhood	Reasoning-behavior gap persists across lifespan

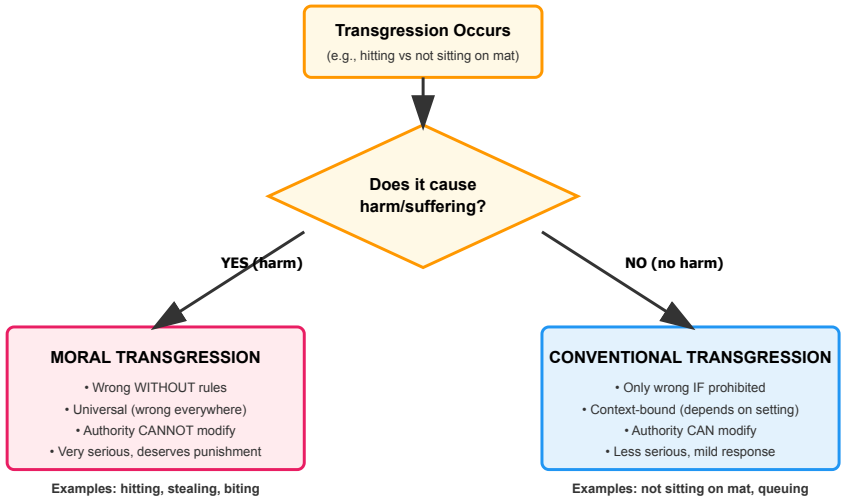
SYNTHESIS: Social domain understanding (30 mo) emerges LONG BEFORE Kohlberg's conventional morality (adolescence). Both theories needed: early intuitive harm recognition + gradual reasoning sophistication.

Kohlberg's Stage Progression (Visual)



CRITICAL: Most adults remain at Stages 3-4. Context determines which stage reasoning is used.

Moral vs Conventional Decision Tree



HARM PRINCIPLE: If conventional transgression causes harm (physical, emotional, social) → shifts to moral domain. Context determines domain classification.

Reasoning vs Appraisal: Key Distinction

Dimension	Moral Reasoning (Kohlberg)	Moral Appraisal (Social Domain)
Core Question	What SHOULD be done?	Is it right or wrong?
Theoretical Tradition	Rationalist (cognitive, thought)	Sentimentalist (evaluative, intuition/emotion)
Development Pattern	Slow hierarchical stages (6 stages)	Early-emerging distinction (30 months)
Method	Hypothetical dilemmas, verbal justification	Harm perception, rule contingency judgments
Age of Competence	Adolescence for conventional morality (Stages 3-4)	30 months for moral-conventional distinction
Gender Differences	Males score "higher" (Stage 4 justice > Stage 3 care)	No gender differences in distinction ability
Cultural Variation	Universal sequence claimed (but biased toward individualist cultures)	Universal harm recognition (but conventions vary by culture)
Behavioral Prediction	Poor reasoning-behavior link (context, personality intervene)	Understanding ≠ compliance (impulse control, emotional regulation needed)

INTEGRATION: Neither predicts behavior alone. Reasoning without emotion = empty principles. Intuition without reasoning = can't handle complex dilemmas. BOTH needed.

Common Exam Errors to Avoid

Error	Correction
Kohlberg measures behavior or feelings	**NO:** Measures reasoning about what "should" be done (NOT what they would do, NOT how they feel)
Stages are fixed/invariant	**NO:** Context-dependent; people use multiple stages simultaneously
30-month-olds are "pre-conventional" = no moral understanding	**NO:** They distinguish moral (harm) from conventional (rules) at 30 months (Smetana 1981)
Care vs Justice = Moral vs Conventional	**NO:** Different distinctions. Care/justice = Gilligan's orientations (gender). Moral/conventional = harm vs social rules
Stage 6 is common or everyone progresses to it	**NO:** Very rare (~1%). Most adults remain at Stages 3-4. Everyone thinks they're 5-6 but aren't
Everyone progresses through all stages sequentially	**NO:** Not hierarchical; people jump between stages based on context
Moral reasoning predicts moral behavior	**NO:** Poor link (personality, social anxiety, group effects, situational factors intervene)
Understanding moral rules means you'll follow them	**NO:** Development paradox: 3-year-olds know hitting is wrong but still hit (impulse control lags understanding)

Key Theorists & Contributions

Theorist	Contribution	Key Finding/Critique
Piaget	Early moral reasoning research, clinical interviews	Hypothetical dilemmas to assess moral understanding
Kohlberg	6-stage hierarchical model of moral reasoning	Pre-conventional → Conventional → Post-conventional. Measures what people think "should" be done
Gilligan (1982)	Gender bias critique of Kohlberg	Male-only sample; care (Stage 3, females) vs justice (Stage 4, males) orientations; hierarchy creates gender bias
Turiel	Social domain theory	Moral vs conventional distinction: harm-based vs rule-based transgressions
Smetana (1981)	Early moral understanding empirical evidence	30-month-olds distinguish moral (universal, unalterable) from conventional (context-bound, modifiable) - NO age differences
Eisenberg	Ecological validity critique	Hypothetical dilemmas ≠ real moral decisions (people respond differently when actually facing dilemmas)

Quick Scenario Analysis Tool

Scenario	Domain/Stage	Key Reasoning
Child hits another child	**Moral**	Causes pain (harm), wrong everywhere, inherently wrong, authority can't modify
Not sitting on mat at preschool	**Conventional**	No harm, only wrong at school, modifiable by authority, mild response
Stealing toys from friend	**Moral**	Causes harm (unfairness, distress), violates rights, universal
Not saying grace before meal	**Conventional**	Social/religious convention, context-specific, no inherent harm
Man punches bus harasser	**Multiple stages possible**	Stage 2 (impress woman), Stage 3 (meet expectations), Stage 6 (protect vulnerable) - SAME behavior, DIFFERENT reasoning
15-year-old reports friend's shoplifting	**Could be Stage 2, 3, 4, or 5**	Stage 2 (avoid trouble), Stage 3 (adult expectations), Stage 4 (uphold law), Stage 5 (property rights) - context determines
3-year-old says hitting wrong everywhere but still hits sibling	**Development Paradox**	Understanding (30 mo moral-conventional distinction) ≠ behavior (impulse control lags)

EXAM STRATEGY: For moral domain questions, check if harm occurs. For Kohlberg stage questions, check motivation (punishment? approval? principles?) NOT the behavior itself.

Stage Quick Identification Checklist

When you see this reasoning, it's this stage:

- **Stage 1:** "I'll get punished" / "They got in trouble so must be wrong"
- **Stage 2:** "What's in it for me?" / "I get a reward" / "Everyone does it"
- **Stage 3:** "That's what good people do" / "What will others think?" / "Being a good friend/citizen"
- **Stage 4:** "It's the law" / "Rules maintain order" / "Without laws, society breaks down"
- **Stage 5:** "Laws can be changed by majority" / "This rule doesn't benefit most people" / "Competing principles"
- **Stage 6:** "My ethical principles require this" / "Universal human rights" / "Personal conscience overrides law"

Context Clues:

- **Pre-conventional (1-2):** Only talks about self (punishment, reward) - egocentric
- **Conventional (3-4):** Talks about others' expectations or society's rules - needs Theory of Mind
- **Post-conventional (5-6):** Talks about abstract principles, weighing competing values - rare

Moral vs Conventional Quick Test

Ask these 3 questions:

Test Question	If MORAL	If CONVENTIONAL
1. Would it be OK if the teacher/authority said it was OK?	NO - still wrong	YES - becomes OK
2. Is it wrong in all contexts (home AND school)?	YES - universal	NO - context-bound
3. Does it cause harm to someone?	YES - inherent harm	NO - just breaks rule

Edge Cases (Harm Principle):

- If conventional transgression causes harm → shifts to moral domain
- Example: Not wearing clothes (conventional) BUT forced in Arctic (moral - causes harm)
- Example: Not removing shoes in place of worship (conventional) BUT deeply offensive to others (moral - emotional harm)

Kohlberg Criticisms Quick Reference

Remember: 7 Major Flaws

- **1. Reasoning ≠ Behavior:** Can't predict actions from reasoning (personality, context intervene)
- **2. Gender Bias (Gilligan):** Male-only sample, care (female) vs justice (male), hierarchy biased
- **3. Not Hierarchical:** Context-dependent, use multiple stages simultaneously
- **4. Ecological Validity (Eisenberg):** Hypothetical ≠ real pressure
- **5. Cultural Bias:** Collectivist cultures value Stage 3 > Stage 4 (hierarchy is Western)
- **6. Articulation Limits:** Kids <7 can't explain reasoning verbally (doesn't mean they lack it)
- **7. Stage 6 Too Rare:** ~1% reach it; measurement may be inadequate

Social Domain Theory Advantages:

- No gender bias (no differences in distinction ability)
- Universal harm recognition (moral transgressions recognized across cultures)
- Doesn't require verbal articulation (can test younger children)
- Emerges very early (30 months) suggesting innate/early-learned

L09: Moral Development II - Sentimentalist Tradition & Emotional Binding

CORE THESIS: Moral development transitions from **outcome-weighted judgments** and **emotionally-unbound rule knowledge** (age 4) toward **intention-privileging judgments** and **emotionally-binding moral understanding** (age 8). Young children simultaneously **know moral rules yet attribute positive emotions to successful transgressors**, revealing that moral knowledge develops before the emotional binding that makes violations feel personally aversive. The central developmental shift involves integrating cognitive rule understanding with emotional response systems through the Violence Inhibition Mechanism (distress cues → withdrawal) and Darwin's dual-instinct model (social instincts vs appetites).

Theoretical Frameworks

Theory	Core Mechanism
Sentimentalism (Hume, Darwin)	Moral behavior emerges from **emotion/empathy**, not pure reasoning
Rationalism (Kohlberg)	Moral behavior emerges from **cognitive reasoning** about principles
VIM (Blair, 2005)	Violence Inhibition Mechanism: **distress cues → withdrawal response → negative reinforcement**
Darwin's Dual Instinct	**Social instincts (constant, moderate)** vs **Appetites (sudden, strong)**. Dissatisfaction = guilt

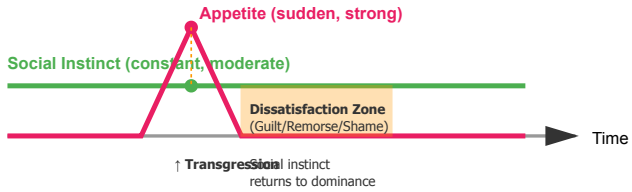
Key Distinction: Sentimentalist privilege **feeling** over reasoning; rationalists privilege **thinking** over emotion. Most behavior involves BOTH systems.

Blair VIM Studies (Psychopathy Model)

Study Component	Finding
Emotion Recognition	High psychopathy group: **impaired fear/sadness recognition** (4.73 vs 2.20 errors). Normal for other emotions
M/C Distinction	High PSD: **smaller moral-conventional gap**. Seriousness diff: 1.23 (high) vs 1.84 (low)
Predictive Power	M/C "failers" scored **higher on PSD** (21.95 vs 18.39), motivation facet, impulsivity

EXAM TRAP: Blair himself **revised VIM theory** - children with psychopathic traits CAN feel empathy under certain conditions. VIM doesn't explain all antisocial behavior!
Mechanism: VIM creates negative reinforcement loop: distress cue (80% intensity) > threshold (60%) → withdrawal → ΔR = -0.2 units. Over 10 episodes: cumulative = -2.0 units.

Darwin's Dual-Instinct Model



Model Formula: S = 5 (constant). A(t) = 10 × $e^{-t/2}$. At t=0: A(0)=10 > S=5 (transgression). At t=2: A(2)=3.7 < S=5. Dissatisfaction D = S - A(2) = 1.3 guilt units.

Intention vs Outcome Weighting

Age	Weighting Pattern	Formula
Under 7	**Outcome-dominant**: Use BOTH but overweight outcome	β≈0.7, α≈0.3 (5:1 ratio)
Adults	**Intention-dominant**: Intention primary determinant	α≈0.8, β≈0.2 (4:1 ratio)

Classic Example: Chris breaks 1 cup intentionally vs Billy breaks 15 accidentally. Under 7: Billy naughtier (outcome). Factorial design: B>C (outcome effect), C>A (intention effect), D>B (both factors).

Cultural Link: Cancel culture mirrors **kindergarten moral reasoning** - emphasizing outcome (who was hurt) over intention (what was meant).

Heyman & Gelman (1998) Water Hose Study

Scenario: Tima sprays Ashira with water. Manipulate: Intention (P+/P-) × Outcome (O+/O-).

Condition	Kindy Rating	Adult Rating
P+ / O+ (thinks cool, is happy)	8/10	7/10
P+ / O- (thinks cool, is upset)	3/10	6/10
P- / O+ (thinks upset, is happy)	7/10	3/10
P- / O- (thinks upset, is upset)	2/10	2/10

Analysis:
- **Kindergarten:** Outcome effect = [(8+7)/2 - (3+2)/2] = 5.0. Intention effect = [(8+3)/2 - (7+2)/2] = 1.0. **Ratio 5:1**
- **Adults:** Intention effect = 4.0. Outcome effect = 1.0. **Ratio 4:1 (reversed)**

Moral Judgment Weighting Formula

General Model:

$$\text{Judgment} = \alpha \times \text{Intention} + \beta \times \text{Outcome}$$

Age Group	α (Intention)	β (Outcome)	Interpretation
Age 5 (Kindy)	0.3	0.7	Outcome-dominant: β/α = 2.33
Age 8	0.6	0.4	Transitional: α/β = 1.5
Adults	0.8	0.2	Intention-dominant: α/β = 4.0

Key Insight: Children DON'T ignore intention - they use BOTH dimensions but weight them differently. Not a categorical shift but a **continuous reweighting**.

Happy Victimizer Paradigm (Nunner-Winkler & Sodian, 1988)

Scenario Structure

Bob and Jerry are friends. Jerry shows Bob lollies, puts them in coat. Jerry leaves. **Bob steals lollies.** Jerry returns, sad (lollies gone).

Question	Age 4 Response	Age 8 Response
Is stealing wrong?	**YES**	**YES**
How does Bob feel?	**GOOD** (got what wanted)	**BAD** (guilty/ashamed)

HV Scoring System

Response Type	Score
Happiness	+2
Mixed (happy but...)	+1
Neutral	0
Sadness	-1
Guilt/Shame	-2

Example Calculation: Age 5 group (n=20): 12 children (+2), 5 children (+1), 2 children (0), 1 child (-2). Mean = [12(2) + 5(1) + 2(0) + 1(-2)]/20 = 27/20 = **+1.35 (strong HV)**. Age 8: Mean = **-0.50 (moral emotion)**. Developmental shift = 1.85 units over 3 years ≈ 0.62 units/year.

Happy Victimizer Insights & Priming

What HV Reveals

- **Moral knowledge precedes moral emotion** - children know rules before feeling bound by them
- **Separate trajectories:** Cognitive moral understanding vs emotional-moral binding converge age 7-8
- Young children = **motivational honesty** (if didn't feel good, wouldn't do it)
- Age 4 lacks **emotionally binding tie** between wrongness and personal aversion

Priming Effects (Ages 5-7)

Prime Type	Effect on Response
Moral evaluation first ("Is stealing wrong?")	↑ Guilt/shame attribution (activate moral frame)
Desire/wish first ("Bob really wanted lollies")	↑ Happy victimizer responses (activate motivational frame)

COMMON MISINTERPRETATION: HV responses at age 4-5 are **NOT psychopathy** - they're a normal developmental stage! Only concerning if persists beyond age 8 AND occurs with other signs (lack empathy in other contexts).

Developmental Transition Markers

- **Age 4:** Pure HV ("happy, got candy")
- **Age 5-6:** Priming-sensitive ("happy but... depends")
- **Age 7:** Mixed responses emerging ("happy AND bad")
- **Age 8:** Moral emotion dominant ("feel bad/guilty")

Personality Attribution Development

Age	Process	Example
4-5 years	**SEPARATE:** Behavior→Trait OR Trait→Behavior (not chained)	Bobby doesn't share → "selfish" (today only). Tomorrow: fresh slate
7-8 years	**INTEGRATED:** Behavior→Trait→Future Behavior (stable)	Bobby doesn't share → "selfish" → predict won't share toys tomorrow

Attribution Persistence Model

Age 5 Update Rule: New_Attribution = 0.1 × Previous + 0.9 × Current (rapid reset)
Age 8 Update Rule: New_Attribution = 0.6 × Previous + 0.4 × Current (stable traits)
Example: Day 1: Bobby refuses share. Attribution = 0.8 (selfish). Day 2: Bobby shares pencils.

- Age 5: 0.1(0.8) + 0.9(0) = **0.08** (mostly reset)
- Age 8: 0.6(0.8) + 0.4(0) = **0.48** (still somewhat selfish)

Recovery Time to Neutral: Age 5 ≈ 3 days. Age 8 ≈ 45 days (**15× longer**).

CLINICAL IMPLICATION: Early intervention critical **BEFORE age 7-8** when peer personality attributions solidify. After Grade 2, child labeled "aggressive" faces years of self-fulfilling prophecy.

Malti & Krettenauer (2013) Meta-Analysis

Sample: 42 studies, >8,000 participants, ages 4-20

Relationship	r	Interpretation
Moral emotion attribution → Antisocial behavior	**-0.35**	STRONGER link: Moral emotions primarily **INHIBIT harm**
Moral emotion attribution → Prosocial behavior	**+0.20**	WEAKER link: Removing barriers ≠ creating motivation

Why Asymmetry?

- **Antisocial:** Requires **overcoming inhibition**. Moral emotions create binary gate (strong/absent).
- **Prosocial:** Requires **positive motivation** beyond just removal of barriers. Moral emotions necessary but not sufficient.

Behavioral Prediction Example

Classroom of 30 children, HV assessment:

- **Group A (n=10):** Strong moral emotions (mean = -1.5)
- **Group B (n=10):** Moderate (mean = 0)
- **Group C (n=10):** HV pattern (mean = +1.5)

Predicted antisocial acts/month (base = 5):

- Group A: 5 × (1 - 0.35 × 1.5) = **2.4 acts**
- Group B: **5.0 acts**
- Group C: 5 × (1 + 0.35 × 1.5) = **7.6 acts**

Predicted prosocial acts/month (base = 10):

- Group A: 10 × (1 + 0.20 × 1.5) = **13 acts**
- Group B: **10 acts**
- Group C: 10 × (1 - 0.20 × 1.5) = **7 acts**

Note: **3.2× range** for antisocial vs **1.9× range** for prosocial.

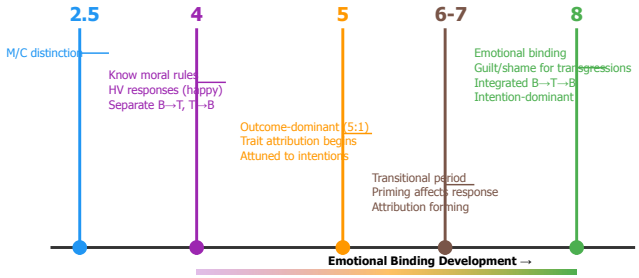
Critical Distinctions for Exam

Concept A	≠	Concept B
Moral Knowledge	≠	**Emotional Binding** Knowing rule is wrong ≠ feeling personally aversive
Emotional Attribution	≠	**Personal Binding** Predicting others feel bad ≠ feeling bad yourself
Recognition Deficit	vs	**Response Deficit** Can't identify emotion vs can't respond appropriately
Antisocial	≠	**Prosocial** Not flip sides - distinct constructs with different correlates
Behavior→Trait	vs	**Trait→Behavior** Age 4-5: separate. Age 7-8: integrated chain

THREE-LEVEL ASSESSMENT:

1. **Rule Knowledge:** "Is stealing wrong?" (develops by age 2.5)
2. **Emotional Attribution:** "How does thief feel?" (develops 4→8)
3. **Personal Binding:** How child feels when THEY transgress (observe actual behavior)

Developmental Timeline: Age Milestones



Age	Key Capabilities
2.5	Moral/conventional distinction established and stable
4	Know rules; separate B→T & T→B; HV responses (feel good)
5	Attuned to intentions; outcome-dominant (5:1); trait attribution begins
6-7	Transitional; priming-sensitive; personality attributions forming
8	Emotional binding complete; guilt/shame; integrated B→T→B; intention-dominant

Experimental Paradigm Comparisons

Paradigm	What It Reveals	Critical Age
Moral-Conventional Distinction	Can differentiate harm-based from rule-based violations. Tests conceptual understanding.	Develops by **2.5 years**, stable thereafter
Happy Victimizer	Integration of moral knowledge with emotional binding. Balances cognitive + emotional.	Transition **4→8 years**
Intention-Outcome	Relative weighting of motive vs consequence in moral judgment.	Shift begins **5 years**, adult-like by **adolescence**
Factorial Design	Allows independent estimation of α (intention weight) and β (outcome weight). Controls confounds.	Method (not age-specific)
VIM Recognition Task	Tests ability to recognize distress cues (fear/sadness). Links emotion recognition to moral behavior.	Deficit in psychopathy (all ages)

Design Choice Decision Tree

- **Testing rule knowledge?** → Use M/C distinction
- **Testing emotional integration?** → Use Happy Victimizer
- **Testing judgment weighting?** → Use factorial intention × outcome design
- **Testing mechanism?** → Use VIM recognition + behavior link

KEY METHODOLOGICAL POINT: Single-comparison designs (1 broken cup vs 15 broken cups) CONFOUND intention and outcome. Must use **complete factorial** (2×2 or larger) to independently estimate weighting parameters.

Common Exam Confusions & Traps

Misconception	Truth
Young children don't understand intentions	**FALSE:** They understand but **OVERWEIGHT outcomes**. Not blind to intentions - use BOTH dimensions.
HV responses indicate psychopathy	**FALSE:** Normal at age 4-5. Developmental stage, not pathology. Only concerning if persists past age 8.
VIM explains all antisocial behavior	**FALSE:** Blair himself revised theory. Children with psychopathic traits CAN feel empathy under conditions.
Moral emotions create prosocial acts	**PARTIAL:** Stronger link to INHIBITING antisocial (r=-0.35) than promoting prosocial (r=+0.20).
Cancel culture is new phenomenon	**INSIGHT:** Mirrors kindergarten reasoning (outcome over intention) - developmental regression under social pressure.
Age 4 children lack theory of mind	**FALSE:** They HAVE theory of mind (recognize intentions) but lack emotional-moral binding.
Prosocial = opposite of antisocial	**FALSE:** Distinct constructs. Different neural bases, different developmental trajectories, different correlates.

Key Concepts Quick Reference

- **Emotional Binding:** Moral violation feels personally aversive, not just cognitively "wrong"
- **VIM Activation:** Distress cues (fear/sadness in victim) → withdrawal schema → negative reinforcement of inhibition
- **Happy Victimizer Phenomenon:** Attributing positive emotions to successful transgressor despite knowing act is wrong
- **Moral Self-Concept:** Identity where moral transgressions are emotionally binding vs externally punished only
- **Outcome Weighting:** Young children use intention information but assign higher weight to outcome severity
- **Attribution Persistence:** Age 5: 3 days to reset reputation. Age 8: 45 days (15× longer - stable traits)
- **Sentimentalist Core Claim:** Children are moral BECAUSE empathic, not because they reason correctly about rules
- **Darwin's Dissatisfaction:** Mismatch between appetitive behavior (past) and social instinct (present) = guilt/remorse
- **Recognition vs Response Deficit:** Can identify emotion vs can respond appropriately to identified emotion
- **Priming Effects:** Order of questions shifts HV responses (moral evaluation first → guilt; desire first → happy)

Formulas & Calculations Cheat

Intention-Outcome Weighting

Judgment = α × Intention + β × Outcome

Outcome effect = [(P+O+ + P-O+)/2 - (P+O- + P-O-)/2]

Intention effect = [(P+O+ + P+O-)/2 - (P-O+ + P-O-)/2]

VIM Negative Reinforcement

If distress_intensity > threshold → withdrawal

ΔR = -k (cumulative over episodes)

Example: 10 episodes × -0.2 = -2.0 cumulative reinforcement

Darwin's Dual Instinct

S = constant (social instinct baseline)

$A(t) = A_0 \times e^{-t/\tau}$ (appetite decay)

Dissatisfaction = S - A(t) when S > A(t)

Attribution Update Rules

Age 5: New = 0.1 × Previous + 0.9 × Current

Age 8: New = 0.6 × Previous + 0.4 × Current

HV Developmental Rate

Change = Mean_5 - Mean_8 = 1.35 - (-0.50) = 1.85 units

Rate = 1.85 ÷ 3 years ≈ 0.62 units/year

Behavioral Prediction (Malti & Krettenauer)

Antisocial = Base × (1 - 0.35 × HV_score)

Prosocial = Base × (1 + 0.20 × HV_score)

(HV_score: negative = moral emotion, positive = happy victimizer)

L10: Abnormal Development - Callous-Unemotional Traits

Core Thesis

Callous-unemotional (CU) traits arise not from absent empathy or fearlessness but from **impaired automatic attention allocation** (underactive basolateral amygdala) that causes children to miss crucial social learning opportunities, creating **cascading developmental failures** that manifest as severe antisocial behavior.

Critical Insight: Subtle cognitive deficits present from birth snowball through development. These children show intact explicit processing but impaired implicit/automatic processing.

Key Concepts & Definitions

Term	Definition
Callous-Unemotional Traits	Reduced empathy, low guilt/shame, limited prosocial emotions, reduced affect. Childhood analogue of psychopathic personality traits.
Hot Children	~70% of antisocial children: emotionally volatile, reactive aggression only, comorbid anxiety/ADHD, respond well to parent management training.
Cold Children	~30% with CU traits: unemotional, proactive + reactive aggression, low anxiety, heritability 0.81-0.82, poor treatment response.
Reactive Aggression	Response to triggers/provocations. Present in both hot and cold children.
Proactive Aggression	Goal-directed, planned harmful behavior. Specific to CU traits, predicts adult criminal behavior.
Primary Psychopathy	Genetic/neurodevelopmental origin, low anxiety, early onset, male predominant (5-10:1), heritability ~0.81.
Secondary Psychopathy	Trauma/abuse response, high anxiety, balanced sex ratio (2:1), reactive attachment disorder pattern.
Limited Prosocial Emotions	DSM-5 specifier for conduct disorder indicating CU traits (clinical term avoiding "psychopathy" label).
Basolateral Amygdala (BLA)	Automatic attention allocation, encodes specific stimulus features, rapid prediction error response. UNDERACTIVE in CU traits.
Central Amygdala (CeA)	General valence encoding (approach/avoid), explicit processing, physiological fear response. INTACT in CU traits.

Critical Distinctions

Comparison	CU Traits	ASD
Cognitive Empathy	INTACT (understands why)	IMPAIRED
Affective Empathy	IMPAIRED (doesn't feel)	INTACT
Attention Issue	Automatic social attention	Intense focus, shifting difficulty
Aggression	Proactive + reactive	Rare, defensive only

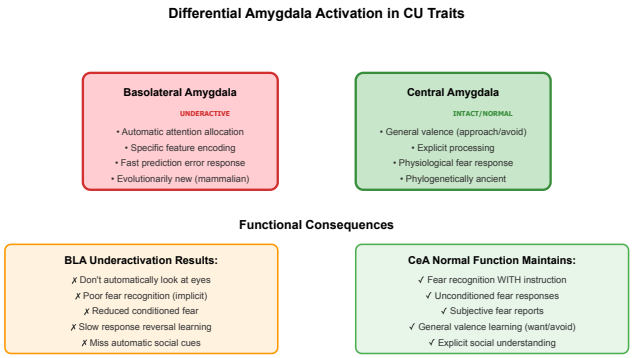
Assessment Trap: Questionnaire items overlap between ASD and CU traits. Key differentiator: empathy pattern reversal.

Four Theoretical Frameworks

Theory	What's Intact?	What's Impaired?	Why Incomplete?
1. Empathy Deficit	Cognitive empathy	Affective empathy only	Can't explain learning deficits in non-social tasks
2. Low Fear	Unconditioned fear, subjective fear reports	Conditioned fear only	Fear system partially intact; attention modulates "fearlessness"
3. Punishment Insensitivity	Acquisition learning	Response reversal, passive avoidance	Only insensitive when rewards present; behavioral inflexibility, not true insensitivity
4. Amygdala Dysfunction	Varies by study	Varies by study	Contradictory findings until BLA vs CeA separated

Theoretical Evolution: Each theory captures partial truth. Solution emerges from differential amygdala activation model distinguishing BLA (automatic) from CeA (explicit).

Differential Amygdala Activation Model



Clinical Implication: When you direct CU children to "look at the eyes," fear recognition normalizes because you bypass damaged automatic system (BLA) and engage intact explicit processing (CeA). This proves explicit systems remain functional.

Three Main Replicated Findings

1. Fear Recognition & Eye-Tracking

Dadds et al. (2006): CU children don't look at eye region of faces. When instructed "look at the eyes," deficit disappears entirely.

Mechanism: Subcortical visual pathway (dark/white ratio detection → BLA activation → gaze shift to eyes) is disrupted. Attention allocation failure, not recognition impairment.

2. Response Reversal & Behavioral Flexibility

Pattern: Intact acquisition (learn button = reward) but impaired reversal (continue pressing when button → loss).

Mechanism: BLA encodes specific features ("this button in this context"), CeA encodes general value ("wanting"). BLA underactivation = contextual updating fails while general approach continues.

3. Conditioned Fear & Attention

Newman et al. (2010): Reduced conditioned fear normalizes when explicitly directed to attend to threat cues.

Mechanism: Deficit isn't in fear capacity but automatic threat detection. Intact CeA generates normal fear when threats enter awareness through top-down attention.

Research Paradigms Explained

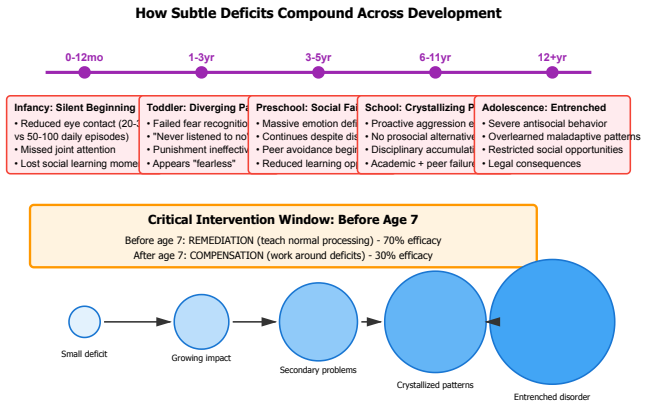
Paradigm	What's Measured	Normal Response	CU Response	Mechanism Revealed
Fear-Potentiated Startle	Startle enhancement to conditioned threat	40-60% increase	10-20% increase	Intact fear system, impaired conditioning
Iowa Gambling Task	Choice patterns across outcome histories	70% good decks by trial 50	45% good decks by trial 50	Explicit knowledge ≠ behavioral control
Passive Avoidance	Trials to stop after reversal	3-5 punishment trials	8-12 punishment trials	Slow contingency updating, not insensitivity
Response Reversal	Switches after contingency change	Swift adaptation	Perseveration on previous reward	Reward→punishment transitions specifically impaired

Primary vs Secondary Psychopathy Pathways

Feature	Primary	Secondary	Clinical Implication
Etiology	Genetic/neurodevelopmental	Trauma/attachment disruption	Address biology vs trauma
Anxiety	LOW (T<40)	HIGH (T>60)	Anxiety = treatment leverage in secondary
Onset	Early, insidious (<age 3)	Following trauma exposure	Earlier intervention critical for primary
Sex Ratio	Male predominant (5-10:1)	More balanced (2:1)	Consider secondary in females with CU
Heritability	0.81-0.82 (very high)	Lower, environment dominant	Genetic counseling for primary
Treatment Target	Explicit social learning	Trauma-focused, attachment	Fundamentally different approaches
Prognosis	Guarded, lifelong management	Better if trauma addressed early	Secondary may "recover"

Key Differentiator: Both score similarly on CU measures. Anxiety level is the critical clinical marker: low = primary, high = secondary.

Developmental Snowball Effect



The Compounding Effect: 200ms slower to orient to emotional faces × thousands of daily interactions × 365 days × 10 years = massive cumulative social learning deficit by age 10.

Clinical Decision Guide

Diagnostic Decision Tree

Step	Assessment	If YES → Next Step	If NO → Diagnosis
1	Proactive aggression present?	Continue to Step 2	Hot child (reactive only)
2	Shows empathy/remorse?	Hot child + ADHD likely	Continue to Step 3
3	Anxiety level	Low (T<40) = Primary CU	High (T>60) = Secondary CU
4	Age of onset	Early (<3yr) = Primary	Post-trauma = Secondary

Treatment Selection Matrix

Profile	Intervention	Expected Response
Hot Child	Parent management training, emotional regulation skills	Good (70-80% efficacy)
Primary CU (age <7)	Explicit social learning, attention training ("look at eyes")	Moderate (50-70% efficacy)
Primary CU (age >7)	Compensatory strategies, lifelong management	Limited (30-40% efficacy)
Secondary CU	Trauma-focused CBT, attachment therapy	Better if caught early (60-70%)

Common Assessment Traps

- **ASD vs CU confusion:** Both show apparent empathy deficits. Key: empathy pattern reversal (CU = affective impaired, ASD = cognitive impaired).
- **ADHD comorbidity:** Impulsivity ≠ proactive aggression. ADHD shows reactive only, CU shows both.
- **Age-inappropriate expectations:** All toddlers show limited empathy. Frequency + severity + functional impairment required for diagnosis.
- **Parent bias:** CU traits rated by interpreting behavior, not observing internal states. Cross-validate with multiple informants.

Exam Quick Reference

High-Yield Values

Heritability: 0.81-0.82 Hot children: ~70% Cold children: ~30% Sex ratio (primary): 5-10:1 M:F Sex ratio (secondary): 2:1 M:F Critical window: <age 7 Earliest intervention: age 3

Memory Aids

- **BLA vs CeA:** BLA = Broken in CU, CeA = Completely intact
- **Primary vs Secondary:** Primary = Primarily genetic, Secondary = Stress/trauma
- **Empathy patterns:** CU = Can understand, can't feel. ASD = Can feel, can't understand
- **Aggression types:** Reactive = Response. Proactive = Predatory

Common Exam Confusions

Wrong Assumption	Correct Understanding
"Psychopaths have no fear"	Unconditioned fear intact, conditioned fear impaired
"Punishment doesn't work"	Only insensitive when rewards present; actually behavioral inflexibility
"Amygdala is broken"	BLA underactive, CeA normal - differential activation
"CU = no empathy"	Cognitive empathy intact, affective empathy impaired
"High heritability = no intervention"	Early intervention still effective; developmental plasticity

Landmark Studies

Study	Year	Finding	Significance
Dadds et al.	2006	CU children don't look at eyes; instruction normalizes fear recognition	Proved attention allocation deficit, not fundamental recognition impairment
Newman et al.	2010	Directing attention normalizes conditioned fear in psychopaths	Attention modulates "fearlessness"; deficit in automatic threat detection
Cleckley	1941	Low anxiety, not antisocial behavior, as defining psychopathy feature	Established clinical description; low fear hypothesis origin
Lykken	1957	Reduced conditioned fear response in psychopathy	Empirical support for low fear hypothesis
Blair (vocal tone)	1990s	Fear and sadness recognition deficits in vocal tone	First demonstration of specific emotion recognition impairment

The Advocacy Imperative

"Who will advocate for these kids if not you?"

These children face dual disadvantage: biological vulnerabilities often paired with environmental adversity (parents with CU traits, less warm parenting). Understanding the cognitive mechanics underlying their behavior transforms them from "evil children" to children with disabilities deserving support and accommodation.

Historical Parallel: 50-100 years ago, ADHD children were "naughty kids" who got the cane. Now we recognize specific cognitive difficulties. CU traits deserve the same reconceptualization: subtle information-processing differences, not moral deficiency.

Economic Argument: Every year of delayed intervention compounds difficulties across social, educational, and family domains, making early intervention both clinically superior and economically efficient.

Developmental Insight: The behaviors look dramatic (severe violence, persistent antisocial conduct), which makes us want dramatic explanations (abuse, evil). But the actual core deficits are subtle—subtle deficits present from birth that snowball through development.

L11: Adolescent Development - Timing Mismatches & Paradoxes

Conceptual Backbone - The Fundamental Asynchrony

Central Thesis: Adolescent development = temporal mismatch between THREE systems: (1) Hormonal changes triggering sensation-seeking/reward-orientation (begins ~10.5 girls, 11.5 boys via PUBERTY), (2) Chronologically-driven cognitive control via PFC maturation (continuing through age 25), (3) Social amplification via peer influence (peaks 14-16). **The paradox:** By age 15, adolescents match adults in hypothetical risk assessment (cold cognition), yet show 2-3x higher real-world risk-taking because peer presence doubles risk-taking in adolescents but has ZERO effect on adults. **Critical error students make:** Conflating chronological age with developmental stage—a 15-year-old at Tanner 5 faces fundamentally different challenges than same-aged peer at Tanner 3, as HORMONE LEVELS (not birthdays) drive arousal/risk while cognitive control develops on fixed timeline.

Three Stages Framework

Stage	Core Challenge	Physical	Cognitive	Social
Early 10-15	Managing rapid body changes with concrete thinking	Max mismatch: adult hormones, child cognition	Minimal abstract thought	Intense but unstable friendships, mood volatility
Middle 14-17	Navigating peer influence while PFC develops	Mostly complete, limbic dominates	Abstract emerging but inefficient	PEAK peer influence, authority challenges
Late 16-19	Integrating adult capabilities, neural efficiency growing	Complete	Abstract present, PFC still maturing to 25	Individual relationships dominate, peer wanes

Exam Key: Stages overlap (fuzzy boundaries), determined by MULTIPLE indicators (Tanner stage + age + social behavior), NOT age alone. Same age = different stages based on pubertal timing.

The Expanding Maturity Gap

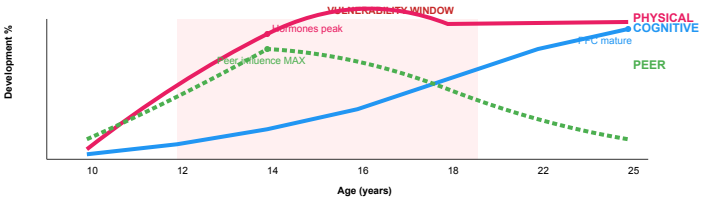
Measure	1920s	Now (2020s)	Change
Puberty onset (F)	14.6 years	10.5 years	4.1 yr EARLIER
School leaving	14 years	17 years	3 yr LATER
Employment age	14 years	17-18 years	3-4 yr LATER
NET GAP	~0 years	**~7 years**	MASSIVE EXPANSION

Consequences

- **1920s alignment:** Biology, education, work synchronized - coherent transition
- **Modern crisis:** Biological adulthood (10.5) without social recognition (17) = 7-yr frustrated maturity
- **Antisocial behavior peak 11-17:** Gang leadership provides status/respect schools can't offer biologically mature but socially restricted 14-year-olds
- **Teenage pregnancy stable (~2.5-2.8%):** 10x exposure window offset by contraception (10x window × 0.1x per-encounter risk = stable)

Theory Link: Adolescent-limited antisocial behavior (Moffitt) = rational response to irrational social structure demanding biological adults perform as children

Developmental Timelines: The Fundamental Mismatch



Maximum vulnerability: Ages 13-15, when hormonal acceleration outpaces cognitive control development. Physical changes are Tanner-stage driven (variable), cognitive changes are age-driven (fixed).

Physical & Hormonal Changes

Age	Females	Males	Both Sexes
10-11	Onset: breast buds, body shape changes	-	Adrenarche begins (body odor, pubic hair initial)
11-12	**Growth spurt PEAKS**	Testes/penis enlarge, erections + ejaculation	Bone growth > muscle = clumsiness phase
12-14	Menarche (range 8-13), cycles irregular 3-5 yrs	**Testosterone 10-fold increase** (5-50 → 220-800 ng/dL)	Appetite/sleep needs increase
14-15	Growth plates close, near adult height	**Growth spurt PEAKS**, voice changes	Secondary characteristics established
16-17	Physical maturity, regular cycles	Growth plates close, facial hair	Adult body configuration

Key Features

- **Bone > muscle growth:** Proprioception lag → clumsiness (knocking things, falling)
- **Growth spurt includes:** Height, weight, heart/lung size, muscular strength
- **Sleep needs:** 9-10 hrs (genuine biological requirement, not laziness)
- **Females 2-yr earlier:** Puberty 10.5 vs 11.5, peak growth 12 vs 14

Social consequence: Same-age classroom spans "little boys" to "men" (Year 9 photo) → differential status, sport ability, social expectations despite identical chronological age

Hormonal Cascades & Behavioral Impacts

Hormone	Change Magnitude	Behavioral Impact	Stabilization
Testosterone (M)	**10-fold:** 5-50 → 220-800 ng/dL (ages 10-14)	Aggression ↑, competitiveness ↑, sexual interest, muscle dev	~17-18 yrs
Testosterone (F)	2-fold gradual increase throughout puberty	Arousal, mild aggression increase	Cycles w/ menstruation
Estrogen/Progesterone	Cyclical, irregular 3-5 yrs post-menarche	Mood cyclicity, breast dev, fat distribution, bone density	Regular ~16-18
Growth Hormone	Peaks during spurts (F:12, M:14)	Rapid height, ↑ appetite, ↑ sleep needs	Plates close F:14-15, M:16-17

Sensation-Seeking Formula (Worked Example)

SS Score = 2.3 + (0.014 × testosterone ng/dL) + (1.2 × Tanner stage)

- **13-yr male, Tanner 3, T=326:** SS = 2.3 + 4.56 + 3.6 = **10.46** (moderate risk: skateboarding, competitive gaming)
- **15-yr male, Tanner 5, T=691:** SS = 2.3 + 9.67 + 6.0 = **17.97** (high risk: substance experimentation, dangerous driving)

Obesity link (Lee 2007): 354 girls age 3→12. Overweight girls: 80% breast dev before age 9. **Causation confirmed:** Body fatness CAUSES early puberty (not reverse), BMI triggers hormonal cascade independent of age.

Tanner Scale Assessment (1-5)

Stage	Physical Markers	Hormonal Status	Behavioral Correlates
1	Prepubertal - no development visible	Baseline hormones	Child-like behavior, low sensation-seeking
2	Initial: breast buds (F), testes enlarge (M)	Hormones rising	Mood changes begin, body image issues emerge
3	Continued dev, pubic hair increases	Mid-puberty surge	**Sensation-seeking BEGINS**, parent conflict ↑
4	Advanced, approaching adult configuration	**HIGH hormones**	**PEAK parent-adolescent conflict**, max risk-taking
5	Adult body configuration	Stabilizing (M) / Cycling (F)	Conflicts decrease, behavior stabilizes

Critical Correlations (Exam-Essential)

- **Parent-adolescent conflict:** r = 0.71 with Tanner stage vs r = 0.23 with age (HORMONES drive conflict, NOT age)
- **Sensation-seeking (11-14 yr olds):** NO correlation with age, SIGNIFICANT correlation with pubertal stage
- **Assessment method:** Self-report using visual guides (privacy-protected, non-invasive, culturally sensitive)

Clinical application: Two 14-yr females: Student A (Tanner 4, T=50 ng/dL) shows emotional volatility + conflict; Student B (Tanner 2, T=10 ng/dL) emotionally stable. Identical age, 5x hormone difference explains behavioral divergence despite cognitive equivalence.

Brain Development: Back-to-Front Maturation

Process	What Happens	Function Improved	Timeline
Myelination	White matter ↑ 1-2% annually	100-fold faster transmission, cross-region communication	Through mid-20s
Synaptic Pruning	Gray matter ↓ 1-2% annually in PFC	Signal-to-noise ratio, specialized processing	Experience-dependent, early 20s
DLPFC	Develops EARLIER (dorsolateral)	Working memory, planning, organization	Functional by ~16-18
VMPFC	Develops LATER (ventromedial)	**Risk-reward calibration**, emotion regulation	Continues through 25
PFC-Limbic Connectivity	**DECREASES with age** (negative correlation)	Emotion regulation efficiency ↑	Integration matures by early 20s

Neural Efficiency Calculation (Worked Example)

Efficiency Index = (PFC activation / Limbic activation) × (1 / Connectivity correlation)

- **Adult (emotion regulation task):** PFC=100, Limbic=80, r=0.3 → Efficiency = (100/80) × (1/0.3) = **4.17**
- **Adolescent (age 15, same task):** PFC=140, Limbic=136, r=0.7 → Efficiency = (140/136) × (1/0.7) = **1.47**
- **Interpretation:** Adolescent shows 2.8-fold LOWER efficiency despite 40% HIGHER PFC activation → effortful processing, poor outcomes

Pattern interpretation: Adolescents show DIFFUSE, HIGH activation (inefficient effort). Adults show FOCAL, LOW activation (efficient processing). More activation ≠ better function in developing brains.

Executive Function Development

Function	Age Trajectory	Brain Region	Exam Example
Response Inhibition	Anti-saccade errors ↓ linearly age 6→23	DLPFC	Stroop task: interference ↓ age 7→12
Stop-Signal RT	Shorter delays with age (better braking)	DLPFC, ACC	Impulse control improves steadily
Verbal Fluency	Linear increase age 6→14	Frontal cortex	"Name farm animals in 1 min" - more with age
Iowa Gambling	Good deck choices: 50%→55%→75% (ages 6→15→25)	**VMPFC**	Risk-reward calibration matures LATE
Social Processing	Emotion extraction efficiency ↑, mPFC-STS connectivity ↓	STS, TPJ, mPFC	"Are you giving me evils?" - paranoia in mid-adolescence

Iowa Gambling Task Detail

- **Advantageous decks (C,D):** Win $50/choice, occasional losses → net positive
- **Disadvantageous decks (A,B):** Win $100/choice BUT larger occasional losses → net negative
- **Age 6-9:** Draw equally from all decks (can't figure it out)
- **Age 10-15:** 55-60% from good decks by final block (learning)
- **Age 18-25:** 75% from good decks (mature calibration)

Chronological development: Executive functions are AGE-linked (NOT hormone-linked). DLPFC develops earlier than VMPFC → can plan complex behaviors but misjudge risk-reward balance.

The Adolescent Paradox: Cold vs Hot Cognition

Domain	Cold (Hypothetical Lab Tasks)	Hot (Real-World Social Contexts)	Why Disconnect?
Risk Recognition	Match adults by age 15	Enter dangerous situations 2-3x more than adults	Reward salience overwhelms risk recognition
Probability Estimation	Calculate odds correctly by 16	Take low-prob/high-consequence risks more often	Present-bias stronger, steep future discounting
Consequence Awareness	Articulate comprehensive negative outcomes	Proceed despite knowing consequences	Peer presence shifts cost-benefit toward risk
Safety Strategies	Propose appropriate protective behaviors	Fail to implement known behaviors	Implementation requires exec control (immature)

Hot vs Cold Decision-Making Formula (Worked Example)

Actual Resistance = Cold Knowledge × (1 - Peer Influence) × Executive Control Maturity

- **Scenario:** Texting while driving (16-year-olds)
- **Cold assessment (classroom):** 95% correctly identify 23x crash risk, 1-in-4 annual accident chance
- **Hot context (driving with texting friends):** Only 35% resist texting
- **Calculation:** 0.95 × (1 - 0.60) × 0.50 = 0.95 × 0.40 × 0.50 = **0.19 (19% resistance)**
- **Gap quantification:** 76% difference between knowing (95%) and doing (19%) = THE PARADOX

Intervention implication: Education about risks is INEFFECTIVE (adolescents already know). Need environmental modifications that bypass executive control requirements (phone-disabling apps, speed alerts to parents) to address hot contexts where failures occur.

Social Environment as Amplifier

Age Group	Alone	With Friends	Peer Effect	Mechanism
Adolescents 13-16	1.3 risky restarts	~3.0 risky restarts	**2.5x increase**	Peer approval activates ventral striatum (reward); evaluation anxiety overwhelms PFC
Youths 18-22	1.3	~2.0	1.75x increase	Declining but still present peer sensitivity
Adults 24+	1.3	1.3	**NO effect**	Mature PFC-limbic integration resists social influence

Mechanisms of Peer Amplification

- **Social reward:** Peer approval activates SAME ventral striatum regions as monetary rewards
- **Evaluation anxiety:** Social performance monitoring consumes cognitive resources (30% exec function decline)
- **Conformity pressure:** Bypasses individual decision-making entirely (76% conform at 14 → 42% at 18 → 28% adult)
- **Specificity:** PEER presence triggers effect (not parents) - social exclusion activates physical pain circuits more strongly in adolescents

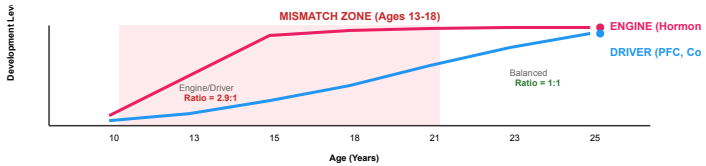
Peer Influence Magnitude Formula (Worked Example)

Risk = Base × (1 + Peer Effect)^n where n = number of using friends

- **15-yr-old, marijuana decision:** Base = 15%
- **One using friend present:** 15% × (1 + 1.5) = **37.5%**
- **Three using friends:** 15% × $(2.5)^3$ = **234%** (capped ~90% practically)
- **Same adult (age 30):** Base 15% REMAINS 15% regardless of peer presence

Intervention strategy: Can't eliminate peer influence (isolation paradoxically increases power). Must leverage it positively: train popular students as peer educators, ensure prosocial models have high status, create contexts where positive behaviors earn peer respect.

Powerful Engine, Unlicensed Driver



Engine-Driver Ratio (Worked Example)

Engine Power = (T-level/Adult) × (Dopamine-sens/Adult) | Driver = (PFC-myelin/Adult) × (Exec-score/Adult)

- **14-yr male:** Engine = (400/600) × (1.7/1.0) = 0.67 × 1.7 = **1.14**
- **14-yr male:** Driver = (0.65/1.0) × (0.60/1.0) = **0.39**
- **Mismatch ratio:** 1.14 / 0.39 = **2.92** (nearly 3x more acceleration than braking)
- **Age 25:** Engine = 1.0, Driver = 1.0, Ratio = **1.0** (balanced)

1920s vs Now Comparison

Era	Pattern	Risk Level
1920s	Engine started midway through driver training	Lower - systems more aligned
Now	Engine FULL POWER before driver training begins	Higher - 7-yr asynchrony gap

Intervention approach: Can't suppress engine (compression increases explosive potential). Can't expect premature driver competence (biological reality). Must provide external scaffolding: graduated privileges, structured environments, supervised practice in controlled risk contexts.

Systems Integration: Multi-Domain Vulnerability

System Interaction	Vulnerability Created	Peak Risk Period	Protective Factors
Hormones × Cognition	Knowing risks but taking them anyway; emotional decisions despite logical knowledge	Tanner 3-4 + age 13-15 (high hormones, low control)	Structured environments that externally limit options
Hormones × Social	Risk-taking specifically in social contexts; peer contagion effects	Ages 14-16 when peer orientation highest	Positive peer groups, adult supervision of peer interactions
Cognition × Social	Immature cognition can't resist social pressure; poor social decision-making	Early adolescence before abstract thinking develops	Social skills training, practice in low-stakes contexts
All Three Systems	Multiplicative vulnerability; cascading failures (one bad decision → worse situations)	Age 14-15 with early puberty + high peer exposure	Multi-domain support addressing all systems simultaneously

Three-System Risk Calculation (Worked Example)

Total Risk = Biological × (1 - Cognitive) × Social

- **Party scenario, early-maturing 14-yr:** Bio(Tanner 4) = 0.8, Cog(age 14 exec) = 0.4, Social(5 peers) = 2.0
- **Calculation:** 0.8 × (1-0.4) × 2.0 = 0.8 × 0.6 × 2.0 = **0.96 (96% risky behavior probability)**
- **Same party, late-maturing 14-yr:** Bio(Tanner 2) = 0.3, Cog = 0.4, Social = 2.0 → Risk = **0.36 (36%)**
- **Same party, 14-yr alone:** Bio = 0.8, Cog = 0.4, Social = 1.0 → Risk = **0.48 (48%)**

Why Adolescence Is Hard (Exam Summary): (1) Layers of change - simultaneous physical/cognitive/emotional, (2) Different rates - chronological vs hormone-linked, (3) Peer variability - same age spans Tanner 2-5, (4) Societal mismatch - look like adults, lack control, (5) Historical expansion - 7-yr gap between biology and permission.

Hormonal vs Cognitive: Two Independent Timelines

Domain	Driven By	Correlation	What It Predicts
Physical changes	**HORMONES** (Tanner stage)	-	Body development, growth spurts, secondary sex characteristics
Parent conflict	**HORMONES** (Tanner stage)	**r = 0.71**	Argument frequency, emotional volatility
Sensation-seeking	**HORMONES** (pubertal stage)	No corr w/ age in 11-14 sample	Risk-taking propensity, novelty pursuit
Arousal/Reward	**HORMONES** (dopamine, testosterone)	-	Motivation intensity, competitive drive, sexual interest
Executive functions	**AGE** (chronological)	Linear improvements	Working memory, planning, inhibition, organization
Abstract thinking	**AGE** (PFC development)	Emerges mid-adolescence	Hypothetical reasoning, future planning, meta-cognition
Emotion regulation	**AGE** (PFC-limbic connectivity)	Decreasing connectivity w/ age	Control over emotional responses, impulse management
Parent conflict (age)	Age (for comparison)	**r = 0.23**	Weak predictor compared to hormones

Critical Insight for Exams

- **Two independent timelines:** Hormonal (variable onset, Tanner-linked) + Cognitive (fixed, age-linked)
- **Early maturers (worst vulnerability):** High hormones (Tanner 4-5) while cognitive control immature (age 13-14) = maximum mismatch
- **Late maturers (lower risk):** Cognitive control develops first (age 15-16) before hormone surge (Tanner 3) = better balance
- **Same-age variability:** Two 14-year-olds can differ by 4.1 years in biological maturity (early vs late puberty onset)

Exam Quick Reference & Common Confusions

High-Yield Facts

- **Puberty onset:** F: 10.5, M: 11.5 (NOW) vs 14.6 (1920s) = 4.1 yr earlier
- **Growth spurt peaks:** F: 12, M: 14 (2-yr sex difference)
- **Testosterone increase (M):** 10-fold (5-50 → 220-800 ng/dL), ages 10-14
- **PFC maturation:** Continues through age 25 (not finished at 18)
- **DLPFC before VMPFC:** Working memory develops before risk-reward calibration
- **Peer effect magnitude:** 2.5x adolescents (13-16), 1.75x youths (18-22), 1.0x adults (24+)
- **Parent-adolescent conflict:** r=0.71 Tanner stage vs r=0.23 age
- **Iowa Gambling:** 55-60% good choices (10-15 yrs) → 75% (18-25 yrs)
- **Maturity gap:** 0 years (1920s) → 7 years (now)
- **PFC-limbic connectivity:** DECREASES with age (more efficient when lower)

Common Exam Confusions

Wrong Assumption	Correct Understanding
Age predicts pubertal stage	Same age can span Tanner 2-5 (4+ yr biological difference)
Adolescents don't understand risks	Cold cognition INTACT by 15 - problem is hot implementation
More brain activation = better	DIFFUSE high activation = inefficient; FOCAL low = mature
Higher PFC-limbic connectivity = better	LOWER connectivity = more efficient (negative correlation with age)
Education reduces risk-taking	Ineffective - need environmental restructuring for hot contexts
Eliminate peer influence	Can't eliminate - must channel positively via prosocial models
Brain mature at 18	PFC continues developing through 25, especially VMPFC
Testosterone spike at age 3-4	FALSE - no evidence; single prenatal spike + adolescent only

MCQ Decision Trees

- **If question about conflict/sensation-seeking:** Look for TANNER STAGE (not age)
- **If question about executive function/planning:** Look for AGE (not puberty)
- **If hypothetical scenario with good reasoning:** Cold cognition intact (DLPFC)
- **If real-world poor decision with peers:** Hot cognition failure (VMPFC + social amplification)
- **If intervention for risk-taking:** Environmental modification (not education)
- **If same-age behavioral differences:** Check pubertal stage differences

Social-Emotional Processing Development

Skill	Developmental Change	Neural Substrate	Clinical Manifestation
Facial expression reading	Continues improving through adolescence (ERP latency ↓)	STS, fusiform gyrus, amygdala	Difficulty extracting relevant cues from peer faces
Biological motion processing	Fronto-temporal pathway maturation age 10-19	Left STS pathway	Reading body language, posture meaning
Mentalizing (ToM)	mPFC-STS/TPJ connectivity DECREASES with age	arMPFC, STS, TPJ	Understanding others' mental states, intentions
Emotion discrimination	Efficiency ↑ as limbic-PFC integration improves	Amygdala, VMPFC, ACC	"Are you giving me evils?" - paranoia in mid-adolescence
Social vs basic emotions	High mPFC-STS coactivation in adolescents (inefficient)	mPFC, STS mentalizing network	Embarrassment, social anxiety require more neural effort

Neural Efficiency Pattern

- **Adolescent pattern:** HIGH connectivity between cognition (PFC) and emotion (STS/limbic) = systems interfere with each other
- **Adult pattern:** LOW connectivity = independent, efficient processing
- **Age-related DECREASE in connectivity = GOOD** (negative correlation = maturation)
- **Mid-adolescence turbulence:** Decision-making interferes with emotion recognition and vice versa

Clinical example: "She's looking at me funny" - inability to extract relevant social cues + abstract thought capability ("maybe she's thinking about me") + hormonal drive for social status = middle adolescence friendship turbulence.

Learning Outcomes Integration

LO1: Comprehensive Understanding of Changes

- **Physical/hormonal (Tanner-linked):** Testosterone 10-fold ↑, estrogen cyclicity establishes 3-5 yrs, growth spurts F:12/M:14
- **Cognitive (age-linked):** Executive functions linear progression, DLPFC before VMPFC, continues to 25
- **Asynchrony evidence:** Iowa Gambling 55%→75% (ages 10-15→18-25) while sensation-seeking correlates with Tanner NOT age

LO4: Environmental Interaction & Well-Being

- **Peer presence doubles risk-taking:** 2.5x in adolescents (13-16) vs NO effect in adults (24+)
- **Social context amplifies hormonal drives:** Before cognitive control matures, creating vulnerability
- **Well-being impacts:** Increased family conflict (r=0.71 with Tanner), peer influence vulnerability (conformity 76%→28% across development), maturity gap frustration (biology 10.5, permission 17)
- **Modern challenges:** 7-yr gap between readiness and permission, earlier puberty (obesity link), prolonged educational dependence

Answer structure for LO questions: (1) Identify which timeline (hormonal vs cognitive), (2) Specify measurement/correlation, (3) Link to behavioral outcome, (4) Note interaction with social/environmental context.

Intervention Implications Summary

Problem	Why Education Fails	Effective Approach
Risky driving	Already know risks (cold cognition intact)	Phone-disabling apps, speed alerts, graduated licensing
Substance use	Peer presence overwhelms individual knowledge	Train popular students as peer educators, prosocial status models
Antisocial behavior	Stems from maturity gap (status-seeking), not ignorance	Legitimate pathways to adult status/respect within age constraints
Parent conflict	Hormonally driven (r=0.71 Tanner), not cognitive deficit	Recognize as normal, adjust expectations to pubertal stage not age
Peer influence	Can't eliminate (evolutionary social sensitivity)	Channel positively via structured peer activities, adult mentorship

Multi-System Intervention Principles

- **Biological:** Adequate sleep (9-10 hr), nutrition, exercise to optimize development
- **Cognitive:** Scaffold executive function through structure, practice in low-stakes contexts
- **Social:** Engineer positive peer contexts, adult supervision, prosocial high-status models
- **Environmental:** Graduated privileges matching demonstrated competence, external structure compensating for immature internal control

Best comprehensive approach: Structured after-school programs combining positive peer activities (leverage social motivation) + adult mentorship (external scaffolding) + skill-building (cognitive development) - addresses all three systems simultaneously.

L12: Adult-Child Interaction - Theory & Practice

CENTRAL THESIS: The four principles (Consent, Comfort, Reliability, Do No Harm) form a hierarchical decision structure where context doesn't just modify application—it fundamentally redefines meaning. Consent in research (parent signs, child assents) transforms into rights-based architecture in forensic contexts (freedom to speak vs understanding of rights) and mutates again in clinical settings (engagement vs refusal as therapeutic data). **Context-dependency is the critical hinge**: a child's silence in research signals withdrawal of assent (stop immediately), in forensic interviews preserves legal rights (document and respect), and in therapy becomes clinical information itself (explore gently). Same behavior, opposite responses based on professional context.

Four-Principle Architecture

Principle	What It Gates	Context Transformation	Failure Mode
1. CONSENT	Whether interaction proceeds at all	Written forms (research) → Miranda-like rights (forensic) → therapeutic contracts (clinical)	Legal liability, invalid data, ethical violations
2. COMFORT	Quality and quantity of information obtained	Physical environment (research) → trauma-informed spaces (forensic) → therapeutic milieu (clinical)	Reduced disclosure, defensive responding, session termination
3. RELIABILITY	Validity of conclusions drawn	Inter-rater reliability (research) → legal admissibility (forensic) → clinical utility (therapeutic)	False positives, wrongful convictions, misdiagnosis
4. DO NO HARM	Justification for any intervention	Minimal risk (research) → justice (forensic) → therapeutic benefit (clinical)	Retraumatization, developmental disruption, trust erosion

EXAM KEY: Principles form hierarchical dependency chain—consent gates all interaction, comfort enables data collection, reliability justifies interaction, harm prevention validates purpose. Failure at any level cascades downward.

Consent: Tripartite Architecture

Context	Primary Consent	Child Override?	Refusal Signals	Proceeding Without = ?
Research	Parent (consent) + Child (assent)	**YES** - child refusal overrides parental consent	Verbal "no", behavioral withdrawal, distress signals, looking at door	IRB violations, data inadmissible, potential assault charges
Forensic (Witness)	Child has autonomous rights	N/A - child is primary agent	Silence, "I don't want to talk"	Violated testimony inadmissible, mistrial potential
Forensic (Suspect)	Child + Guardian + Legal counsel	Complex - depends on competency	Request for parent/lawyer, silence	Miranda violations, confession excluded, case dismissal
Clinical	Parent/Guardian (unless emancipated)	Cannot override but can refuse participation	Non-engagement, selective mutism, behavioral resistance	Cannot force treatment, document refusal, consider mandated reporting if neglect

Research Consent Specifics

- **Age 8-9+:** Written consent form; **Younger:** Verbal assent ("Do you want to play this game now?")
- **Informed Check:** "Tell me what we're doing today" (child repeats back)
- **Explaining vs Cajoling:** Explain = "Task takes 20 minutes on computer"; Cajole = "Super fun task! Really quick!"
- **Incentivizing vs Bribing:** Incentive = "Thanks for concentrating, here's a sticker"; Bribe = "If you complete, I'll give you a sticker"
- **Essential Details:** Where? Parents present? Camera/recording? Toilet access? Fed/hydrated recently?

Comfort: Five-Factor Model

Factor	Problem Solved	Implementation	Success Marker
Familiarity	Novelty-induced stress suppressing recall	Pre-meeting tour, multiple sessions, consistent location	Child initiates conversation, explores space independently
Environment	Physical discomfort disrupting attention	Child-sized furniture, clear exit paths, soundproofing	Child settles physically within 5 minutes
Explanation	Uncertainty anxiety blocking disclosure	Explicit process maps, duration clarity, role definition	Child can repeat back what will happen
Affect	Adult emotional leakage contaminating responses	Video self-review, neutral responding, matched energy	Child mirrors your emotional state
Language	Comprehension mismatches creating false data	Vocabulary matching, "own words" encouragement, no jargon	Child uses their natural vocabulary freely

MULTIPLICATIVE EFFECTS: Excellence in 4 factors cannot compensate for failure in the 5th. All must be optimized.

Comfort: At-Risk Children Protocols

Language Calibration

- Match age/mental age (not just chronological)
- Professional boundary maintained, but not distant
- "Use your own words" - encourage their vocabulary
- **Don't try to be cool** - children detect inauthenticity immediately

Spatial Dynamics (CRITICAL)

- **Personal Space:** Outside elbow range (interpersonal space boundary)
- **If Child Violates:** "I need you to step back to here" (no judgment, just boundary)
- **CHAIR 2 RULE (At-Risk Kids):**
  - Chair 1 (closest): Blocks exit → triggers trapped feelings → avoid
  - Chair 3 (farthest): Too much distance → enables flight response → avoid
  - **Chair 2 (optimal):** Accessible exit (reduces anxiety) + engagement distance (maintains connection)

Body Language & Affect

- Engaged with child, relaxed posture, professional distance
- **Neutral responding to disturbing content** (video self-review essential)
- Predict behavior: identify trauma triggers, read body language continuously
- **Ask for help from senior staff** - not expected to know intuitively

Honesty vs Transparency

- **Honest:** "Task takes 20 minutes, then you're free to go"
- **Transparent (better):** "Takes about 20 min; some kids finish in 10, some take 40"

Example from transcript: Student asks "What would you do if I raped you?" → Instructor reframes to duty of care, not literal threat interpretation. Troubled children test boundaries through provocative statements requiring decoding, not literal response.

Reliability: Quantity vs Veracity

Core Tension: Techniques that maximize quantity (repeated questions, suggestion, pressure) systematically degrade veracity through contamination. Conversely, techniques protecting veracity (open-ended prompts, free recall) often yield insufficient detail. **Hierarchy:** Veracity must be preserved even at cost of quantity (elaborate false information worse than sparse truth).

Technique	Quantity Effect	Veracity Effect	When Justified
Free Recall ("Tell me everything")	Low yield, high relevance	Maximum accuracy, minimal contamination	**ALWAYS first, exhaustively**
Cued Invitations ("Tell me about [child's word]")	Moderate yield, maintains narrative flow	High accuracy if using child's language	After free recall exhausted
Directive Questions ("Where/When/Who")	High yield for specific details	Moderate risk on peripheral details	For critical missing information only
Option-Posing ("Was it X or Y?")	Forces choice, guarantees response	High contamination risk, suggestion effects	Last resort for essential facts
Suggestive Questions ("He touched you, didn't he?")	Appears to confirm suspicions	**Destroys veracity, creates false memories**	**NEVER justified - forensically inadmissible**

Maximizing Quantity (Within Veracity Constraints)

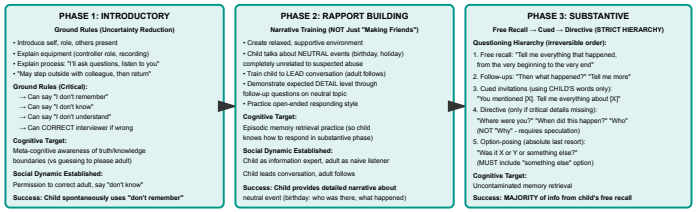
- Build rapport thoroughly before substantive questions
- Take breaks (prevent cognitive fatigue degrading accuracy)
- Inform child of duration honestly and transparently
- Discuss completion options with child (autonomy increases cooperation)

Quality Threats

- Developmental understanding of truth vs falsehood
- Authority effect (desire to please adult interviewer)
- Expectation of "right answer" (creates false confirmation)
- Influence of others pre-interview (witness contamination)

NICHD Protocol: Contamination Prevention System

Developer: Prof. Michael Lamb, Cambridge | **Team:** Developmental psychologists, linguists, police, legal professionals | **Evidence:** NICHD-trained interviewers elicit **4-5x more details via free recall** vs standard interviews, with significantly lower error rates
Core Insight: Order of question types is **irreversible**—once suggestive question asked, contamination cannot be undone by returning to open-ended prompts.



EXAM CRITICAL: Cannot skip phases or reverse order. Contamination is permanent—no mechanism to "clean" contaminated testimony. Prevention is only strategy.

Do No Harm: Active Engineering

Not passive avoidance but active engineering of protective structures. Two categories: interactional harm (boundary violations, inappropriate dynamics) and data-related harm (contamination, false confirmation). Harm in either category invalidates entire interaction's purpose.

Harm Category	Manifestation	Prevention Strategy	Repair Strategy (if occurs)
Interpersonal Space Violation	Child enters personal space (inside elbow range)	Furniture arrangement, clear verbal boundaries upfront	Name without judgment: "I need you to step back to here"
Role Confusion	Child seeks friendship/parental relationship	Consistent professional language, clear role definition	Explicitly restate professional boundaries and purpose
Secret-Keeping Requests	Child asks you not to tell parents/authorities	Upfront transparency about reporting obligations	Explain exactly who will know what and why
Confirmation Bias Display	Your face/body shows reaction to disturbing content	Video self-review, practice neutral responding	**Cannot be repaired—contamination is permanent**
Assuming Understanding	Child nods along without comprehension	Comprehension checks: "Tell me what we're doing today"	Return to explanation, use simpler language

Interaction Don'ts

- Don't talk about child when in earshot (even age 2 understands more than you think)
- Don't pretend to know things you don't—children detect bluffing immediately
- Don't keep secrets—explain confidentiality limits and reporting obligations upfront
- Don't cause fear/concern through emotional reactions to disturbing content

Data-Related Don'ts

- Don't presume debriefing not required (ethical obligation to explain what/why)
- Don't guess child's answer then confirm ("Do you mean cat?")
- Don't provide answer and look for confirmation

Boundary Testing: Troubled children test boundaries as information-seeking behavior. Your response shapes child's template for adult trustworthiness. Example: "Can I have your phone number?" → Response: "I'm glad you feel understood. In our work together, we meet here at scheduled times" (validates feeling while maintaining professional boundary).

Context-Specific Response Decision Tree

Master Decision Sequence: (1) Identify context (researcher/forensic/clinician), (2) Identify principle at stake (consent/comfort/reliability/harm), (3) Apply context-specific operational definition, (4) Select response preserving highest-priority principle. **Hierarchy is non-negotiable:** Cannot trade consent for reliability or comfort for completeness.

Situation	Research Response	Forensic Response	Clinical Response
Child becomes silent mid-session	Check continued assent: "Do you want to continue or stop now?"	Document silence, remind of rights: "Remember you don't have to speak if you don't want to"	Explore resistance as data: "I notice it became quiet. What's happening for you right now?"
Child provides concerning information (abuse disclosure)	Follow mandatory reporting protocols post-session (don't alert child mid-session)	Continue interview without emotional reaction, document precisely (neutral affect critical)	Assess immediate safety, may need to break confidentiality (explain who will know)
Parent wants to be present during interaction	Generally allow unless methodologically problematic (parental influence on responses)	Typically exclude to prevent contamination (parent cues can influence testimony)	Assess clinically—may indicate family dynamics issues worth exploring
Child asks you personal questions	Brief, professional response, redirect to task: "I like dogs. Now let's continue with..."	Minimal response: "We're here to talk about you, not about me"	Consider therapeutic meaning of question, limited self-disclosure if clinically indicated
Child shows increasing distress	Stop immediately, check welfare, offer withdrawal option (consent can be withdrawn anytime)	Pause, assess child's state, may need break (balance with need for timely evidence)	Normalize emotion: "This is hard. Your feelings make sense. We can slow down"
Child gives minimal detail to open-ended prompts	Continue open prompts, accept minimal data (cannot pressure for more)	Exhaust cued invitations using child's words, then directive questions if critical details missing	Explore resistance: "I notice you're giving short answers. What makes it hard to talk about?"

EXAM SCENARIO PATTERN: Same surface behavior → Opposite responses based on context. E.g., child silence: Research = stop immediately (withdrawn assent), Forensic = document and respect (exercising rights), Clinical = explore gently (therapeutic data).

Career Pathways & Skill Translation

Critical Insight: 79% of Relevant Jobs Don't Mention "Psychology"

Employers desperately seek psychology graduates' skills but don't know how to request them. Strategic graduates reverse-engineer position requirements to demonstrate skill alignment, not waiting for "psychology" in job postings.

Your Psychology Skill	How Employers Describe It	Where Desperately Needed	What They Don't Know They Need
Statistical Literacy	"Data-driven decision making"	Consulting (PWC), Market Research, UX	Someone who spots misleading statistics
Scientific Skepticism	"Critical thinking," "analytical skills"	Policy Analysis, Journalism, Defence Intelligence	Immunity to confirmation bias
Behavioral Observation	"Stakeholder management," "user research"	Child Protection, Teaching, Police	Reading nonverbal distress signals
Research Methods	"Project management," "evaluation"	NGOs, Government, Healthcare	Designing unbiased assessment protocols
Interpersonal Calibration	"Communication skills," "rapport building"	Genetic Counseling, Social Services, Medicine	Adjusting interaction style to cognitive level

Career Planning Framework (3 Options)

- **Option 1:** Really good Honours mark → Clinical/Forensic psychology pathway (registered psychologist)
- **Option 2:** Honours (mid-range) → Alternative psych roles, specialized training (e.g., genetic counseling, neuropsych assistant)
- **Option 3:** Without Honours / Don't want Honours → Direct entry roles (see below)
- **It's OK to not have a plan!** Sometimes no plan creates unexpected opportunities (instructor worked 4 years between undergrad and PhD in unplanned roles that shaped career)

Careers Actively Seeking Psychology Grads

Represented at L12 Careers Event

- **Consulting:** PWC (data-driven decision making, stakeholder management)
- **IDcare:** Identity theft counseling (crisis intervention, behavioral patterns)
- **ARTD Consultants:** Mental health consultancy with government (evaluation, program design)
- **Defence (Army): Pays for clinical masters in exchange for service period!**
- **Genetic Counselor:** Counseling for genetic disorders/susceptibility (grad entry masters)
- **Speech Pathology, OT:** Grad entry masters (shift focus but leverage psych knowledge)
- **Teaching:** Graduate entry education (child development expertise valued)
- **Journalism:** Investigative journalism, science communication (critical thinking, research methods)
- **Social Services / Child Protection:** Case management, assessment (behavioral observation)
- **NSW Police:** Specialist roles (child protection officers, forensic interviewers, youth liaison)
- **Graduate Medicine:** Re-shift to medical training (psychology background valued)
- **School Counselor:** Non-clinical pathway (doesn't require clinical masters in some states)

HIDDEN JOB MARKET EXAMPLE: Juvenile justice and child protection advertise "social work or sociology backgrounds" but actively prefer psychology graduates. Why? Superior understanding of developmental trajectories, trauma responses, evidence-based interventions. **Strategic response:** Apply anyway, translate skills—"child development expertise" becomes "understanding of at-risk youth trajectories."

Practical Preparation for Child-Work Careers

Essential Credentials (Obtain Now)

- **Working With Children Check** - Can obtain anytime, required for ALL child-work jobs
- **Criminal Records Check** - Required for ALL child-work jobs
- **Child Protection Training** - Available through various providers, demonstrates commitment

Skill-Building Activities

- **Volunteer:** After-school care, community programs, sports coaching
- **Babysit:** Counts as genuine experience (develop rapport, manage behavior, respond to distress)
- **Role-play with peers:** Practice interviewing techniques, consent processes, boundary-setting
- **Video yourself interacting:** Watch for unconscious behaviors (facial reactions, body language, verbal tics)
- **Be positive role model:** Kids may see you as hero—manage behavior accordingly (e.g., don't smoke where visible, model emotional regulation)

Professional Development

- Manage own emotions and behavior (self-regulation essential for child work)
- Practice neutral affect responding (especially for forensic/research contexts)
- Develop age-appropriate language calibration (match child's developmental level)
- Learn trauma-informed practices (understand triggers, space management, safety)

Building Experience Portfolio

- **Research Assistant:** Child development labs (consent processes, behavioral coding)
- **Youth Mentoring:** Big Brothers Big Sisters, community programs
- **Educational Support:** Tutoring, homework clubs, literacy programs
- **Recreation Programs:** YMCA, Scouts, sports teams (group management skills)

Career Navigation Strategy: Psychology skills desperately needed but poorly understood in job market. Requires active translation rather than passive matching. Don't ignore job descriptions just because they don't say "psychology"—79% of relevant positions don't mention it!

L13: Juvenile Justice Systems

Key Concepts & Definitions

Term	Definition
Minimum Age of Criminal Responsibility	Absolute threshold (10 years in NSW) below which no child can be prosecuted for any offense; requires welfare response instead
Doli Incapax	Latin: "incapable of wrong." Rebuttable presumption ages 10-14 that child lacks criminal capacity unless prosecution proves they knew act was seriously wrong (not merely naughty)
Remand	Pre-trial detention while awaiting court proceedings or bail determination; legally presumed innocent but held in custody
Sentenced Detention	Post-conviction custodial punishment ordered by magistrate; reserved for serious/repeat offending after alternatives exhausted
Diversion	Police discretion to keep youth out of court through cautions or youth justice conferences; 70% don't reoffend
Crossover Kids	Young people cycling between child protection (out-of-home care) and youth justice systems; high overlap population
FASD	Fetal Alcohol Spectrum Disorder; neurodevelopmental impairment from prenatal alcohol exposure; vastly overrepresented in custody
Justice Cascade	Cumulative filtering process where Indigenous youth face higher punitive outcomes at each decision stage (proceed, convict, remand, sentence)
Age Crime Curve	Peak offending years typically 17-24; most young offenders "age out" of crime without intervention
Performance Crime	Offending amplified for social media documentation (filming victims, high-speed chases); post-COVID phenomenon increasing in regional NSW

Critical Legal Distinctions

Comparison	Minimum Age (10)	Doli Incapax (10-14)
Nature	Absolute bar to prosecution	Rebuttable presumption of incapacity
Burden	None - age alone determines	Prosecution must prove beyond reasonable doubt
Evidence Required	Birth certificate	Moral understanding (not just illegality knowledge)
Post-2016 Impact	No change in NSW (other states raised)	Evidentiary bar raised (harder to convict)
Outcome if Not Met	No charges; welfare referral	Not guilty verdict; exits justice system

Exam Trap: "Knew it was illegal" vs. "Knew it was gravely wrong" - only moral culpability (latter) rebuts doli incapax post-2016 High Court ruling.

Custody & Cost Statistics

235 young people in NSW custody on any night (76% remand, 24% sentenced)
$1 million per youth per year (vs. $80k-$200k for adults)
6 youth justice centers, 250 staff per 70-bed center
50% adult recidivism within 2 years (poor ROI despite high cost)

Filtering Pyramid (NSW 2024)

- 21,400 young people proceeded against by police
- 11,400 went to court (rest diverted)
- 225 in custody on any night
- Only 53 serving sentenced detention

National Context

- ~1000 youth in custody Australia-wide
- Queensland highest (300), NSW second (235)
- Separate facilities from adults (contamination prevention)

Indigenous Overrepresentation

8% of NSW youth population = 60% of custody population (7.5x overrepresentation)

System Stage	Indigenous %	Rate Multiplier
Police court actions	57%	16x higher
Found guilty	53%	16x higher
Bail refused (remand)	70%	29x higher
Sentenced custody	57%	17x higher
Out-of-home care	—	7-8x higher

Worsening Despite Closing the Gap: Justice metrics deteriorating, not improving, suggesting system bias + insufficient justice-specific interventions.

Health Survey Data - Trauma Pathways

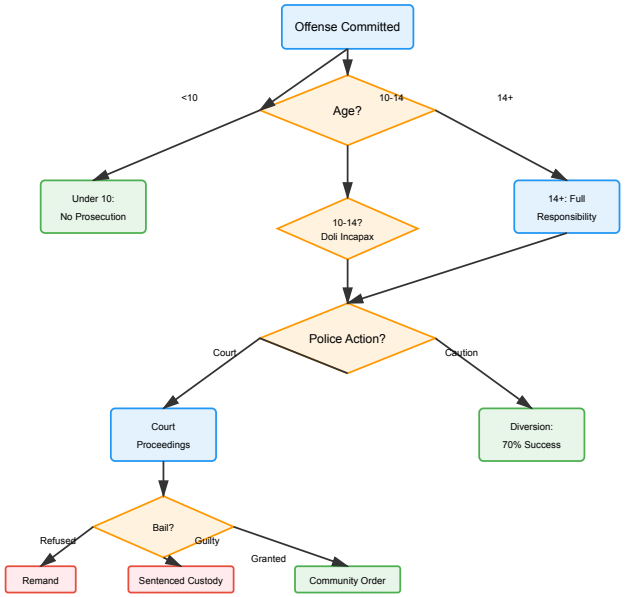
Three waves of detention health surveys (2003, 2009, 2015) show cumulative disadvantage:

Risk Factor	% in Custody	Notes
Out-of-home care history	40-50%	10x community rate
Parental incarceration	50-60%	Intergenerational cycling
Witnessed domestic violence	70-80%	Normalized violence exposure
Substance dependence	60-70%	Self-medication + boredom
Neurodevelopmental impairment	High (FASD epidemic)	Historically under-diagnosed
De-schooled before 16	Majority	Schools exclude, don't retain
Head injuries	High prevalence	Linked to impulsivity, violence

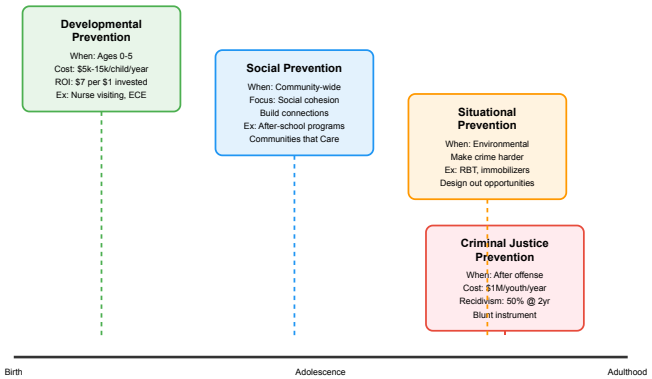
Young Women in Custody (Hyper-Marginalized)

- ~15 girls (2015) down to ~6 currently
- Higher rates: out-of-home care, abuse, self-harm, suicide ideation
- Many pregnant before 14
- System designed for boys; interventions don't translate

Youth Justice Decision Flowchart



Four Prevention Models - Timing & Impact



Policy Tension: Prevention operates on generational timescales (lag 10-15 years) while punitive responses satisfy immediate political demands. Current system invests at wrong end (criminal justice) despite poor ROI.

Diversion vs. Court Processing

Diversion (70% Success Rate)

- **Police Caution:** 15-min warning at station; cheap, effective for first-time minor offenses
- **Youth Justice Conference:** Restorative justice; victim participation; community service/apology outcomes
- **Eligibility:** Lower-order offenses, limited history, child admits offense
- **Philosophy:** Avoid labeling, maintain school attendance, prevent system contamination

Court Processing

- **When:** Serious offenses, repeat offending, diversion failed/refused
- **Outcomes:** Not guilty (doli incapax), good behavior bonds, community service, supervision orders, detention
- **Detention Criteria:** Repeat serious offending, violent crimes, alternatives exhausted

Remand Crisis: Indigenous youth 29x more likely to have bail refused due to homelessness (no fixed address), prior breaches, perceived risk coding disadvantage as danger.

Evidence for Rebutting Doli Incapax

Evidence Type	What Courts Look For	Insufficient (Post-2016)
Verbal Statements	"I knew it was really wrong and would hurt them"	"I knew it was illegal" (factual only)
Concealment	Hiding evidence, lying to police (suggests shame/guilt)	Simple fleeing (could be fear, not moral understanding)
Prior Contact	Multiple police interactions showing system awareness	Single prior diversion (developmental variability)
Victim Awareness	Understanding harm inflicted (psychological, physical)	Generic knowledge "stealing is bad" (abstract only)

Critical Distinction: Knowing legal consequences vs. understanding moral gravity. Post-2016, only latter rebuts doli incapax.

Offending Trends - Post-COVID Changes

15-Year Decline (to 2020)

- Prolonged reduction in youth crime rates
- Flattening of age-crime curve
- Custody numbers historically low

Post-COVID Spike (2020+)

- Rapid increase in certain offenses (motor vehicle theft up 120% in regional NSW)
- Younger offenders (including under-10s)
- **Performance crime:** Filming victims, high-speed chases for TikTok, armed home invasions for social media theater
- Police report 7-8 kids in stolen cars, some as young as 6-7, driven by 14-year-old at 200+ km/h

Offense Type Distribution

- Spectrum: Very minor (graffiti) to very major (murder, terrorism)
- Most: Middle range (theft, assault, property damage)
- Custody houses all types - contamination risk

Exam Quick Reference - Key Numbers

Metric	Value
NSW custody (any night)	235 youth (172 remand, 53 sentenced)
Australia-wide custody	~1000 youth
Cost per youth per year	$1 million
Cost per adult per year	$80k-$200k
NSW youth justice centers	6 facilities
NSW adult prisons	36 facilities (13,100 inmates)
Diversion success rate	70% don't reoffend
Adult recidivism (2 years)	50% return to custody
Indigenous % in custody	60% (vs. 8% population)
Indigenous bail refusal rate	29x higher than non-Indigenous
Developmental ROI	$7 saved per $1 invested (Heckman 2006)
Girls in custody (current)	~6 (down from 15 in 2015)
Out-of-home care kids (NSW)	~14,000 at any time
Peak offending age range	17-24 years

Common Exam Confusions

Often Confused	Actual Distinction
Remand vs. Sentenced	Remand = pre-trial (legally innocent); Sentenced = post-conviction (guilty verdict)
Min age vs. Doli incapax	Min age = absolute bar (<10); Doli = rebuttable presumption (10-14)
Illegal vs. Wrong	Knowing "it's illegal" ≠ understanding "it's gravely wrong" (post-2016 standard)
Diversion vs. Not guilty	Diversion = police discretion (pre-court); Not guilty = court verdict (doli incapax)
Child protection vs. Justice	Protection = welfare response (<10 or court referral); Justice = criminal response (10+)
Prevention types	Developmental (earliest), Social (community), Situational (environmental), Criminal Justice (reactive)

High-Yield Facts for Essays

- **RP v The Queen (2016):** High Court raised evidentiary bar for rebutting doli incapax; prosecution must prove moral understanding, not just factual knowledge of illegality
- **International comparisons:** NSW age 10 is low; Europe uses 14-15; ACT raised to 14, VIC/NT to 12 (NT later reverted)
- **Justice cascade:** Indigenous overrepresentation compounds at each stage (proceed 16x, bail refused 29x, sentenced 17x) - systemic not individual
- **Crossover kids:** Child protection and youth justice overlap heavily; out-of-home care is pipeline to custody (40-50% custody population has care history)
- **Cost-benefit failure:** $1M/youth/year with 50% recidivism vs. $7 ROI for early intervention - system invests at wrong end
- **FASD epidemic:** Fetal alcohol spectrum disorder vastly overrepresented in custody; historically under-diagnosed; raises questions about early screening
- **Closing the Gap failure:** Justice metrics worsening despite health/education investments - suggests system bias + lag time + insufficient justice-specific interventions
- **Gender dynamics:** Girls hyper-marginalized (higher abuse, self-harm, pregnancy <14); system designed for boys; interventions don't translate
- **Post-COVID phenomena:** Social media performance crime; younger offenders; TikTok amplification; filming victims for theater
- **Workforce challenges:** 60-70 psychologist shortfall in NSW; regional areas especially desperate; multidisciplinary teams (psych, speech path, OT, social work)
- **Evidence base problem:** Most rehabilitation models imported from Canada/UK/US; questionable applicability to Indigenous contexts, colonial legacy, dispersed geography
- **Labeling effects:** Why diversion emphasized - avoid stigma, maintain school, prevent system contamination from older/sophisticated offenders

Policy Tensions - Exam Synthesis Points

1. **Prevention timing vs. political demands:** Developmental prevention operates on generational timescales (results in 10-15 years) but politics demands immediate visible action, driving investment to reactive criminal justice despite poor ROI
2. **Diversion risk assessment:** Who needs intervention vs. who will be fine without us? Over-intervene = wasted resources on low-risk youth; under-intervene = serious reoffending we could have prevented. No perfect solution.
3. **Individual vs. system explanations:** Do Indigenous youth offend more due to disadvantage (social prevention response) or get processed more punitively due to bias (justice reform response)? Evidence supports BOTH - need dual-lever interventions.
4. **Doli incapax post-2016:** Raised evidentiary bar protects developmentally immature 10-14s from inappropriate conviction BUT frustrates system when clear offenders avoid sanction, creating pressure to raise minimum age outright rather than case-by-case assessment
5. **Remand as poverty punishment:** Can't meet bail = detained treats homelessness/instability as criminality; Indigenous 29x higher refusal rate codes disadvantage as danger; bail reform vs. intensive support programs trade-off
6. **Scaling challenges:** Small passionate programs work well; statewide rollouts often fail (diluted fidelity, can't replicate passion); evaluation shows success locally ≠ success at scale
7. **Interdisciplinary necessity:** No single discipline solves these problems; psych + speech path + OT + social work + Indigenous-led approaches required; but professional silos and funding structures prevent true collaboration
8. **Regional vs. urban:** Highest crime rates outside Sydney; hardest to attract workforce (fly-in/fly-out undermines community relationship); context-specific interventions (justice reinvestment in regional towns) vs. one-size-fits-all state programs

Psychologist Role & Workforce Context

Current Demand

- 60-70 psychologist shortfall in NSW Corrective Services
- Youth Justice NSW actively recruiting
- Regional areas especially desperate (Bourke, Bree, Walgett, Wilcannia)
- 3-year rotation incentives: subsidized housing, extra leave, priority coastal placement after

Multidisciplinary Context

- **Speech pathologists:** Language/communication disorders vastly overrepresented in custody
- **Occupational therapists:** Daily living skills, sensory needs, neurodevelopmental support
- **Social workers:** Family engagement, housing, welfare navigation
- **Indigenous workers:** Cultural safety, kinship connections, community liaison

Lecturer's point: "Don't see yourselves as the only people who can shape and change lives, cause you're not." Interdisciplinary collaboration essential; no single discipline solves complex trauma-crime pathways.

Notable Interventions & Models

Communities That Care (Seattle model, Victoria)

- Population-level community assessment of problems AND strengths
- Rally assets around shared goals (not branded as "crime prevention")
- Sport, music, culture, religion - whatever brings people together
- Social psychology approach (community-level, not individual-by-individual)

Justice Reinvestment

- Redirect money from incarceration to community prevention in high-crime towns
- Indigenous-led, culturally grounded, localized responses
- Address rural/regional context where crime rates highest

Evidence-Based Programs

- **Perry Preschool Program:** High-quality early childhood education; $7 return per $1 invested (Heckman 2006)
- **Elmira Nurse Visiting:** Prenatal/postnatal home visits; maternal health + parenting support
- **First 1000 Days:** Investment in ages 0-3; brain development, attachment security

Evidence base caveat: Most imported from Canada/UK/US. Questionable applicability to Indigenous contexts, colonial legacy, dispersed geography. Need Indigenous-led research and interventions.

L14: Classic Theories of Cognitive Development

Central Epistemological Question

Where does knowledge come from? How do children transition from knowing nothing at birth to possessing structured symbolic knowledge by age 2?

Three Classic Answers:

- **Piaget (Constructivism):** Self-constructed through sensorimotor exploration and reflective abstraction. Child = agent of own development.
- **Vygotsky (Socioculturalism):** Culturally transmitted through scaffolded social interaction. Knowledge = internalized cultural tools.
- **Chomsky (Nativism):** Genetically specified innate cognitive structures. Language faculty = biologically determined.

Semiotic Function: Capacity to use symbols (signifiers) to represent objects/events (significates). KEY developmental achievement enabling language and abstract thought. *How it emerges is the theoretical battleground.*

Piaget: 6 Sensorimotor Stages (0-24m)

Stage	Age	Key Achievement	Diagnostic Example
1. Reflex Mod	0-1m	Reflexes voluntary; first agency	Spontaneous grasping (not reactive)
2. 1° Circular	1-4m	Repeat actions on own body for pleasure	Thumb sucking (discovered by chance, repeated)
3. 2° Circular	4-8m	Repeat actions on objects; vision+grasp integration	Shake rattle for noise; systematic object exploration
4. Coord 2°	8-12m	Means-ends separation; intentional goals	Move obstacle to get toy; A-not-B error; Jacqueline juice/soup
5. 3° Circular	12-18m	"Infant scientist"; deliberate variation	Drop ball from different heights to test bounce
6. Mental Comb	18-24m	Internal representation; symbolic play; deferred imitation	Lucienne's doll carriage (pause → solve); matchbox+mouth

Critical Transition: Stage 6 = overt exploration becomes covert. External physical problem-solving → internal mental simulation. Enables language explosion (18-24m).

Piaget: Core Mechanisms & Assumptions

Concept	Definition/Implication
No Innate Knowledge	Born with reflexes ONLY + capacity to learn. No cognitive structures/content.
Active Organism	Innate tendency to exercise skills. Autodidactic (self-teaching) through exploration.
Assimilation	Fit new experiences into existing schemes (use rattle-grasp on newspaper).
Accommodation	Modify schemes when they fail (adjust grasp for newspaper texture/shape).
Equilibration	Tension between A/A drives stage transitions when disequilibrium occurs.
Logical Necessity	Universal sequence = discovering world's logico-mathematical structure. NOT age-based!
Constructivism	Rejects empiricism (passive learning) AND nativism (innate structures). Child constructs knowledge.

Endpoint: Formal operations (abstract hypothetical reasoning over symbolic representations = "peak" human cognition)

Vygotsky: Sociocultural Critique

Dimension	Piaget	Vygotsky
Starting State	Autistic/egocentric infant (oriented to own body)	Inherently social from birth (seeks engagement)
Source of Symbols	Self-constructed via correspondences (mouth ↔ matchbox)	Culturally provided (language, tools transmitted socially)
Role of Adults	Minimal; child autodidactic	Central; scaffolding in ZPD drives development
What's Internalized	Logical-mathematical structure of objective reality	Cultural ways of thinking; culture-specific tools
Dev Direction	Individual → Social (egocentrism fades with age)	Social → Individual (external speech internalized)
Egocentric Speech	Immaturity; fades as child becomes less egocentric	Private speech for self-regulation; increases with task difficulty
Universal Patterns	Logical necessity (discovering world structure)	Universal human sociality (all cultures scaffold)
Cultural Differences	Superficial (content varies, structures same)	Fundamental (different tools shape cognition)

ZPD (Zone of Proximal Development): Gap between independent capability and scaffolded performance. Learning LEADS development (not readiness-dependent). Example: 4yo solves puzzle alone (current level) vs. with father's hints "corners first" (ZPD level) → internalizes strategy.

Core Critique: Why make every child reinvent symbols? Culture provides ready-made symbolic systems. Piaget "hides behind wall of facts" without explaining symbol origins.

Chomsky: Nativist Challenge

Poverty of Stimulus Argument: Language complexity + universality cannot arise from sensorimotor construction OR social learning. Children acquire intricate grammatical knowledge without adequate input/correction.

Linguistic Phenomenon	What Children Know (Without Teaching)	Why Experience Can't Explain
Pronoun Reference	"John believes *he* is intelligent" (*he* = John or other) "John believes *him* to be intelligent" (*him* ≠ John ever)	No explicit teaching; never make errors; no corrective feedback; abstract syntactic binding principles
Structure-Dependent Questions	"Who is Sam waiting for?" ✓ *"Who did Susan ask why Sam was waiting for?" ✗	Never extract from embedded clauses; rule not in stimulus; know syntactic islands implicitly
Auxiliary Placement	"The man who is tall is in room" → "Is the man who is tall in room?" (move main-clause *is*)	Never produce *"Is the man who tall is in room?"; know hierarchical phrase structure (not linear "move first *is*")
Adjective Order	"The red car" (never "the car red" in English)	No one teaches this; already correct before school; cross-linguistic parametric variation

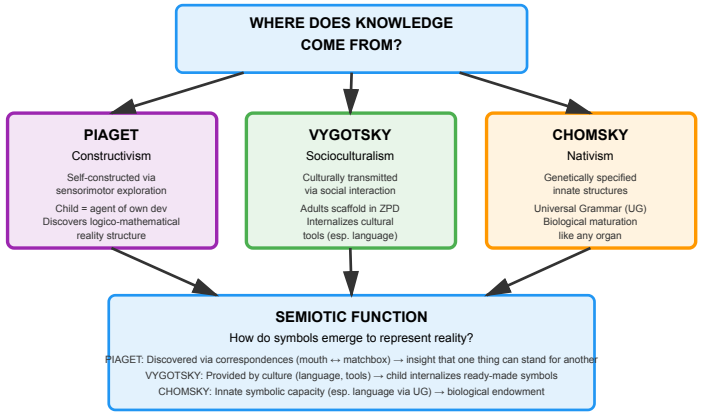
Chomsky's Claim: Universal Grammar (UG) = genetically determined language faculty specifying constraints on humanly accessible grammars. Language develops like any organ (eye, heart) via biological maturation, NOT construction.

Core Critique: Sensorimotor exploration cannot yield abstract syntactic knowledge. If symbolic representation (language) requires innate structures, Piaget's entire anti-nativist framework collapses.

Three-Way Theoretical Comparison

Question	Piaget	Vygotsky	Chomsky
What's innate?	Reflexes + learning capacity only	Social engagement capacity	Domain-specific structures (UG)
Role of experience?	Necessary for construction; discover reality	Central; provides cultural tools/scaffolding	Triggering; sets innate parameters
Why universal?	Logical necessity of world structure	Universal human sociality	Shared genetic endowment
How symbols emerge?	Discovered via correspondences	Transmitted by culture	Innate symbolic capacity
What drives dev?	Equilibration (A/A conflict)	Social interaction in ZPD	Biological maturation
Can teaching accelerate?	Limited; must be ready (stage)	Yes; teaching in ZPD IS development	Can't teach genetically impossible
Main empirical challenge?	Infants competent earlier; language too complex	Universal sequences despite input variation	Must specify innate/learned boundary; plasticity

Visual: Theoretical Positions Flowchart



Exam Strategies & Common Pitfalls

Assessment Focus

Scientific argumentation = how evidence supports theoretical positions (NOT mere fact recall). Questions ask: "How does experiment X support theory Y?" "What would theorist Z say about finding W?"

Stage Diagnosis Decision Tree

- **Stage 3 vs 4:** Repeating successful actions (3) vs. intentional means-ends separation + flexible recombination (4)
- **Stage 4 vs 6:** Overt trial-and-error tied to visible objects (4) vs. covert mental simulation with pause before acting (6)
- **A-not-B Error:** Diagnostic of Stage 4 → knows object exists (has object permanence) but representation tied to action history, not current location

Egocentric Speech Interpretation

- **Piaget:** Immaturity → fades uniformly with age (becoming less egocentric)
- **Vygotsky:** Functional private speech → increases with task difficulty → internalizes as inner speech
- **Diagnostic Test:** If speech increases with challenge → supports Vygotsky. If decreases with age regardless of task → supports Piaget.

Evidence Selection Strategy

- **Support Piaget:** Show sensorimotor experience necessary (motor-disabled children delayed in cognitive milestones); universal sequences independent of culture
- **Support Vygotsky:** Cultural variation in cognitive outcomes; scaffolding accelerates development; social isolation impairs cognition
- **Support Chomsky:** Poverty of stimulus (complex knowledge without adequate input); universal grammatical patterns; dissociation (language impaired, general cognition intact)

Common Errors

- **Treating stages as age-based:** Focus on logical prerequisites + qualitative reorganization, NOT chronological norms
- **Assuming theories mutually exclusive:** Modern synthesis recognizes all three processes (construction, social transmission, innate constraints) operate simultaneously
- **Confusing "innate" with "present at birth unchanged":** Nativist claims = genetic specification of developmental trajectories that unfold via maturation

High-Yield Examples Quick Reference

Example	Theory/Concept	Significance
Newspaper Grasping	Piaget A/A	**Assimilation:** Use rattle-grasp → fails (crumples). **Accommodation:** Modify pressure/finger position for texture.
Jacqueline (9m): Juice/Soup	Piaget Stage 4	Anticipates events based on means-ends (spoon from glass = juice = open mouth). Not fooled by mother's trick → understands origin matters.
Lucienne (18m): Doll Carriage Stuck	Piaget Stage 6	Novel problem (against wall) solved without trial-and-error. **Pauses** → mental simulation → walks to other side. Covert vs. overt problem-solving.
Lucienne: Matchbox + Mouth	Piaget Semiotic	Opens/closes mouth corresponding to box opening → **representational insight:** one thing can stand for another. Foundation for arbitrary symbols (words).
11m Infant: A-not-B Error	Piaget Stage 4	Toy hidden at B (watches), searches at A (previous location). Has object permanence but representation tied to action scheme history, not mental tracking.
4yo Puzzle + Father Scaffolding	Vygotsky ZPD	Fails alone; succeeds with hints ("corners first"). Gap = ZPD. Over time, internalizes strategy → independent performance. Learning leads development.
5yo Talks Aloud During Hard Puzzles	Vygotsky Private Speech	Silent on easy tasks; verbal self-talk on difficult ones. Supports Vygotsky (functional re-externalization) over Piaget (age-based decline in egocentrism).
"John believes he/him is intelligent"	Chomsky Poverty	*He* can = John; *him* cannot. Never taught, never err, know by 3yo. No sensorimotor correspondence → innate binding principles (UG).
"Who did Susan ask why Sam waited for?"	Chomsky Structure-Dep	Ungrammatical (extraction from embedded clause = syntactic island violation). Children never produce such errors → innate structural knowledge.
"The man who is tall is in room" → "Is...?"	Chomsky Hierarchical	Move main-clause *is* (not relative-clause *is*). Never *"Is the man who tall is...?". Know hierarchical phrase structure, not linear "move first *is*".

Piaget: Key Quotations

- **"The functioning of intelligence alone is hereditary and creates structures only through an organization of successive actions performed on objects."** (Psychogenesis of Knowledge) → No innate content; only process is innate.
- **"An epistemology could neither be empiricist nor preformationist, but could only consist of a constructivism."** → Rejects both passive learning AND nativism.
- **"Children discover the logical-mathematical structure of reality."** → Universal sequence explained by objective world properties, not genes or culture.
- **"External physical exploration gives way to internal mental exploration."** (Stage 6) → Overt becomes covert; symbolic representation enables thinking detached from immediate perception.
- **"The semiotic function allows children to use mental symbols to represent objects and events."** → Critical transition from sensorimotor to representational intelligence.

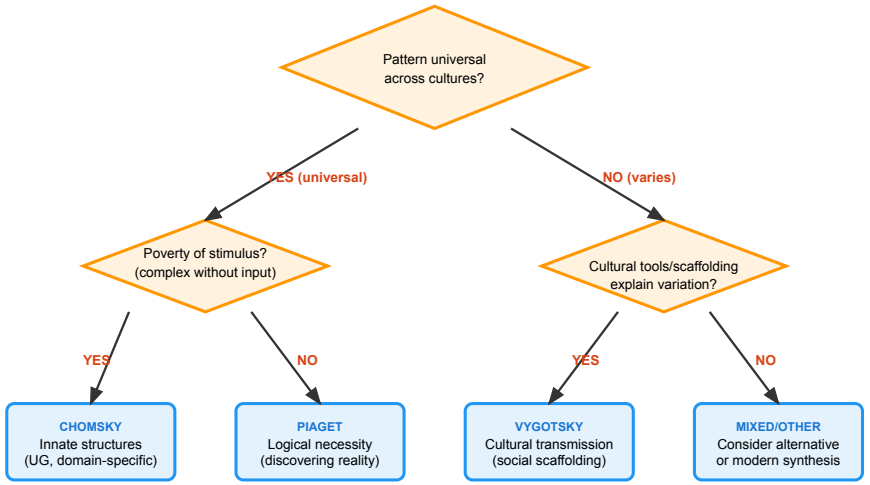
Vygotsky: Key Quotations & Critiques

- **"The infant is not autistic but inherently social from birth."** → Direct attack on Piaget's starting assumption.
- **"Piaget hides behind a wall of facts without explaining where symbols come from."** → Critique: sensorimotor sequence doesn't explain semiotic function emergence.
- **"Development moves from social (external speech) to individual (inner speech), not the reverse."** → Contradicts Piaget's individual → social trajectory.
- **"What a child can do with assistance today, she can do alone tomorrow."** (ZPD) → Learning leads development (not readiness prerequisite).
- **"Symbols are cultural inventions transmitted through interaction, not self-discovered."** → Why reinvent the wheel?
- **"Private speech increases with task difficulty, then internalizes."** → Functional tool for self-regulation, not developmental immaturity.

Chomsky: Key Quotations & Poverty Arguments

- **"A genetically determined language faculty specifies a class of humanly accessible grammars."** (Reply to Piaget) → UG constrains possible languages.
- **"We have explicit linguistic knowledge that simply has no basis in linguistic experience."** → Poverty of stimulus = complex knowledge without adequate input.
- **"It is precisely what seems self-evident that is most likely part of our hereditary baggage."** → Never taught, never err = innate.
- **"Mutations specific to humans that gave rise to innate structures are no more biologically inexplicable than those for the eye."** → Defense against Piaget's "biologically inexplicable" objection.
- **"Language develops like any other maturing aspect of the child—a mental organ."** → Biological maturation, not construction or social learning.
- **"Children know pronoun constraints without training procedures that could convey such information."** → Example of knowledge impossible to learn from experience.

🔗 Decision Tree: Which Framework to Apply?



Decision Process:

1. Check universality → 2a. If universal, check input poverty → 2b. If varies, check cultural scaffolding

Additional checks: Domain-specificity (Chomsky), stage transitions (Piaget), ZPD effects (Vygotsky)

Example Application: Language syntax = Universal + Poverty of stimulus + Domain-specific → **Chomsky**. Conservation of number = Universal + Requires experience + Domain-general → **Piaget**. Tool use strategies = Cultural variation + Scaffolding-dependent → **Vygotsky**.

✅ Exam MCQ Pattern Recognition

Question Type 1: Stage Diagnosis

Pattern: "An Xm-old infant does behavior Y. Which stage?"

- **Strategy:** Ignore age! Focus on qualitative behavior: Intentionality? Mental representation? Body vs. object focus?
- **Key Markers:** Pause before acting (Stage 6), Means-ends (Stage 4), Vision+grasp (Stage 3), Body-centered pleasure (Stage 2)

Question Type 2: Theory Comparison

Pattern: "How would Piaget and Vygotsky interpret behavior Z differently?"

- **Strategy:** Identify the dimension of disagreement: Egocentric speech? Symbol origins? Role of adults? Developmental direction?
- **Common Pairs:** Egocentric speech (immaturity vs. functional tool), Universality (logical necessity vs. universal sociality)

Question Type 3: Evidence Support

Pattern: "Which observation would support Theory X against Theory Y?"

- **Strategy:** What does X require to be true that Y denies? Find evidence showing X's requirement.
- **Example:** Support Piaget vs. Chomsky? Show sensorimotor experience necessary (motor-disabled → language delayed)
- **Example:** Support Chomsky vs. Piaget? Show poverty of stimulus (complex knowledge without adequate input)

Question Type 4: Assumption Identification

Pattern: "What core assumption does Theory X make?"

- **Piaget:** No innate knowledge; active organism; logical necessity of sequence
- **Vygotsky:** Inherently social from birth; culture provides tools; learning leads development
- **Chomsky:** Domain-specific innate structures; poverty of stimulus; biological maturation

Question Type 5: Explanatory Burden

Pattern: "What must Theory X explain to be successful?"

- **Piaget:** How symbols emerge from sensorimotor construction without innate knowledge
- **Vygotsky:** Why universal patterns exist despite cultural variation in input
- **Chomsky:** Specify boundary between innate and learned; explain plasticity within constraints

Common Distractors

- **Age-based stage answers:** Reject if behavior doesn't match qualitative description (age is approximate!)
- **Confusing similar concepts:** Assimilation ≠ Accommodation; Primary ≠ Secondary; Egocentric ≠ Private speech
- **Extreme positions:** "Piaget says no learning" (wrong—he says active construction). "Chomsky says no experience needed" (wrong—triggering role)

L15: Infant Cognition I - Research Methods & Habituation Paradigm

Core Challenges of Infant Research

Challenge	Implication for Methods
Cannot talk	No verbal reports or self-reflection; must infer from behavior
Cannot follow instructions	Cannot use explicit task paradigms; rely on natural responses
Short attention span	Trials measured in seconds; sessions must be brief (10-20 min)
Limited behavioral repertoire	Can only: suck, turn head, reach, look, crawl (older infants)
Rapid development	Methods valid for 4-month-olds may fail at 6 months; age-specific designs needed

Historical Context: Piaget's limitations - unsystematic observations of own children, no quantification, informal tests (e.g., hiding objects for object permanence). Modern methods require systematic measurement.

Experimental Methods Toolkit

Category	Measure	Use Case
Behavioral	**Looking time**	PRIMARY measure; reveals cognitive processing
	Sucking rate	Newborns; rate increases with stimulus interest
	Head turning	Auditory localization; orienting responses
	Reaching	Manual exploration; object preference
	Crawling	Spatial navigation; only if studying locomotion
Physiological	Heart rate	Arousal/attention; deceleration = engagement
	ERPs	Event-Related Potentials; neural discrimination
	fMRI/optical imaging	Brain activation patterns (less common in infants)

- **Endpoint of infant methods:** ~15-18 months when verbal comprehension and pointing emerge
- **Why looking time dominates:** Available from birth, non-invasive, reveals processing without requiring responses

Key Terminology

Term	Definition
Habituation	Systematic decrease in looking time with repeated exposure to same/similar stimuli; indicates encoding & boredom
Novelty Preference	Looking longer at novel vs. familiar stimulus after habituation; proves discrimination ability
Familiarity Preference	Looking longer at familiar during early exposure; "I'm trying to get it" phase before full habituation
Dishabituation	Recovery of looking time when novel stimulus presented; synonym for showing novelty preference
Generalization of Habituation	Remaining habituated to novel stimuli that fit learned pattern; indicates category/pattern learning
Baseline	Average looking time in first 3 trials; individual infant's initial interest level
Criterion	Pre-defined rule for ending habituation (typically: 3 consecutive trials < 50% baseline)

Habituation Paradigm Setup

Physical Environment

- **Room:** Dark, minimal distractions
- **Seating:** Infant on caregiver's lap facing screen
- **Caregiver control:** Headphones with masking audio to prevent inadvertent attention direction based on stimulus exposure
- **Screen:** Controlled visual display for stimuli
- **Camera:** Records infant's face/eyes for coding

Trial Sequence

1. **Attention getter:** Swirling visual (e.g., red star) + chime sound to orient infant to screen
2. **Stimulus presentation:** Target image/video appears
3. **Looking time recording:** Researcher/software tracks duration of fixation
4. **Look-away:** Infant disengages, trial ends (or fixed duration in familiarization)
5. **Inter-trial interval:** Return to attention getter
6. **Repeat:** Continue until habituation criterion met

Classic vs. Modern Measurement

Method	Process
Classic (manual)	Researcher watches camera feed, holds keyboard button while infant fixates; releases on look-away
Modern (automated)	Eye-tracking software detects gaze direction & duration; automatic trial termination

Habituation Criterion Formula

Standard Criterion (Most Common)

Step 1: Calculate Baseline

$$\text{Baseline} = \frac{T_1 + T_2 + T_3}{3}$$

Average of first 3 trials

Step 2: Set Threshold

$$\text{Threshold} = 0.50 \times \text{Baseline}$$

50% of baseline (some studies use 60%)

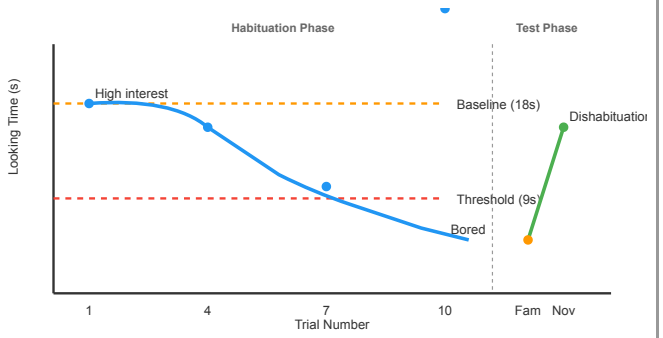
Step 3: Apply Criterion Rule
Habituation achieved when:
3 consecutive trials ALL < Threshold

Example Calculation:
Trials: 18s, 16s, 20s, 14s, 11s, 9s, 8s, 7s, 6s
Baseline = (18+16+20)/3 = **18s**
Threshold = 0.50 × 18 = **9s**
Trials 7-9 = {8s, 7s, 6s} all < 9s → **Criterion met at Trial 9**

Key Properties

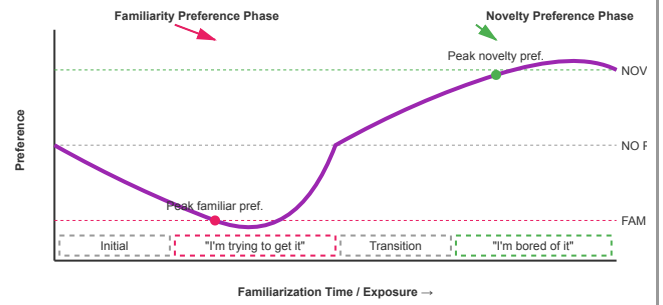
- **Individualized:** Each infant's criterion based on their own baseline (accounts for temperament)
- **Pre-registered:** Criterion rule specified before data collection (prevents researcher bias)
- **Variable exposure:** Fast habituators (~6 trials) vs. slow (~15+ trials) see different total stimulus time

Idealized Habituation Curve (Monotonic Model)



- **Assumption:** Looking time monotonically decreases with exposure
- **Test logic:** Novel > Familiar indicates discrimination
- **Limitation:** Oversimplified - real pattern is non-monotonic (see Hunter & Ames)

Hunter & Ames (1988): Non-Monotonic U-Shaped Curve



Key Insights

- **NOT monotonic:** Preference changes direction over exposure time
- **Early exposure:** Brief familiarity preference as infant encodes/processes stimulus
- **Full habituation:** After sufficient encoding, novelty preference emerges
- **Implications:** Null results ambiguous - could reflect insufficient exposure OR genuine discrimination failure

Factors Influencing Curve Shape

What Extends Familiarity Preference Phase?

Factor	Effect	Mechanism
Younger age	Longer familiarity phase	Slower cognitive processing; more time needed to encode patterns
Complex stimuli	Longer familiarity phase	More features to encode; richer information requires extended processing
Novel category	Longer familiarity phase	No prior schema; building new representation from scratch
Older age	Faster transition to novelty pref.	More efficient processing; faster encoding & habituation
Simple stimuli	Faster transition to novelty pref.	Fewer features to track; rapid encoding completion

Critical Implication: When using habituation methods, must ensure infants reach novelty preference phase. If test occurs during familiarity phase, predictions reverse! This is why habituation criterion is essential.

Methodological Consequences

- **Age comparisons:** 4-month-olds vs. 6-month-olds may show opposite patterns on same task if exposure not optimized
- **Null interpretation:** No preference could mean: (1) under-habituated, (2) over-habituated/fatigued, (3) genuine inability
- **Individual differences:** Fast vs. slow processors may be at different curve positions at test

Habituation vs. Familiarization: The Great Debate

HABITUATION METHOD (Criterion-Based)

Procedure:

- Trials continue until individual infant meets criterion (e.g., 3 trials < 50% baseline)
- Exposure varies by infant (fast vs. slow habituators)
- Ensures each infant in novelty preference state at test

Advantages:

- Guarantees all infants fully habituated before test
- Clear interpretation: novelty pref. expected, so significant result = discrimination
- Accounts for individual processing speed differences

Disadvantages:

- Uncontrolled exposure time confounds analyses (fast hab. see less than slow)
- Cannot cleanly separate processing speed from discrimination ability
- Longer sessions for slow habituators (fatigue risk)

FAMILIARIZATION METHOD (Fixed Trials)

Procedure:

- All infants see identical number of trials (e.g., 10 trials × 20s each)
- Exposure perfectly controlled across participants
- Test phase identical regardless of habituation state

Advantages:

- Controlled exposure eliminates confound with processing speed
- Can map non-monotonic curve by varying trial count across conditions
- Simpler protocol (no online criterion calculation)

Disadvantages:

- Uncertain processing state at test (some in familiar pref., others novelty pref.)
- Unpredictable direction: can find significance in EITHER direction
- Null results completely ambiguous (what phase were they in?)
- Higher false positive risk (bidirectional hypothesis)

Field Consensus: No universal agreement. Habituation purists argue familiarization is uninterpretable without knowing state. Familiarization advocates argue exposure confounds are worse. Choice often depends on reviewer/advisor preferences, not empirical superiority. Modern solution: ManyBabies collaborations pre-register methods to reduce flexibility.

Perceptual Discrimination: Visual Acuity Example

Classic Paradigm

Phase	Stimulus	Purpose
Habituation	Black & white stripes (varying widths)	Infant encodes stripe pattern until bored
Test	Solid gray field	If stripes perceived, gray is novel; if stripes looked gray (low acuity), gray is familiar

Results by Stripe Width

- **Thick stripes → Gray:** Novelty preference (infant could see stripes)
- **Thin stripes → Gray:** NO novelty preference (stripes appeared gray; below acuity threshold)

Interpretation Logic

If visual acuity sufficient: Stripes are distinct from gray → Dishabituation to gray
If visual acuity insufficient: Stripes blur into gray → No dishabituation (gray looks familiar)

Developmental Pattern

- **Newborns:** Can discriminate thick stripes, not thin (limited acuity)
- **Older infants:** Can discriminate progressively thinner stripes (improving acuity)
- **Method benefit:** Precise mapping of perceptual thresholds without verbal report

Cohen & Strauss (1979): Generalization of Habituation

Design: 3 Between-Subjects Conditions

Condition	Habituation Stimuli	Variation Level
I	1 face, 1 orientation	Zero variation (identical stimulus repeated)
II	1 face, multiple orientations	Moderate variation (same identity, different angles)
III	Multiple faces, multiple orientations	High variation (different identities & angles)

Test Stimuli (Same for All Conditions)

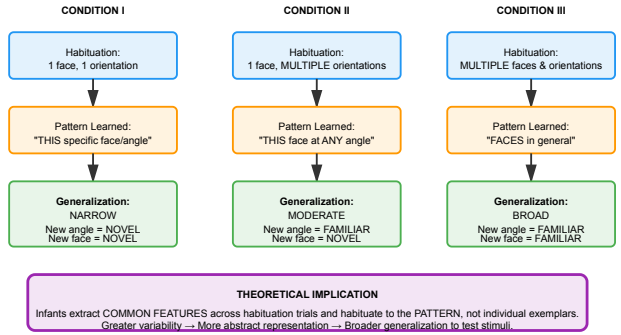
- **P_3:** Familiar face at familiar orientation (old exemplar)
- **F_1:** Familiar face at NOVEL orientation (new angle, same identity)
- **F_n:** NOVEL face at novel orientation (new identity)

Results: Dishabituation Patterns

Condition	P_3 (Fam/Fam)	F_1 (Fam face/Nov orient)	F_n (Nov face/Nov orient)
I	LOW (habituated)	**HIGH** (dishabituation - new angle is novel!)	**HIGH** (dishabituation - new face is novel!)
II	LOW (habituated)	LOW (generalized - seen many angles before)	**HIGH** (dishabituation - new face breaks pattern)
III	LOW (habituated)	LOW (generalized - fits "faces at angles" pattern)	LOW (generalized - just another face at an angle)

Key Finding: Broader variation in habituation → Broader generalization at test. Infants abstract PATTERNS, not just memorize individual stimuli. Generalization scope matches habituation variability.

Generalization Principle: Visual Model



Implications for Testing Cognitive Abilities

- **Category learning:** If infant generalizes, they've formed category/pattern representation
- **Abstraction capacity:** Generalization reveals ability to extract commonalities across instances
- **Developmental differences:** Younger infants (< 30 weeks) showed novelty preferences in all conditions - couldn't learn patterns
- **Method power:** Generalization paradigm tests WHAT infants learn, not just WHETHER they discriminate

Interpretation Decision Tree

Observed Result	Interpretation	Common Error
Strong novelty pref. (novel >> familiar)	✓ DISCRIMINATION confirmed; infant fully habituated & can tell stimuli apart	None - ideal outcome
No preference (novel ≈ familiar)	⚠ AMBIGUOUS: Could be (1) under-habituated, (2) cannot discriminate, (3) fatigued/distracted	Concluding "cannot discriminate" without ruling out methodological issues
Familiarity pref. (familiar > novel)	✓ CAN discriminate but not fully habituated; still in encoding phase (Hunter & Ames curve)	Interpreting as "prefers familiar category" vs. incomplete processing
Generalization (no dishab. to pattern-matching novel)	✓ PATTERN LEARNING success; abstracted commonality, treats novel as familiar	Interpreting as discrimination failure instead of abstraction success

Diagnostic Follow-Ups for Null Results

1. **Age comparison:** Test older infants - if they succeed, younger may lack ability (not methodological artifact)
2. **Individual differences:** Split by habituation speed - if fast habituators show effect, aggregate null is exposure issue
3. **Physiological validation:** Check heart rate deceleration during habituation (confirms encoding)
4. **Extended criterion:** Use stricter criterion (e.g., 6 trials < 50%) - if still null, supports genuine inability

Methodological Checklist: Valid Habituation Study

Essential Design Elements

- ✓ **Pre-registered criterion:** Baseline calculation & threshold rule specified before data collection
- ✓ **Caregiver blinding:** Headphones with masking audio to prevent inadvertent cueing
- ✓ **Attention getter:** Reorientation stimulus between trials (e.g., swirling star + chime)
- ✓ **Counterbalancing:** Novel/familiar stimuli side-balanced across infants
- ✓ **Reliability coding:** At least 20% of videos double-coded by blind coder (inter-rater reliability > 0.90)
- ✓ **Test phase control:** Present novel AND familiar (within-subjects) or include control group

Common Validity Threats

Threat	Consequence	Control Strategy
Caregiver cueing	Infant looks where caregiver looks, not based on own interest	Headphones with masking; caregiver cannot see/hear stimuli
Experimenter bias	Coder holds button longer for "expected" novel stimulus	Blind coding; automated eye-tracking
Side preference	Infant prefers looking left/right regardless of stimulus	Counterbalance stimulus position across trials
Fatigue	Declining attention over session (not true habituation)	Brief sessions (< 20 min); track trial-by-trial engagement

High-Yield Exam Facts

- **Primary DV in infant research:** Looking time (duration of visual fixation)
- **Standard habituation criterion:** 3 consecutive trials < 50% of baseline (mean of first 3 trials)
- **Attention getter purpose:** Reorient infant's gaze to screen between trials (e.g., swirling star + sound)
- **Why caregiver wears headphones:** Prevents inadvertent attention direction based on hearing stimuli
- **Habituation vs. familiarization trade-off:** Controlled state vs. controlled exposure
- **Hunter & Ames (1988) model:** Non-monotonic U-shaped curve: No pref → Familiar pref → No pref → Novelty pref
- **Factors extending familiarity phase:** Younger age, complex stimuli, novel categories
- **Cohen & Strauss (1979) key finding:** Broader habituation variation → Broader generalization to test stimuli
- **Generalization of habituation:** Infants habituate to PATTERNS, not individual stimuli
- **Dishabituation = novelty preference:** Recovery of looking time to novel stimulus after habituation
- **Age limit for methods:** ~15-18 months, when verbal comprehension & pointing emerge
- **Piaget's limitation:** Unsystematic observations of own children; no quantification or experimental control
- **Perceptual discrimination logic:** If infant shows novelty pref., they can discriminate; if not, ambiguous
- **Null result ambiguity:** Could be discrimination failure, insufficient exposure, or wrong curve phase
- **Replication crisis note:** Many old infant findings likely wouldn't replicate; ManyBabies collaborations address this

Common Confusions to Avoid

Confusion	Clarification
Habituation = boredom with EVERYTHING	NO - Habituation is STIMULUS-SPECIFIC. Dishabituation to novel proves boredom was about that stimulus, not general fatigue.
Familiarity preference = preference for familiar category	NO - It's a processing phase (Hunter & Ames). Indicates incomplete encoding, not a stable preference.
Generalization = discrimination failure	NO - Generalization is PATTERN LEARNING. Infant abstracted commonality & correctly treats pattern-matching novel as familiar.
No novelty preference = cannot discriminate	AMBIGUOUS - Could also be under-habituated, over-habituated, or wrong phase. Need diagnostics.
Baseline = average across all habituation trials	NO - Baseline = average of FIRST 3 trials only (establishes initial interest level).

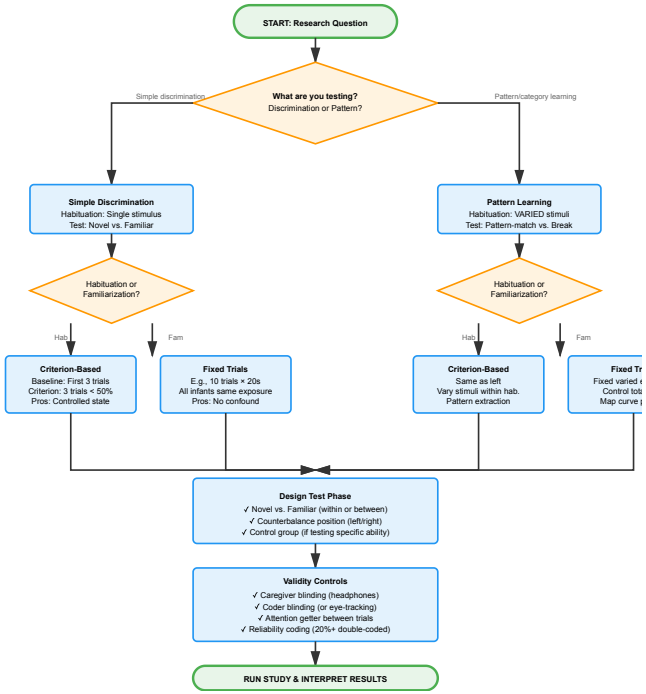
Key Studies Summary Table

Study	Research Question	Method	Key Finding	Theoretical Contribution
Hunter & Ames (1988)	Is preference change over exposure monotonic or non-monotonic?	Familiarization with varying exposure durations; map preference direction at each duration	U-shaped curve: Initial exposure → Familiarity pref. → Novelty pref. as encoding completes	Challenged monotonic habituation assumption; explained null results & familiarity preferences
Cohen & Strauss (1979)	Do infants habituate to specific stimuli or abstract patterns?	3 conditions varying habituation breadth (1 face/1 orient, 1 face/multi orient, multi face/multi orient); test generalization	Broader variation → Broader generalization. Condition III generalized to all faces; Condition I didn't.	Proved infants extract patterns, not memorize; generalization scope = habituation variability
Visual Acuity Studies (Various)	At what stripe width can newborns discriminate from solid gray?	Habituate to stripes (varying widths); test with gray field	Newborns show novelty pref. for thick stripes but not thin (threshold = acuity limit)	Demonstrated habituation can map perceptual thresholds; developmental trajectory of acuity

Age Effects Across Studies

- **Cohen & Strauss:** 30-week-olds showed pattern learning; younger infants did NOT (showed novelty to all test stimuli)
- **Visual acuity:** Discrimination threshold improves from birth through first year (progressively finer stripes)
- **General principle:** Younger infants need longer familiarization for complex stimuli; same task may fail at 4 months but succeed at 6 months

Decision Flowchart: Designing Your Habituation Study



L16: Infant Cognition II - Nativism vs Constructivism

Core Theoretical Framework: What Are They Really Arguing About?

Critical Insight: The debate is NOT "nature vs nurture" (both sides agree genes and learning matter). It's about the **architecture of learning mechanisms**: domain-specific modules vs domain-general processes.

Dimension	Nativism (Carey, Spelke, Baillargeon)	Constructivism (Cohen, Cashon)
What is innate?	Domain-specific modules with core knowledge (objects persist, solid objects don't interpenetrate)	Domain-general information processing detecting low-level features (color, motion, edges)
What triggers knowledge?	Specific perceptual inputs activate modules (e.g., common motion triggers object module)	Statistical regularities in environment gradually build representations
Why abilities emerge at specific ages?	Perceptual prerequisites mature, allowing pre-existing knowledge to be expressed (competence precedes performance)	Sufficient experience has accumulated to construct the representation
What does gradual development prove?	Gradual maturation of input systems (perception, attention) that feed innate modules	Gradual construction of knowledge through hierarchical integration

Key Concepts & Definitions

Term	Definition
Cognitive Modularity	Mind contains specialized subsystems for specific domains (language, objects, faces) with information encapsulation and innate specification
Core Knowledge	Innate principles about domains (objects persist when occluded, solid objects block motion) that modules apply when triggered
Object Unity	Perceiving spatially separated visible surfaces as parts of single unified object when occluder hides connecting portion
Object Permanence	Understanding that objects continue to exist when completely out of view (deeper than unity - requires representing fully hidden objects)
Common Motion	Coordinated movement of disconnected surfaces in same direction/speed - nativists claim this is the specific trigger for object module
Violation of Expectation	Paradigm where perceptually familiar event is physically impossible; longer looking to impossible event suggests conceptual surprise
Competence-Performance Gap	Knowledge may exist (competence) but not be expressed in behavior (performance) due to motor, memory, or executive function limitations

Quick Reference: Developmental Timelines

Age	Object Unity	Object Permanence
Newborn	Minimal occlusion only (Slater 1996)	No evidence
2 months	Small occluder (Johnson & Aslin)	No evidence
3.5-4 months	Large occluder (Kellman & Spelke)	Violation paradigm success (Baillargeon) - DISPUTED
5 months	Robust	Feature memory YES, spatial continuity NO (Meltzoff & Moore)
8-9 months	Robust	Manual search success + spatial continuity understanding (Piaget's timeline)

Study 1: Kellman & Spelke (1983) - Object Unity

Method

- **Habituation:** 4-month-olds see red rod moving horizontally behind yellow occluder (top and bottom portions visible, moving together)
- **Test:** Occluder removed, show (a) complete rod OR (b) broken rod (two pieces)
- **Key manipulation:** Moving condition vs stationary condition

Results

- **Moving condition:** Infants looked longer at broken rod (conceptually novel despite perceptual familiarity)
- **Stationary condition:** No preference (module not triggered without common motion)

Nativist Interpretation

Common motion triggered innate object module, which inferred unified rod. Broken rod violates expectation.

Constructivist Counter

Similar-appearing surfaces moving together is learnable statistical regularity. Johnson & Aslin (1998) show gradual development: 2-month-olds need small occluder, 4-month-olds succeed with large occluder.

Study 2: Baillargeon (1987) - Drawbridge Paradigm

Method

- **Familiarization:** Drawbridge rotates 180° (flat to upright to flat on other side)
- **Test:** Box placed behind drawbridge
  - Possible event: Rotation stops at ~120° (contacts box) - perceptually novel
  - Impossible event: Full 180° rotation (passes through box) - perceptually familiar

Results

- 4.5-month-olds looked longer at impossible event

Nativist Interpretation

Infants represent hidden box via core knowledge of object permanence and solidity. Conceptual surprise overrides perceptual familiarity.

Constructivist Counter (Cohen & Cashon)

Baillargeon included infants who didn't fully habituate. Per Hunter & Ames (1988), incompletely habituated infants show familiarity preferences. Longer looking to impossible (familiar, more motion) could be familiarity preference, not physics knowledge.

Study 3: Meltzoff & Moore (1998) - Memory vs True Permanence

Feature Memory Task

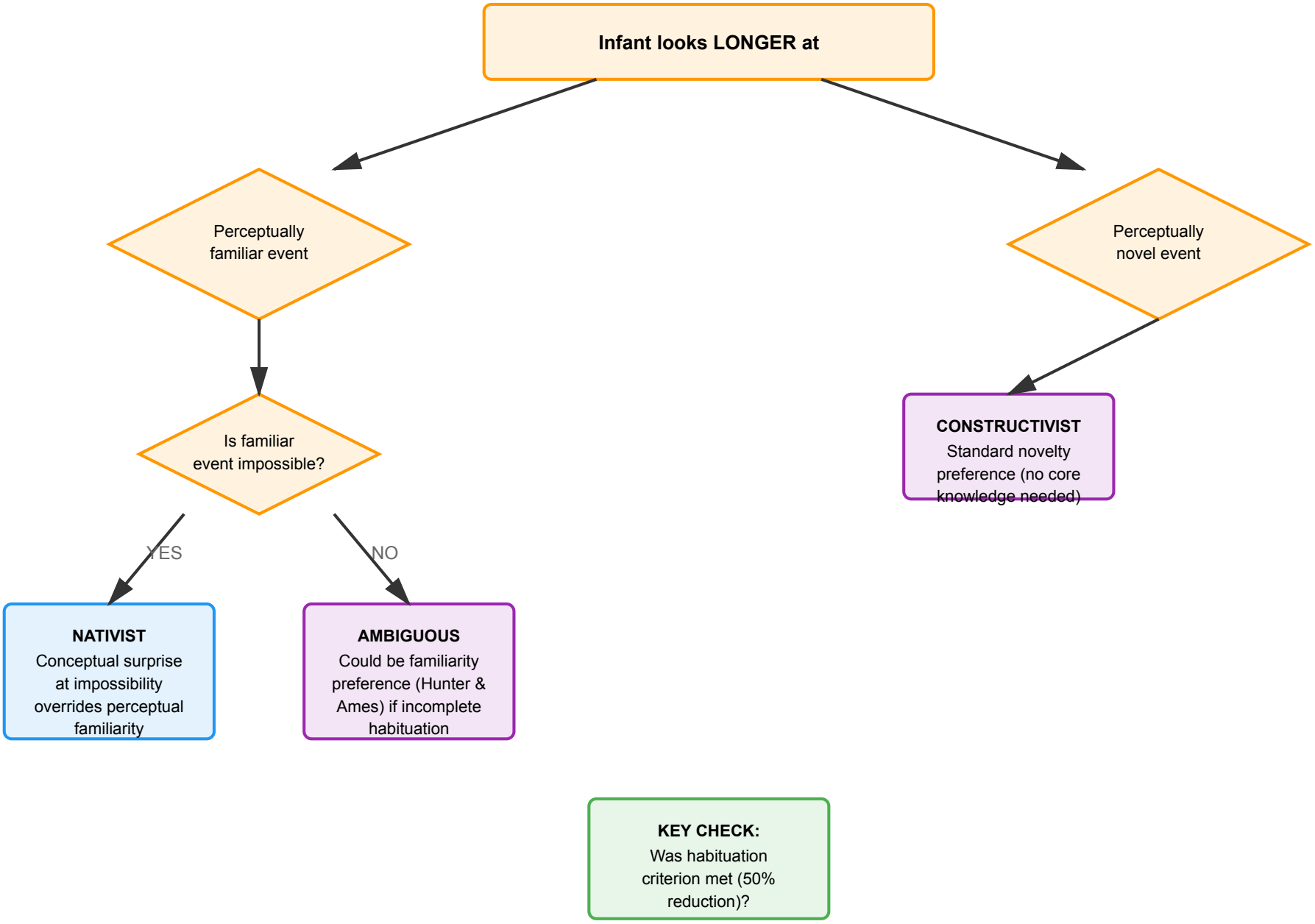
- Object (cylinder) goes behind screen, either same or different object emerges
- **5-month-olds:** Look longer at shape change (have perceptual memory)
- **9-month-olds:** Look longer at shape change

Spatial Continuity Task

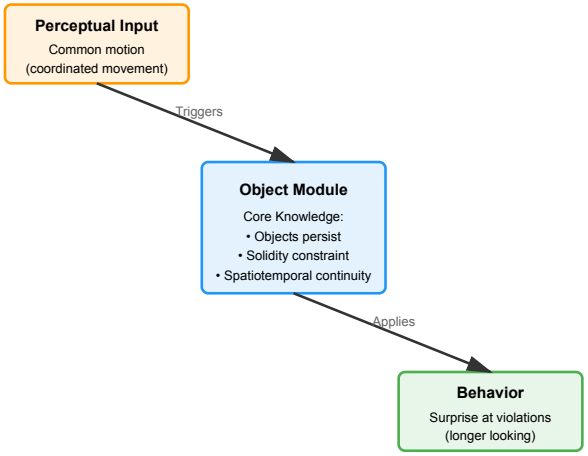
- Object goes behind Screen 1, emerges from behind Screen 2 without appearing in gap (violates spatiotemporal continuity)
- **5-month-olds:** NO longer looking (don't expect continuous path)
- **9-month-olds:** Look longer at violation (expect continuous trajectory)

Key Dissociation: 5-month-olds have feature memory but NOT true object permanence (no understanding of spatial continuity). Supports Piaget's 8-9 month timeline and constructivist piecemeal development.

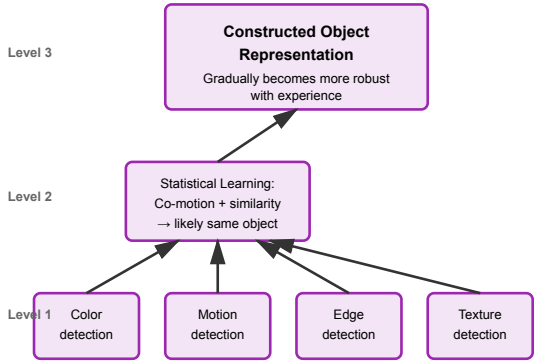
Visual Decision Tree: Interpreting Looking Time Results



Nativist Module Architecture



Constructivist Hierarchical Learning



Paradigm Comparison: Habituation vs Violation

Feature	Habituation (Cohen)	Violation of Expectation (Baillargeon)
Assumption	Infant comes with NO prior knowledge of stimuli	Infant comes WITH core knowledge that creates expectations
Criterion	Must reach 50% reduction in looking time	Uses familiarization (no strict criterion)
Typical result	Novelty preference after full habituation	Longer looking to impossible event (even if perceptually familiar)
Critical confound	If incomplete habituation → familiarity preference possible	Cohen critique: Baillargeon included incompletely habituated infants

Calculating Habituation Criterion

Formula: Habituation achieved when looking time reduces by 50% from baseline

Example Calculation:

- Trials 1-3 mean: 45s (baseline)
- Trials 10-12 mean: 20s
- Reduction: $\frac{45-20}{45} = \frac{25}{45} = 0.556 = 55.6\%$
- **Criterion MET** (exceeds 50%)

If criterion NOT met:

- Trials 1-3 mean: 50s
- Trials 8-10 mean: 32s
- Reduction: $\frac{50-32}{50} = 0.36 = 36\%$
- **Criterion NOT MET** → Familiarity preference possible (Hunter & Ames 1988)

Cohen & Cashon's Methodological Critiques of Baillargeon

Critique	Problem	Alternative Explanation
Incomplete habituation	Baillargeon included infants who didn't reach 50% reduction criterion	Longer looking to impossible event could be familiarity preference for complex stimulus (Hunter & Ames), not physics knowledge
Perceptual confound	Impossible event (180° rotation) contains more motion than possible event (120°)	Infants may prefer more motion for perceptual reasons, unrelated to representing hidden object
Complexity preference	Full rotation is perceptually more complex than partial rotation	Familiarity preference for complex displays (incompletely habituated infants) produces same pattern as conceptual surprise

Control needed: Test with visible box (no occlusion). If no preference emerges, supports that preference depends on representing hidden object. If same preference, suggests perceptual confound.

Common Exam Errors & Fixes

Common Error	Why It's Wrong	Fix
Equating early ability with innateness	Rapid learning is possible - 4 months = billions of visual experiences	Check if development is gradual (constructivist) or step-like (nativist)
Thinking "module" means no development	Nativists claim modules are innate but expression depends on maturing perceptual prerequisites	Nativists locate development in input systems; constructivists in knowledge representation itself
Assuming looking time and reaching measure same thing	Looking may measure perceptual expectations; reaching measures conceptual permanence + goal-directed reasoning	Recognize competence-performance distinction and converging evidence requirement
Accepting longer looking to impossible = core knowledge	Could be familiarity preference if habituation incomplete	Check: (1) habituation criterion met? (2) perceptual confounds controlled? (3) effect size substantial?

Argument Construction Templates

Nativist Argument Template:

1. Identify specific perceptual trigger (e.g., common motion)
2. Show ability emerges suddenly when trigger becomes perceivable
3. Demonstrate co-emergence of related abilities (systematicity)
4. Attribute gradual changes to input system maturation, not knowledge construction

Constructivist Argument Template:

1. Document gradual, incremental improvement (newborns → 2mo → 4mo)
2. Show graded effects of task difficulty (more support needed at younger ages)
3. Demonstrate dissociations between related abilities (feature memory before spatial continuity)
4. Attribute changes to representation construction, not just input maturation

Carey's Defense: Why Co-Emergence Matters

Carey's Key Argument: If conceptually-related abilities (object unity, solidity understanding, object individuation via spatiotemporal cues) all emerge simultaneously at 4 months, this supports a unified innate module activating. Constructivism has no principled reason why these distinct abilities should co-emerge since each is learned from different experiences.

Ability	Age of Emergence	Nativist Explanation	Constructivist Challenge
Object unity (common motion)	~4 months	All emerge together because object module comes online when motion perception matures (single unified system)	Co-emergence could be coincidence; or similar perceptual prerequisites needed for each; or hierarchical construction happens to reach threshold simultaneously
Solidity understanding	~4 months		
Object individuation (spatiotemporal)	~4 months		

Exam tip: To argue for nativism, emphasize simultaneity. To argue for constructivism, look for any slight age differences or graded emergence within the 4-month window.

Comprehensive Nativism vs Constructivism Comparison

Question	Nativism	Constructivism	Critical Evidence
What explains rapid 0-4 month development?	Perceptual systems mature, allowing pre-existing core knowledge modules to receive input and activate	Massive experience (billions of visual samples) allows domain-general learning to extract statistical regularities	Gradual (constructivist) vs step-like (nativist) emergence; whether multiple abilities co-emerge
Why does object unity depend on common motion?	Common motion is specific perceptual trigger that activates innate object module	Common motion is reliable statistical cue in environment that infants learn to use	Newborn performance (if succeed, suggests learning time needed); simultaneity of object abilities at 4mo
What do violation-of-expectation results demonstrate?	Core knowledge of permanence/solidity. Conceptual surprise overrides perceptual familiarity	Familiarity preference (incomplete habituation), perceptual memory, or motion expectations - not deep conceptual understanding	Was habituation criterion enforced? Perceptual confounds controlled? Spatial continuity understanding dissociates from feature memory?
Why manual search failure until 8-9 months?	Performance limitations: motor planning, means-end reasoning, inhibitory control develop later. Competence-performance gap	True conceptual permanence develops at 8-9 months. Earlier looking-time success reflects shallow perceptual memory	Converging evidence across paradigms (constructivist); dissociations due to performance demands (nativist)
What would falsify each position?	No co-emergence of related abilities; substantial cross-cultural variation; neural networks with no innate knowledge replicate trajectory	Sudden emergence at same age despite different experiences; no gradual development; statistical learning too slow given input	Currently both accommodate most data by adjusting auxiliary assumptions - debate unresolved

L17: Infant Cognition III - Multi-sensory Integration & Dynamic Systems Theory

Core Concepts & Definitions

Term	Definition & Key Points
Dynamic Systems Theory	Development driven by **organism-task-environment** interaction; intelligent behavior EMERGES from brain-body-world coupling, not brain maturation alone
Piecemeal Development	Skills highly context-specific; minimal cross-context generalization. Example: Sitting knowledge ≠ crawling knowledge; must relearn affordances for each motor posture
Embodied Cognition	RADICAL CLAIM: Representations tied to body state; no abstract symbols even in adults (concepts = distributed sensory-motor activations)
Multi-sensory Integration	Brain integrates across modalities (visual, haptic, oral, motor); higher-order correlations formed at integration hubs (ATL, aPFC)
Hierarchical Construction	Higher-level units built from lower-level units. Level 1: Features → Level 2: Feature correlations → Level 3: Meta-patterns
Cognitive Overload Principle	EXAM CRITICAL: When task exceeds capacity, infants REVERT to lower-level processing. More time can = worse performance (7mo E4)
Shape Bias	~18mo generalize novel nouns by shape (not color/texture). Emerges from higher-order correlation: "nouns refer to shape-based categories"
Feature Correlations	Statistical regularities (hooves + giraffe body co-occur). Infants track co-occurrence patterns; form categories via correlation detection
Affordances	What environment permits given bodily capabilities. Learned separately for each motor configuration (sitting vs. crawling vs. walking)
A-not-B Error	Piaget: Incomplete object permanence. **Smith reinterpretation:** Embodied motor memory; postural reset (stand/sit) eliminates error

Landmark Studies & Findings

Study	Finding	Theoretical Interpretation
Thelen - Twins Study	Intensive roller-skating training (Johnny) didn't accelerate sitting/crawling/walking vs. untrained twin (Jimmy)	Motor learning context-specific; minimal cross-task generalization proves piecemeal development
Visual Cliff	New crawlers (6mo) cross deep side; experienced crawlers (9mo) refuse; new walkers must relearn	Risk perception embodied in posture; spatial knowledge doesn't transfer across motor configurations
Gap Crossing	9mo experienced sitters avoid gaps while sitting; SAME infants attempt gaps when crawling	Affordance knowledge posture-specific; understanding of "how far = too far" not abstract
Smith (1999) A-not-B	Standing up/sitting down between A-trials and B-trial eliminates perseveration	Object representation body-state-dependent; postural reset disrupts motor memory trace
Sticky Mittens	2mo given velcro mittens → accelerate to 6mo-level visual inspection + oral exploration	Motor ability CAUSALLY drives perceptual development; enhanced action → richer multi-sensory input → faster learning
Embodied Semantics (fMRI)	"kick" → leg motor cortex; "punch" → arm; "canary" → yellow visual cortex	Word meanings ARE distributed activations (constitutive, not correlational). No abstract semantic layer required
Younger & Cohen (1983)	10mo learn feature correlations (hoof+giraffe); 4/7mo learn features only	Hierarchical construction emerges with age; higher-order units require greater capacity
Younger & Cohen (1986) E1	Easy task (3 features, all corr.): 7mo learn correlations; 4mo features only	Demonstrates capacity threshold; 7mo can do correlations when task simplified
Younger & Cohen (1986) E4	CRITICAL: 7mo given extended habituation → REVERTED to feature-level (like 4mo)	Proves overload principle: attempted correlations → failed → strategic shift to achievable goal (features)
Landau et al. (1988)	18mo generalize "dax" to same-shape objects; ignore color/texture changes	Shape bias operational by 18mo; accelerates word learning via meta-level inference
Gershkoff-Stowe (2004)	Shape bias correlates with vocab: <25 nouns (weak ~30%); 26-50 (emerging ~60%); 51+ (strong ~90%)	Higher-order pattern emerges from experience; learned through word-object pairings, not innate

Younger & Cohen Feature Correlation Paradigm

Method Overview

- **Stimuli:** Line-drawing "animals" varying on 3-5 features: feet (hoof/paw/talons), body (giraffe/elephant/horse), ears (pointed/round), tail (fluffy/thin/curly), legs (2/4)
- **Habituation Phase:** 8-12 trials; programmed correlations preserved (e.g., hoof feet ALWAYS with giraffe body; paw feet ALWAYS with elephant body)
- **Test Phase (3 trial types):**
  - **C (Correlated):** Familiar features + preserves correlations → Should be familiar
  - **U (Uncorrelated):** Familiar features + VIOLATES correlations → Novel IF learned correlations
  - **N (Novel):** Completely new features → Always novel (control)

Interpretation Logic

Pattern	What Infant Learned
C low, U low, N high	**Features only** (both C and U familiar because features seen before)
C low, U high, N high	**Correlations** (U novel because violates learned statistical structure)
Flat habituation (no decrease)	**Attempting correlations but overloaded** (task exceeds capacity)

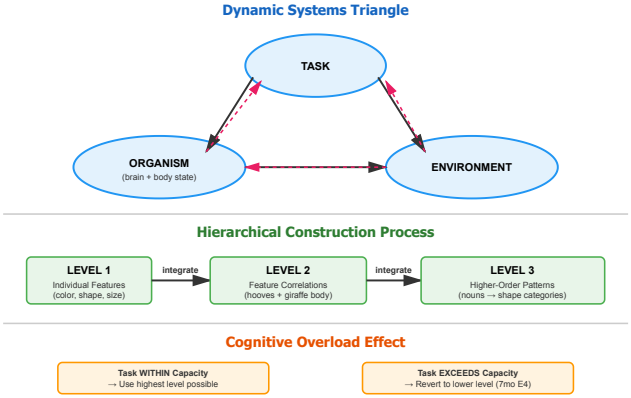
Complete Results Table

Study	Task Complexity	4 months	7 months	10 months
Y&C 1983	HARD: 4 features, 2 pairs correlated	Features only	Features only	**Correlations** ✓
Y&C 1986 E1	EASY: 3 features, ALL perfectly correlated	Features only	**Correlations** ✓	—
Y&C 1986 E2	MEDIUM: 3 features, only 2/3 correlated	Features only	**No habituation** (overloaded)	**Correlations** ✓
Y&C 1986 E4	MEDIUM + extended habituation time	—	**REVERTED to features** (critical!)	—

Exam-Critical 7-Month Pattern

- **Easy task:** Learn correlations successfully (capacity sufficient)
- **Medium task (12 trials):** No habituation (attempting correlations, overloaded, haven't given up yet)
- **Medium task (extended trials):** Revert to features (attempted → failed → strategic simplification)
- **Implication:** Extended time can produce WORSE outcomes when task exceeds capacity (proves adaptive strategy shift)

Visual Models: Dynamic Systems Framework



Shape Bias Development (4-Step Process)

Step	Process	Example
1	Learn specific word-object associations	Hear "cup" around cup-shaped objects; "ball" around round objects (ostensive naming)
2	Extract 1st-order generalizations within each category	ALL cups share cup-shape; ALL balls share roundness (within-category pattern)
3	Detect higher-order correlation ACROSS categories	Meta-pattern: "Object nouns typically refer to shape-based categories" (emerges at ~50 nouns)
4	Deploy generalization as default inference strategy	Hear novel "dax" → assume shape-based category → rapid learning from single exemplar

Brain Architecture for Multi-sensory Integration

Integration Level	Brain Region	Function & Evidence
Modality-Specific	Motor cortex, Visual cortex, Auditory cortex	Distributed activations for word meanings. **Evidence:** "kick"→leg motor area (somatotopic); "canary"→yellow visual area
Multimodal Hub	Anterior Temporal Lobe (ATL)	Integrates ALL modalities; encodes higher-order regularities (co-activation patterns). Activates for virtually all concrete nouns
Highest Integration	Anterior Prefrontal Cortex (aPFC / BA10)	Fluid intelligence, analogical reasoning. Detects **relations among relations** (aspirin:pain::muffler:noise). Massively expanded in humans vs. primates

Key Theoretical Claims (Dynamic Systems)

- **Radical anti-representationalism:** No discrete abstract concepts even in adults; sensory-motor activations ARE meanings (constitutive, not correlational)
- **Piaget's "failure" reinterpreted:** Couldn't explain how abstract symbols emerge from sensorimotor experience because **symbols don't emerge** (they don't exist)
- **aPFC function:** Highest-level statistical integrator detecting patterns-of-patterns, NOT symbol manipulator. Damage → impaired analogy but preserved basic semantics
- **Language statistics sufficiency:** ChatGPT analogy—language statistics alone can produce intelligent behavior without perceptual grounding (supports statistical learning theory)
- **Embodiment persists:** All cognition remains grounded in sensory-motor-linguistic patterns throughout life; apparent abstraction is illusion from complex integration

Vocabulary Size & Shape Bias Thresholds

Noun Count	Shape Generalization %	Status
0-25 nouns	~30%	Weak/absent bias
26-50 nouns	~60-70%	Emerging bias (threshold crossing)
51-100+ nouns	~90%+	Strong, robust bias

Key insight: Correlation with vocabulary SIZE (not age) proves learned, not innate. Higher-order pattern requires sufficient category-learning experiences.

Exam-Critical Distinctions & Common Errors

Top Exam Traps

Common Error	Correct Understanding
A-not-B error = incomplete object permanence (Piaget)	**Smith reinterpretation:** Embodied motor memory (reach-left-from-sitting habit). Postural reset (stand/sit) eliminates error
Embodied semantics: motor activation is side-effect of retrieval	Motor activation **IS** meaning (constitutive). No separate abstract representation layer required
Shape bias is innate constraint (nativist view)	Shape bias **learned** through vocabulary experience. Correlates with noun count (not age). Trainable
More processing time → better learning (always)	If task exceeds capacity, extended time → reversion to lower-level strategy (7mo E4 proves this)
Spatial knowledge is abstract and body-independent	Spatial understanding **embodied** and posture-specific. Gap-crossing: sitting knowledge ≠ crawling knowledge
7mo "no habituation" = disengagement/fatigue	7mo attempting correlation learning but overloaded. Flat curve = struggling with too-hard task, not disengaged
C low, U low = learned nothing	Learned features successfully, just not correlations. Failure is at higher level only

Framework Comparison: Piaget vs. Dynamic Systems vs. Nativist

Dimension	Piaget	Dynamic Systems	Nativist
Abstract concepts?	Yes (semiotic function)	**NO** (embodied forever)	Yes (innate, amodal)
Role of body	Foundation, later transcended	**Constitutive at all ages**	Peripheral/irrelevant
Development pattern	Stage-like, qualitative shifts	**Piecemeal, context-specific**	Domain-specific enrichment
Mechanism	Equilibration (assim./accom.)	**Statistical learning**	Maturation + triggering
Generalization	Within-stage transfer	**Minimal cross-context**	Innate knowledge applies broadly
A-not-B explanation	Object concept incomplete	**Embodied motor memory**	Executive function failure

Decision Criteria: When Task Exceeds Capacity

- **Predict Feature-Only Learning when:** Age young (4mo), task complex (4+ features, weak correlations), or extended trials reveal reversion (7mo E4 pattern)
- **Predict Correlation Learning when:** Age older (10mo+), task simple (3 features all correlated), or age-appropriate difficulty (7mo + easy task)
- **Predict No Habituation when:** Task slightly exceeds capacity and trials insufficient for reversion (7mo E2 at 12 trials—attempting but overloaded)

Sticky Mittens Mechanism (Feedback Loop)

Enhanced motor control → more controlled object manipulation → richer multi-sensory input (visual angles, haptic exploration) → accelerated perceptual learning → more sophisticated object concepts. **Key:** Intervention creates new affordances (not practice effect); enables qualitatively new organism-environment couplings.

Domain-Specific Feature Weighting (Beyond Shape)

- **Count nouns + artifacts:** Weight shape heavily (chair, car, cup)
- **Count nouns + natural kinds:** Weight shape + texture (furry vs. scaly matters for animals)
- **Mass nouns:** Weight material/substance ("some dax" → generalize by material, not shape)
- **Evidence:** Children sensitive to linguistic form (count vs. mass syntax) by 24 months

L18: Abstract Relational Learning in Infancy

Natural Partitions Hypothesis (Gentner, 1982)

Core Claim: Human cognition parses the world into objects (stable perceptual entities) and relations (dynamic connections between objects).

Objects vs. Relations:

Dimension	Objects (Lower-Level)	Relations (Higher-Level)
Question	"What is this?"	"How are they connected?"
Stability	Stable, cohesive, persistent	Dynamic, context-dependent, transient
Cognitive Load	Low (direct mapping)	High (abstraction needed)
Examples	Dog, blue square, table	Same/different, cause/effect, left-of
Language	Nouns learned early	Verbs/prepositions later, variable
Animals	All recognize objects	Abstract relational matching nearly impossible

Human Uniqueness: Abstract relational thinking (e.g., two blue squares and two red circles both instantiate "sameness" despite zero perceptual overlap) is foundational to human cognition but nearly impossible for non-humans even with extensive training.

Neoconstructivist Framework Principles

Domain-General Hierarchical Learning System

1. **Innate Foundation:** Domain-general information processing system detects low-level features (color, shape, motion)
2. **Hierarchical Construction:** Higher-level units (correlations, categories, relations) formed from relationships among lower-level units through learning
3. **Processing Dependency:** Must first represent objects before representing relations between objects
4. **Efficiency Preference:** Infants use highest-level units available (efficient information compression)
5. **Capacity Constraint:** If system overloaded → revert to lower-level processing

Signature Prediction:

Increasing cognitive load lowers information processing level

Same infant shows relational processing with low-load stimuli but featural processing with high-load stimuli (even when relational structure identical).

Cognitive Load Formula:

$$\text{Relational Processing} = f(\text{Capacity}_{\text{age}} - \text{Load}_{\text{cognitive}})$$

Where

$$\text{Load}_{\text{cognitive}} = \text{Object Complexity} + \text{Object Variability} + \text{Num. Exemplars} + \text{Object Salience}$$

Ferry et al. (2015): 7-9 Months

Method:

Habituation to pairs showing "same" (AA, BB, CC, DD) or "different" (AB, CD, EF, GH). Test: novel objects in familiar vs. novel relation.

Key Results:

Condition	Exemplars	Result
Exp 1	1 pair (AA repeated)	✗ No generalization
Exp 2	4 diverse pairs	✓ Discriminate relations
Novel objects	4 pairs	✓ Strongest evidence
Object Exp only	4 pairs	✗ Salience blocks
Obj Exp + Hab	4 pairs	✓ Success

Critical Finding - Object Experience Effect: When infants *played with* test objects but those objects were **NOT habituated to**, they failed relational discrimination despite succeeding with completely novel objects.

Why: Mere familiarity without habituation increases object salience → consumes resources → blocks relational processing.

Anderson et al. (2018): 3 Months

Method:

Same paradigm, testing youngest possible age with varying exemplar counts.

Key Results:

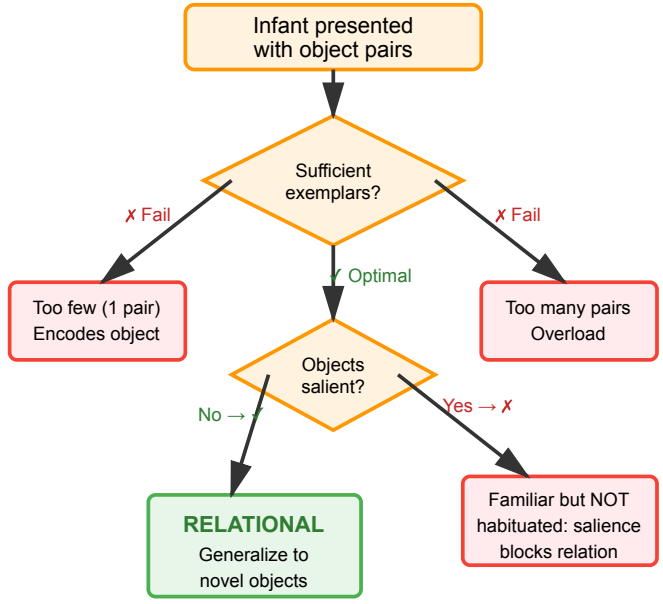
Condition	Exemplars	Result	Interpretation
Exp 1	6 pairs	✗ Fail	Too many - overload
Exp 2	2 pairs	✓ Success	Optimal for 3mo capacity
Novel objs	2 pairs	✓ Success	Generalize to never-seen
Obj Exp only	2 pairs	✗ Fail	Same interference pattern

Age-Capacity Relationship:

- **3 months:** 2 pairs optimal; 6 pairs = overload
- **7-9 months:** 4 pairs optimal; 1 pair insufficient
- **10+ months:** Higher capacity (unless objects complex + variable)

Remarkable: 3-month human infants show more sensitivity to identity relations than adult chimpanzees (who require extensive symbol training for abstract relational matching).

Same/Different: Decision Process



Age-Specific Capacity Limits:

3mo: 2 pairs optimal (6 pairs = overload)

7-9mo: 4 pairs optimal (1 pair insufficient)

10+mo: Higher capacity (unless complex + variable)

Leslie (1984): Causal Perception

Phenomenon:

Michotte's launching effect: When object A contacts B and B immediately moves, we "see" causality directly (perceptual, not inferred).

Method (6-month-olds):

Simple geometric shapes (squares, circles), same objects repeated. Habituation to causal (direct launch) or non-causal (delayed reaction, spatial gap).

Results:

- **Hab to causal:** ✓ Dishabituate to both non-causal types
- **Hab to delay:** ✓ Generalize to gap (both non-causal) but dishabituate to causal
- **Pattern:** Categorize by causal status, not spatiotemporal features

Leslie's Interpretation: Innate causal module triggered by spatiotemporal cues (contact + immediate motion), analogous to object module triggered by common motion.

Oakes & Cohen (1990): Complexity

Method:

Complex realistic toys (dinosaur, airplane, jalopy) instead of simple shapes. Same complex objects repeated across trials.

Critical Results:

Age	Objects	Result
6mo	Simple shapes	✓ Causal (Leslie)
6mo	Complex toys	✗ Featural only
10mo	Complex toys	✓ Causal restored

Interpretation: Object complexity increases load. At 6mo, complex objects consume capacity → revert to featural. By 10mo, increased capacity allows causal processing even with complexity.

Cohen & Oakes (1993): Variability

Method:

Complex objects varying on every trial (different toys in each event). Same launching paradigm.

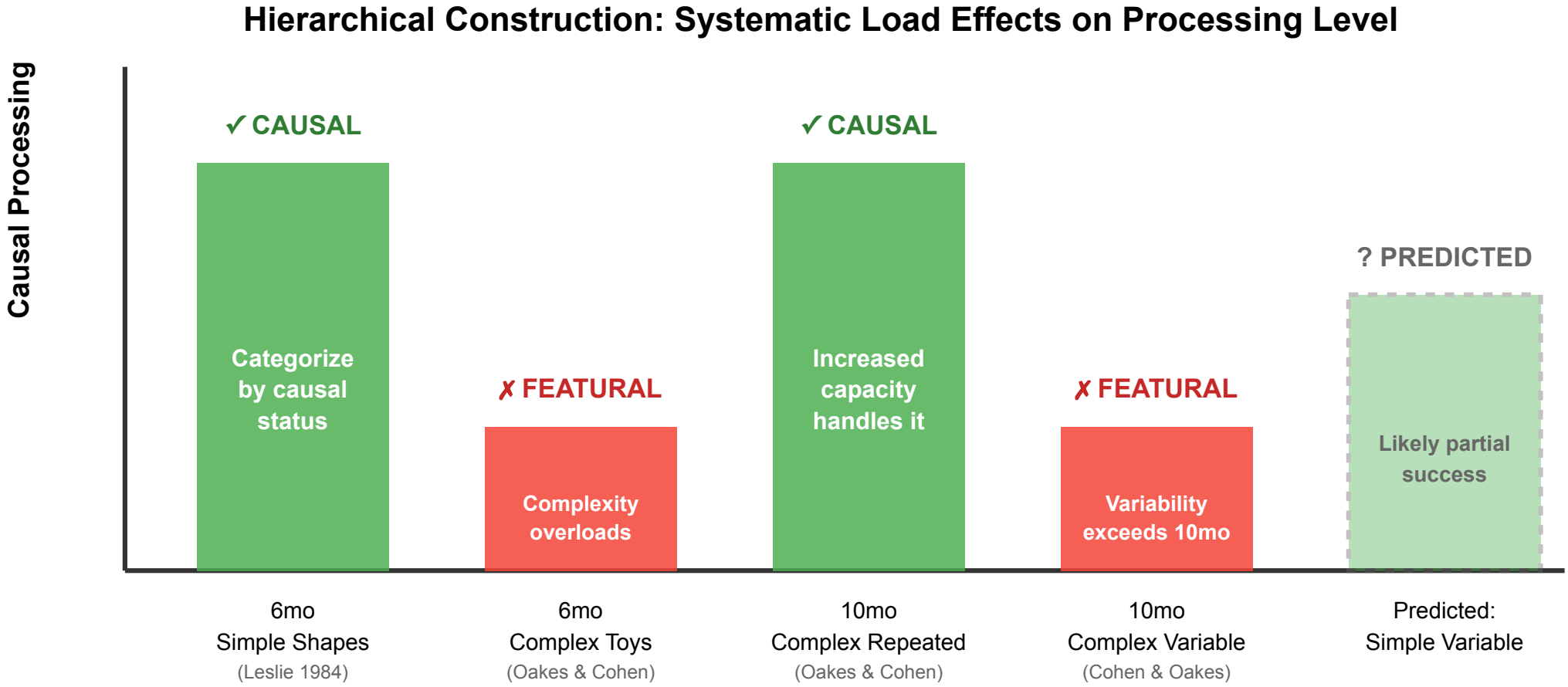
Results (10-month-olds):

Habituation	Pattern at Test
Causal	✗ No preference (equal looking all types)
Delay	✗ Discriminate features, not causal status
Gap	✗ Discriminate features, not causal status

Critical Result: 10mo who showed causal processing with *repeated* complex objects **reverted to featural** when object variability increased.

Cannot be explained by nativism: Same age, same relational structure, only object variability changed → demonstrates capacity-dependent hierarchical construction, NOT innate module.

Causal Perception: Three-Factor Model (Age × Complexity × Variability)



Pattern: Same relational structure (causal vs. non-causal spatiotemporal cues) held constant across all conditions. Systematic variation in processing level based on cognitive load = hierarchical construction. Cannot be explained by innate module maturation (which predicts consistent triggering).

Nativism vs. Neoconstructivism: Direct Comparison

Nativism (Leslie, Carey, Spelke)

- **Innate:** Domain-specific modules (object, causal, number, agency systems)
- **Mechanism:** Specific perceptual inputs trigger pre-existing modules
- **Development:** Module maturation, parameter-setting, enrichment
- **Prediction:** If triggering input present → module fires (robust to task variations)
- **Developmental Change:** All-or-nothing based on module maturation schedule

Problems:

- Cannot explain why 6mo show causal perception with simple objects but NOT complex (same spatiotemporal cues)
- Cannot explain why 10mo show causal with repeated objects but revert to featural with variable objects
- No mechanism for object experience effect (familiar-but-not-habituated interference)
- Predicts early competence should be robust; actual pattern is fragile and load-dependent

Neoconstructivism (Cohen, Oakes, Gentner, Younger)

- **Innate:** Domain-general processing mechanisms (attention, memory, statistical learning)
- **Mechanism:** Higher-level representations constructed hierarchically from lower-level features
- **Development:** Increased processing capacity + accumulated learned representations
- **Prediction:** Increasing cognitive load → lower information processing level
- **Developmental Change:** Graded, capacity-dependent, task-sensitive

Successes:

- Explains object complexity effect: complex objects consume capacity at 6mo → no causal abstraction
- Explains object variability effect: variable objects exceed even 10mo capacity → reversion
- Explains object experience effect: unexpected re-encounter increases salience → blocks relation
- Explains exemplar count non-monotonicity: too few (object-specific), optimal (abstraction), too many (overload)

Exam Quick Reference: Critical Test Questions

Identifying Frameworks:

Nativist Claims Use:

- "Innate module," "core knowledge," "domain-specific system"
- Emphasize **early competence** as evidence for innateness
- Predict **robust performance** once module matures
- Development = maturation or triggering, NOT construction

Constructivist Claims Use:

- "Hierarchical learning," "domain-general," "emergent representations"
- Emphasize **task-dependent variation** in performance
- Predict **cognitive load effects**: high load → lower level
- Development = increased capacity + learning, NOT maturation

Diagnostic Questions:

Q: "Why do 6mo show causal perception with simple shapes but not complex toys?"

- **Nativist:** No explanation (module should fire if spatiotemporal cues present)
- **Constructivist:** Complex toys increase load → consume capacity → prevent causal abstraction

Q: "Why do 10mo show causal perception with repeated but not variable objects?"

- **Nativist:** No mechanism (relational structure identical)
- **Constructivist:** Variable objects require encoding multiple identities → exceeds 10mo capacity

Q: "What uniquely identifies neoconstructivist account?"

Answer: Same infant at same age succeeds with low-load stimuli but fails with high-load stimuli (relational structure held constant). Graded, load-dependent patterns fit hierarchical construction, NOT all-or-nothing modules.

Common Exam Confusions

Confusion #1: Familiarity ≠ Habituation

- **Mere familiarity** (playing with objects) increases salience
- **Habituation** reduces salience through encoding
- Ferry et al.: Familiar-but-not-habituated objects → block relational processing
- Familiar-and-habituated objects → success
- **Why:** Unexpected re-encounter grabs attention to object level

Confusion #2: Exemplar Count (Non-Monotonic)

- **Too few (1 pair):** Encode specific objects ("goldfish-ness"), not relation
- **Optimal (age-dependent):** Forces abstraction while within capacity
- **Too many:** Exceeds capacity → overload → failure
- NOT linear: more exemplars ≠ better (inverted U-shaped function)

Confusion #3: Processing Levels

- Objects = *lower-level* (what things are)
- Relations = *higher-level* (how things connected)
- Relations **built on top of** objects (hierarchical dependency)
- When object processing incomplete → relational unavailable

Age × Capacity Reference Table

Same/Different Learning:

Age	Optimal Exemplars	Constraints	Study
3 months	2 pairs (6 = overload)	Simple; habituate test objects	Anderson+ 2018
7-9 months	4 pairs (1 insufficient)	Simple; avoid salient un-hab	Ferry+ 2015
10+ months	Higher capacity	Can handle unless complex+variable	Cohen & Oakes 1993

Causal Perception (Processing Type):

Age	Simple Objects	Complex Repeated	Complex Variable
6 mo	✓ Causal	✗ Featural	✗ Featural
10 mo	✓ Causal	✓ Causal	✗ Featural

Generalization Test Logic:

To test relational abstraction:

1. Habituate to multiple exemplars of relation R1 (e.g., "same": AA, BB, CC)
2. Test: Novel objects in R1 (DD = familiar relation) vs. R2 (DE = novel relation)
3. If dishabituate to R2 but not R1 → relation abstracted independently of objects
4. If look equally at both → failed to abstract (encoded object-specific features)

Key Studies: One-Sentence Summaries

Study	Core Finding
Ferry+ 2015	7-9mo abstract same/different with 4 diverse pairs but fail with 1 pair or familiar-un-habituated objects
Anderson+ 2018	3mo abstract same/different with 2 pairs but fail with 6 (overload) → earliest relational learning
Leslie 1984	6mo categorize causal vs. non-causal launching events with simple shapes → nativist interpretation
Oakes & Cohen 1990	6mo fail causal perception with complex toys (featural processing) but 10mo succeed → complexity effect
Cohen & Oakes 1993	10mo revert to featural when complex objects vary trial-by-trial → variability exceeds capacity
Gentner 1982	Natural Partitions: cognition divides world into objects (stable) vs. relations (dynamic, harder to perceive)

Critical Comparisons:

- **Leslie vs. Oakes & Cohen:** Same spatiotemporal cues, different object complexity → opposite results (supports constructivism)
- **Oakes & Cohen (10mo) vs. Cohen & Oakes (10mo):** Same age and complexity, different variability → opposite results (supports hierarchical construction)
- **Ferry Exp 2 (4 pairs) vs. Anderson Exp 1 (6 pairs):** Same design, different ages → different optimal exemplar counts (age-capacity relationship)

L19: Abstract Relational Learning Beyond Infancy

Natural Partitions Hypothesis

Aspect	Description
Core Claim	World = objects/substances + relations among them
Objects	Perceptually cohesive, bounded, persistent, trackable
Relations	Dynamic, unstable, infinite variability, change with movement
Prediction	Children form object categories BEFORE relational categories
Evidence	Early vocabulary dominated by nouns (dog, chair) not prepositions/verbs
Universal	English, Italian, Japanese, Korean, Mandarin, Navajo, Tzeltal - NEVER reversed

Relational Shift (Career of Similarity)

Stage	Focus	Example
Early	Common features (object-based)	Uncle = "beardy guy"
Later	Common relationships (relational)	Uncle = "parent's brother"
Island: "beaches + palms" → "land surrounded by water"		

Why Relations Harder

- No perceptual boundaries
- Constant change (context-dependent)
- Infinite ways to conceptualize
- Not automatically segmented by perception

Key Distinctions

Object vs Relation	Criterion
Object concept	Intrinsic features WITHIN entity
Relational concept	Pattern BETWEEN entities
Test	Cross-mapped: object vs relation conflict
True relational understanding	Choose relation despite different objects

Relational representation = structure mapping independent of object identity

Christie & Gentner (2010): Toma Study

Condition	Design	3-year-olds	4-year-olds
Solo	1 example ("This is a toma")	2% relational	25% relational
Sequential	2 examples shown separately	11% relational	38% relational
Comparison	2 examples shown simultaneously	57% relational*	63% relational*
**Significantly above chance (50%); Comparison advantage for 3yo = 55 percentage points!*			

Design Details

- **Toma =** two same animals facing each other (novel made-up relation)
- **Test choice:** Relational match (turtles facing) vs Object match (pig + fish)
- **Cross-mapped:** Object similarity competes with relational similarity

Key Findings

- Comparison ESSENTIAL for 3yo (2% → 57%)
- Sequential presentation insufficient (working memory limits)
- Must be spatially/temporally contiguous for young children
- Effect size LARGER for younger children (lower baseline)

Analogical Comparison Mechanism

Component	Function
Process	Structural alignment: 1-to-1 correspondences based on ROLES not features
Automatic effect	Highlights common relations, downweights object features
Example	Woman receiving food ↔ Squirrel receiving food (role mapping)
Domain-general	Same process: simple comparisons → complex analogies (Rutherford atom)

When Comparison Fails

- Sequential (not simultaneous) presentation
- Working memory overload
- High object salience (distractors)
- Too many examples (cognitive load)

Markman & Gentner (1993)

- **No comparison:** Woman → woman (object match)
- **After comparison:** Woman → squirrel (relational match)

Language: Dual Mechanisms

Mechanism	How It Works
1. Invitation to Compare	Common label signals hidden commonality → triggers comparison search
Example	"This is toma, this is also toma" → Child: "Why both tomas? Let me compare"
2. Reification	Provides stable symbolic representation for transient perceptual patterns
Example	Spatial relations (in, on, between) are continuous → language discretizes

Spatial Prepositions Special

- Perceptually ill-defined (infinite gradations of "above-ness")
- Languages carve space differently (hard to translate)
- English "in" vs Korean "kkita" (tight) vs "nehta" (loose)
- Trains attention to language-specific distinctions

Gentner et al (2013): Homesigner Study

Group	Age	Neutral Condition	Cross-Mapped Condition
Hearing children	4;10	73% correct	53% correct
Homesigners (deaf)	5;6	45% correct*	35% correct (≈chance)
*Chance = 33% (3 shelves); *Above chance but impaired (28% deficit); Cross-mapped = chance (language essential)*			

Task Design

- **Setup:** Two bookshelves with 3 shelves each (top/middle/bottom)
- **Training:** Prize hidden behind card on Shelf 1 → Find on Shelf 2
- **Neutral:** Blank cards (no object interference)
- **Cross-mapped:** Picture cards (e.g., pizza on different shelf heights)

Interpretation

- **Homesign systems:** Nouns + actions, NO spatial prepositions/relational vocabulary
- **Neutral condition:** Homesigners retain some relational capacity (45% > 33% chance) but impaired vs hearing (73%)
- **Cross-mapped:** Collapse to chance when object features compete with spatial relations
- **Implication:** Language REIFIES spatial relations → without it, representations fragile

Normalized impairment: Neutral = 70% loss; Cross-mapped = 90% loss

Lucas et al (2014): Blicket Machines

Training (Machine 1)	Adult (Machine 2)	4-year-old (Machine 2)
One-cause (1 block)	73% one-cause	65% one-cause
Two-cause (2 blocks)	68% one-cause (no transfer!)	62% two-cause (transfer!)

Design

- **Machine 1:** Works with 1 specific block OR specific combo of 2 blocks
- **Machine 2:** New blocks, ambiguous evidence (could be 1 or 2 cause)
- **Real-world analogy:** 1 key to open door vs 2 keys needed (submarine launch codes)

Key Findings

- **Children:** Transfer abstract causal structure (one-cause vs two-cause) to new objects
- **Adults:** Default to one-cause regardless of training (prior belief bias)
- **Explanation:** Lifetime experience → most things need 1 key/button (strong priors)
- **Children flexible:** Recent evidence weighs more heavily (weaker priors)

Gopnik: Theory Theory Framework

Claim	Evidence
Children as intuitive scientists	Test abstract causal hypotheses from early childhood
Abstract from infancy	Don't need language/comparison scaffolding for causal relations
When children "smarter"	Ambiguous evidence + adult priors misleading

Reconciling Gentner vs Gopnik

- **Not contradictory:** Different relation types under different conditions
- **Gentner:** Novel arbitrary relations (toma) with no prior conceptual structure
- **Gopnik:** Causal relations with core knowledge support (infants know causality basics)
- **Gopnik training:** Multiple trials = implicit comparison via repeated instantiation
- **Resolution:** Core knowledge + multiple examples → easy; arbitrary + minimal examples → needs scaffolding

Core Knowledge Number Systems

System	Capacity	Limitation
System 1: Subitizing	Precise small sets (1-3)	Distinguish 2 vs 3 dots, but ONLY small quantities
System 2: Analog Magnitude	Approximate large quantities	350 vs 500 (yes), 350 vs 352 (no)
Gap: No precise representation for arbitrary quantities (e.g., exactly 47)		

Carey's Claim

- Core knowledge INADEQUATE for mature math cognition
- Language enables QUALITATIVE conceptual shift
- Count list structure → numerical order structure

Subset-Knower Stages (Ages 2-4.5)

Stage	Give-N Task Performance
Pre-knower	Recite "1,2,3,4,5..." but NO quantity meaning
One-knower	Give 1 correctly; fail 2+
Two-knower	Give 1-2 correctly; fail 3+
Three-knower	Give 1-3 correctly; fail 4+
Four-knower	Give 1-4 correctly; fail 5+
CP-knower	Understand successor principle → give ANY N

Pattern

- Learn "one," "two," "three," "four" as individual vocab words (like chair, table, fork)
- **Inductive leap at ~age 3.5-4.5:** Discover general principle after 4 individual words
- Count list is AHEAD of understanding (can recite to 10 but only know 1-3)

Successor Principle

$$|S_{n+1}| = |S_n| + 1$$

Next number word = Previous quantity + 1 object

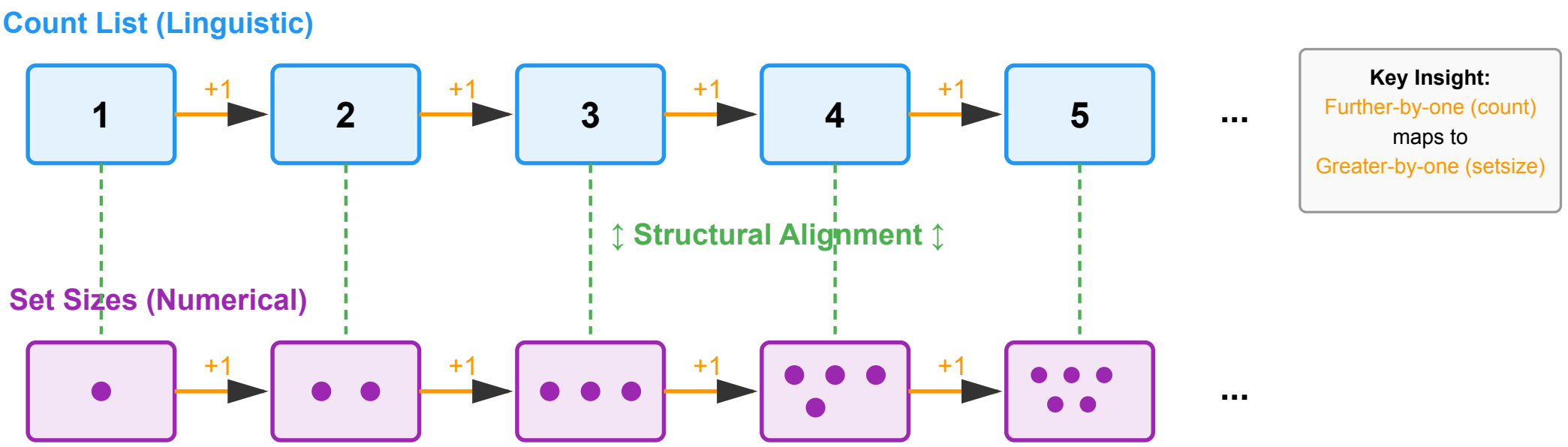
Structure Mapping (Analogical Inference)

Source	Target
Count list: 1 → 2 → 3 → 4	Set sizes: • → •• → ••• → ••••
Further-by-one in count	Greater-by-one in setsize
Mapping: Count-position(n) ↔ Set-size(n)	

Carey & Gentner Bootstrapping

- After learning 2→3 pattern, child induces: applies to ALL n→n+1
- Language structure → conceptual structure (NOT just labeling)
- Count sequence provides ANALOG for numerical order

Visual Model: Successor Principle Structure Mapping



Piraha: Language-Dependence of Number

Aspect	Finding
Number words	None beyond ~3
System 1 (Subitizing)	INTACT: Match small sets precisely
System 2 (Analog)	INTACT: Discriminate large quantities approximately
Exact arithmetic	ABSENT: Cannot perform beyond subitizing range
Implication	Stuck in core knowledge state; number language NECESSARY

Work: Peter Gordon, Mike Frank, Dan Everett

Theoretical Framework Synthesis

Framework	Mechanism	Domain	Key Prediction
Gentner: Analogical Learning	Comparison + language reification	Domain-general (any relation)	Sequential < simultaneous; spatial language-dependent
Carey: Core Knowledge + Bootstrapping	Linguistic structure → conceptual shift	Domain-specific (number, physics)	Impossible to learn exact number without count words
Gopnik: Theory Theory	Hypothesis testing, causal exploration	Causal relations	Early abstract causal reasoning; children flexible
Constructivism (Infancy)	Hierarchical representation building	Object→relation progression	Load-dependent performance; multiple examples needed

Integration Principle

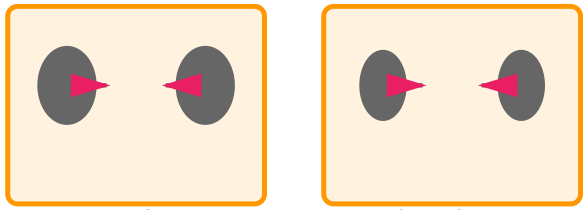
Core knowledge provides constraints → Comparison highlights structure → Language reifies relations → Hypothesis testing consolidates

When to Use Which Framework

- **Spatial prepositions:** Gentner (language-dependent, cross-cultural variation)
- **Causal reasoning:** Gopnik (domain-specific core knowledge, early emergence)
- **Number concepts:** Carey (core knowledge + linguistic bootstrapping)
- **Novel arbitrary relations:** Gentner (domain-general comparison, needs scaffolding)

Visual Model: Comparison Process (Toma Study)

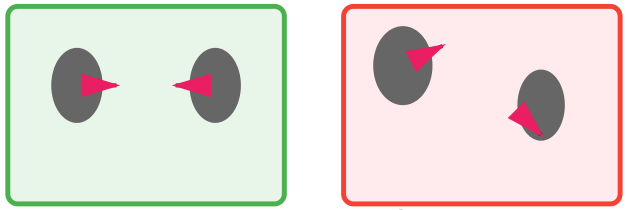
Training: "These are tomas"



2 pigs facing | 2 fish facing

Structural Alignment
(2 same, facing each other)

Test: "Which is also a toma?"



Relational Match
(2 turtles facing)

Object Match
(pig + fish, not facing)

Why Comparison Works:

1. Seeks 1-to-1 correspondences
2. Based on ROLES not features
3. Pig ↔ Fish (both "same pair")
4. Facing ↔ Facing (both have relation)

→ Highlights common structure
→ Downweights object features

Without comparison:
Focus on salient objects (pig, fish)

Results: Comparison Condition

3-year-olds:
Solo: 2% relational
Comparison: 57%

4-year-olds:
Solo: 25% relational
Comparison: 63%

Critical Age Milestones

Age	Relational Learning Capacity
Infancy	Same/different with multiple aligned examples
2 years	Recite count list; learn "one" meaning
2.5-3 yrs	Subset-knower stages (1→2→3→4 as vocab)
3 years	Comparison transforms relational learning (2%→57%)
3.5-4.5	Inductive leap: successor principle (CP-knower)
4 years	Transfer abstract causal structure; comparison→63%
6 years	Fully relational word meanings (uncle, island)

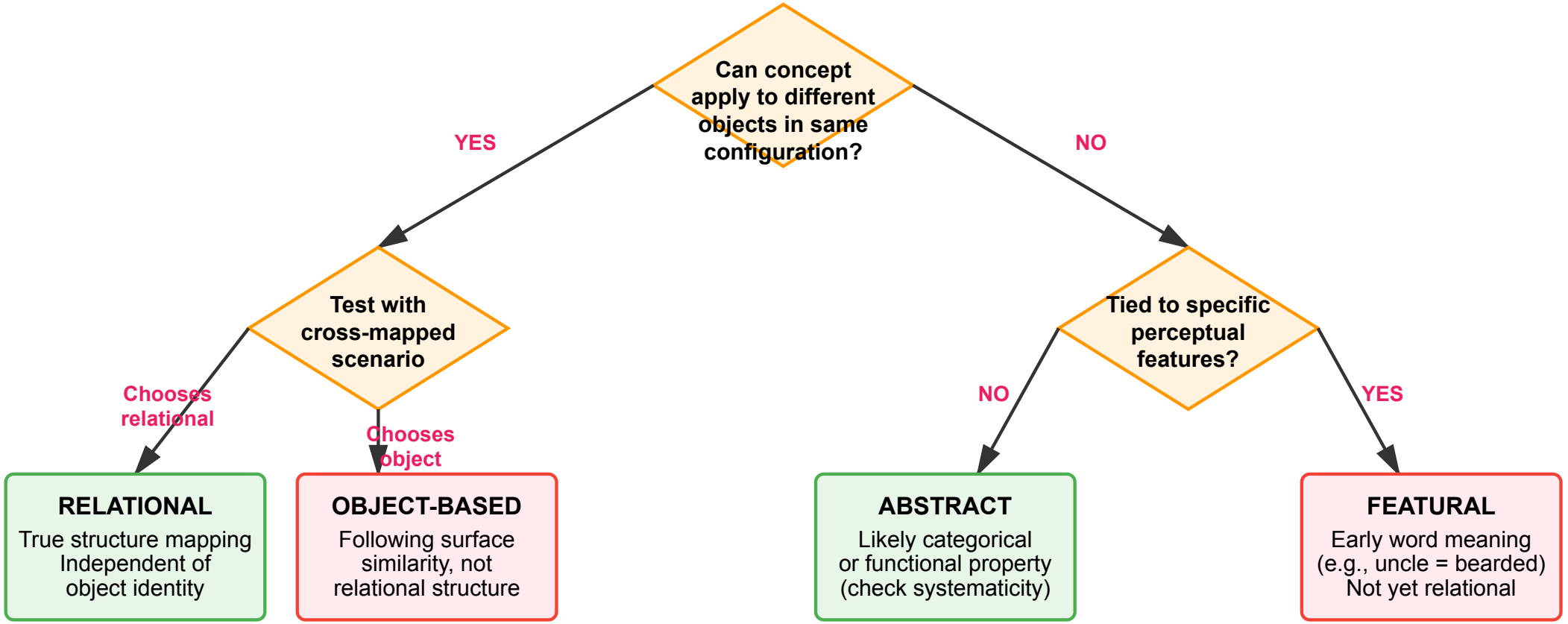
Common Exam Confusions

Confusion	Clarification
Counting = number knowledge	NO. Reciting "1,2,3..." ≠ knowing what numbers mean (Give-N task reveals)
Sequential = comparison	NO. Must be SIMULTANEOUS for young children (working memory limits)
Homesigners can't think	NO. Intact object cognition; SPATIAL RELATIONS specifically impaired
Adults always smarter	NO. When evidence ambiguous + priors misleading, children more flexible
Gopnik vs Gentner conflict	NO. Different relation types: causal (core knowledge) vs arbitrary (scaffolded)
Language just labels	NO. Dual role: (1) Invites comparison, (2) Reifies (creates stable format)

High-Yield Exam Facts

- **Natural Partitions:** Objects perceptually cohesive → universal noun precedence
- **Cross-linguistic:** Magnitude varies (Korean weaker) but NEVER reversed
- **Relational shift:** Features → relations ("career of similarity")
- **Comparison advantage:** 3yo: 2%→57% (55pp); 4yo: 25%→63% (38pp)
- **Working memory:** Sequential fails because can't reconstruct from memory
- **Cross-mapped:** Object vs relation conflict = strongest test of true relational understanding
- **Homesigner:** Neutral 45% vs 73% (28% deficit); Cross-mapped ≈chance (language essential)
- **Blicket:** Adults default to one-cause (priors); 4yo transfer structure (flexible)
- **Core knowledge gap:** Subitizing (1-3) + analog (approximate) ≠ exact arbitrary quantities
- **Subset-knowers:** Learn 1, 2, 3, 4 individually before inductive leap
- **Successor:** Count-position(n) ↔ Set-size(n) via structural mapping
- **Piraha:** No number words → stuck in core knowledge (proof language necessary)

Decision Tree: Is This Object-Based or Relational Understanding?



Key Formulas & Calculations

Comparison Advantage

$$\text{Advantage} = P(\text{relational}|\text{comparison}) - P(\text{relational}|\text{solo})$$

3yo: 0.57 - 0.02 = **0.55** (55 percentage points)
4yo: 0.63 - 0.25 = **0.38** (38 percentage points)

Relative Improvement

Math input error

3yo: 0.57 / 0.02 = **27.5×** increase
4yo: 0.63 / 0.25 = **2.5×** increase

Normalized Impairment (Homesigners)

Math input error

Neutral: (0.73 - 0.45) / (0.73 - 0.33) = **70% loss**
Cross-mapped: (0.53 - 0.35) / (0.53 - 0.33) = **90% loss**

Experimental Design Templates

Testing Relational Understanding (Gentner paradigm)

Component	Design Choice	Why
Training	2+ examples simultaneously	Enable comparison (structural alignment)
Test	Cross-mapped forced choice	Pit object similarity vs relational similarity
Control	Neutral condition (no object conflict)	Baseline relational capacity without interference
Compare	Solo, Sequential, Comparison	Isolate effect of simultaneous alignment

Testing Number Knowledge (Carey paradigm)

Component	Design	What It Reveals
Give-N task	"Give me exactly 5 candies"	Dissociates counting routine from quantity meaning
Knower-level	Highest N child gives correctly	Pre, 1-, 2-, 3-, 4-knower, then CP-knower
Control	Ask for numbers beyond count list	Tests successor principle (can generate infinite)

Testing Language-Dependence (Homesigner paradigm)

Component	Design	Logic
Population	Deaf children of hearing parents (no sign exposure)	Selective language deficit, intact cognition otherwise
Task	Nonverbal spatial reasoning	If language reifies, deficit appears even without verbal task
Control	Age-matched hearing children	Equate general cognitive development

L20: Thinking During Play - Bridging Implicit Competence and Explicit Mastery

Central Thesis: The Implicit-Explicit Gap

Core Argument: Young children's play reveals sophisticated abstract thinking (hypothesis-testing, deductive reasoning, mathematical foundations) that contradicts traditional "preoperational" characterizations. However, this **implicit competence diverges sharply from explicit formal reasoning** required for academic success.

Domain	What Play Reveals (Implicit)	What School Requires (Explicit)
Scientific	Hypothesis generation, sensitivity to confounded vs. clear evidence, causal ambiguity resolution	Control of Variables (COV) strategy, systematic testing, domain knowledge
Logical	Deductive reasoning from premises, counterfactual thinking in pretense	Formal syllogisms, multi-step arguments, validity evaluation independent of content
Mathematical	Classification, patterning, magnitude comparison, symmetry construction	Verbalized rules, linear number line representation, fraction reasoning

The Critical Hinge: Educators mishandle the transition by conflating play's latent cognitive foundations with formal operational mastery. The former emerges naturally; the latter requires intentional scaffolding that makes tacit knowledge the object of explicit reflection.

Play Types: Developmental Progression (Piagetian Alignment)

Type	Age Range	Cognitive Functions	Piagetian Connection
Sensorimotor Play	0-2y (50%)	Repetitive action sequences (e.g., opening/closing door), object permanence, causal schemas	Aligns with sensorimotor stage: learning through action
Symbolic/Pretend	~2y+ (semiotic function)	Symbol manipulation (block = phone), dual representation, inhibiting reality-based responses	Marks preoperational entry: symbolic function enables abstraction
Constructive Play	4-6y (50%)	Building, making, spatial reasoning, symmetry, cause-effect in physical systems	Preoperational: plans multi-step projects but reasoning remains intuitive
Dramatic Play	2-3y (parallel) → 3-5y (group)	Role-taking, perspective-taking (ToM), narrative construction, social coordination	Challenges egocentrism claim: successful group pretense requires coordinating perspectives
Games with Rules	Grows 4-7y	Abstract rule representation, adherence vs. immediate desire, fairness reasoning	Transitioning to concrete operations: can represent and follow abstract rules

Play Benefits & Historical Decline

Documented Benefits

Benefit	Evidence
Stress reduction	Anxious preschoolers show measurably lower anxiety after imaginative play sessions
Social skill development	Children who engage in free play offer more sophisticated solutions to hypothetical social conflicts
Creativity enhancement	Divergent thinking improves after object play
Self-regulation training	Sustaining group play requires impulse control and rule negotiation

Historical Decline (1981-1997)

- **25% decline** in free-play time as parents prioritize structured activities (music lessons, organized sports)
- **Gray et al. (2023):** Correlated with rising child psychopathology diagnoses (confounds: changing diagnostic criteria, cultural awareness)
- **Threat:** Decline eliminates natural context for spontaneous hypothesis-testing, social reasoning, creative problem-solving

Scientific Thinking: Key Studies

Study	Method	Finding	Interpretation
Gopnik: Blicket Detector	4-year-old with toy behaving unexpectedly	Child cycles through 5 hypotheses in 2 minutes	Demonstrates cognitive hallmarks of scientific reasoning: surprise-triggered inquiry, hypothesis generation, systematic testing, theory revision
Schultz & Bonawitz (2007)	Jack-in-box with 2 levers, 2 pop-ups. Confounded (both levers pulled simultaneously) vs. unconfounded (sequential demonstration)	**Confounded:** 65% choose old toy to continue playing. **Unconfounded:** 62% choose novel toy	Play is motivated by drive to resolve causal ambiguity, not merely novelty/fun. Children allocate play effort strategically to construct complete causal models. Play duration inversely correlates with causal certainty
Klahr: Ramp Experiment	Variables: ball type, surface texture, ramp steepness, release height. Ask elementary children to determine what affects distance	Children change ALL variables at once rather than isolating factors one at a time	Failure to apply **Control of Variables (COV) strategy** when multiple factors vary simultaneously. Children lack abstract representation of COV as domain-general heuristic
Schalk et al. (Switzerland)	Inquiry-based physics education on sinking/floating (density as mass/volume ratio)	Children successfully learn both COV strategies AND domain concepts when they explore phenomena, receive scaffolded reflection, and verbalize reasoning	COV can be taught through inquiry-based education with explicit scaffolding and language-mediated reflection

Control of Variables (COV): Failure & Fix

Why Children (and Scientists) Fail

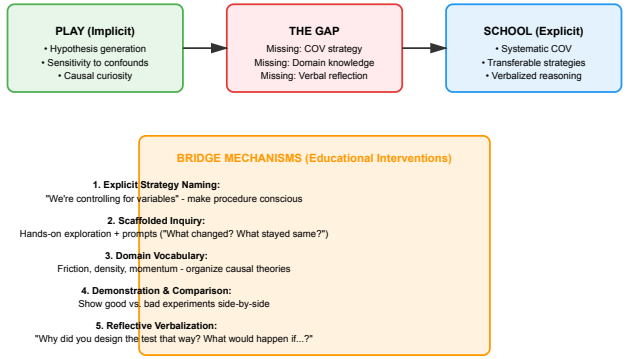
- **Lack abstract representation:** Children don't have a meta-strategy schema for "isolate one variable at a time while holding others constant"
- **Insufficient domain knowledge:** Can't identify which variables are theoretically relevant vs. irrelevant (e.g., friction vs. color)
- **Even professional scientists fail** when their theories don't flag certain variables as confounds (Joseph & Patel, 1990 on diagnostic reasoning)

Educational Fix: Inquiry-Based + Explicit Instruction

Component	Implementation	Example Prompt
Explicit COV teaching	Demonstrate good vs. bad experiments, name the strategy	"We're controlling for variables"
Hands-on exploration	Children test phenomena with scaffolded reflection	"If you want to know whether steepness matters, what should you keep the same?"
Domain vocabulary	Provide technical terms to organize causal thinking	Friction, momentum, inertia, gravitational potential energy
Reflective prompting	Ask "why/how" questions during and after experiments	"What did you change? What stayed the same? Why do you think that happened?"

Decision Rule: Natural competence when causal structure is simple (2-3 variables) and feedback is immediate and perceptually salient. Instructional threshold when multiple factors vary simultaneously.

Scientific Thinking Process Flow



Logical Thinking in Play: Deduction & Counterfactuals

Core Insight: Pretend play inherently involves hypothetical reasoning - establishing imaginary premises ("this block is a phone") and drawing logically consistent inferences from those premises. This requires inhibiting reality-based responses and reasoning deductively within alternative models.

Study	Task	Standard Result	With Scaffolding	Interpretation
Harris (2001): Syllogisms	"All cats bark. Rex is a cat. Does Rex bark?"	4-6yo fail: "No, cats don't bark" (reality bias dominates)	**"Imagine a world where cats bark..."** → Same kids succeed: "Yes, because in that world cats bark"	Imaginative frame **licenses departure from reality**, activating pretense mode. Competence exists but requires pragmatic cues to access. Multiple frames work (not frame-specific)
Buchsbaum et al. (2012): Zando Study	Learn: "Zando" makes birthday box light up/sing. "Non-zando" doesn't. Then: (1) Counterfactual Q: "What if non-zando were zando?" (2) Pretense: Use substitute objects as pretend-zando/box	40% of 4yo pass counterfactual task	Counterfactual success (78% pretense success) vs. failure (32% pretense success). Correlation holds controlling for executive function	Pretense and counterfactual reasoning **share representational structure**: both require maintaining dual models (actual vs. hypothetical) and reasoning within hypothetical while inhibiting actual

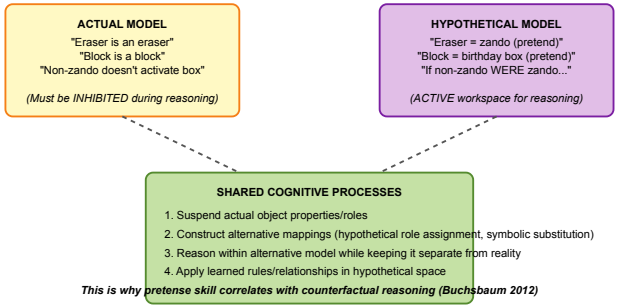
Challenges to Vygotsky's Collaborators (Siberian Work): Harris argues abstract logical reasoning does NOT require formal schooling. Competence exists preoperationally but requires appropriate scaffolding (imaginative framing) to elicit. This aligns with Vygotsky's broader claim that cultural tools (here, imaginative language) enable higher cognition.

When to Use Imaginative Framing vs. Formal Logic

Approach	Use When	Strengths	Limitations
Imaginative Framing ("Imagine if...")	• Reasoning structure is simple (single counterfactual, short inference chain) • Goal is to assess latent competence • Working with young children (ages 3-6)	• Minimal cost (simple prompt) • Accesses reasoning abilities masked by reality bias • Engages intrinsic pretense mode	• Doesn't transfer to formal contexts • Limited to simple inference chains • Context-dependent activation
Formal Logic Instruction	• Task requires multi-step deductive chains • Need to evaluate argument validity independent of content • Goal is domain-general transfer	• Provides metacognitive strategies • Generalizes across contexts • Enables explicit evaluation of validity	• Requires sustained instruction • Less intuitive for young children • Even adults struggle with belief bias

Common Educational Failure: Assuming that because children can reason logically in pretense, they don't need explicit instruction in formal logic. This conflates performance competence with reflective, generalizable skill.

Dual-Model Architecture: Pretense & Counterfactuals



Mathematical Play Behaviors (Seo & Ginsburg 2004)

Observation: 4-year-olds during free play spontaneously engage in sophisticated mathematical behaviors, revealing implicit knowledge.

Category	Example Behavior	Implicit Competence
Classification	Child cleaning up blocks sorts them by size and shape, placing each in corresponding storage box	Attribute-based categorization, set membership reasoning
Pattern & Shape	Child creates bead necklace with yellow-red-yellow-red repetition; builds symmetrical block tower (double-unit base, 2 unit blocks on top, triangular blocks in center)	Periodic sequence construction, bilateral symmetry, geometric intuition about balance
Magnitude	Children spontaneously compare quantities ("I have more dinosaurs than you") and distribute resources fairly	Perceptual magnitude comparison, fairness reasoning
Enumeration	Counting objects during play (though often with errors in one-to-one correspondence)	Number sequence knowledge, emerging cardinality
Spatial Relations	Navigating "inside," "on top of," "next to" during construction and dramatic play	Topological and projective spatial reasoning

The Paradox: Despite these foundations, formal mathematical reasoning fails spectacularly in both children AND adults (e.g., 1/3 lb burger failure, symmetry use without formal definition). Why?

Mathematical Failures & The Implicit-Explicit Disconnect

Adult Mathematical Failures

- **1/3 lb Burger (1980s):** Failed against McDonald's 1/4 lb burger because consumers believed $\frac{1}{4} > \frac{1}{3}$ (larger denominator = larger quantity, ignoring inverse relationship)
- **Symmetry Paradox:** 4-year-olds carefully construct symmetrical structures but fail to define symmetry algebraically years later

Why the Disconnect?

Knowledge Type	Characteristics	Limitations
Implicit/Procedural (Knowing-How)	• Enact patterns without verbalizing rule • Compare magnitudes perceptually • Use symmetry aesthetically • Context-bound, action-based	• Can't explain to others • Doesn't transfer to new contexts • Not accessible for formal instruction • Remains non-verbal
Explicit/Declarative (Knowing-That)	• Verbalize classification criteria • Represent numbers on mental line • Define geometric properties • Generalizable, symbolic	• Requires language scaffolding • Doesn't emerge from play alone • Needs intentional instruction • SES disparities emerge here

SES Disparities: The Language-to-Formalization Gap

Critical Observation

Measure	Low-SES Children	High-SES Children	Implication
Spontaneous mathematical play behaviors	**No difference**	**No difference**	Cognitive capacity is equivalent
Verbal mathematical reasoning (K entry)	**Substantial gap** (lower)	**Substantial gap** (higher)	Difference is in language-mediated reflection, not competence
Language input quantity/quality at home	Lower (fewer "why/how" questions, less extended conversation)	Higher (richer vocabulary, more reflective prompts, extended conversational turns)	Abecedarian intervention connection: language input disparities

The Mechanism

High-SES Advantage: More frequent conversations that prompt metacognitive reflection ("Why did you put the big blocks on the bottom?" "What pattern did you make?") → These conversations **verbalize and formalize** mathematical structures implicit in play → Transform procedural knowledge into declarative, portable concepts

Educational Equity Implication: Play-based learning WITHOUT structured reflection may maintain rather than close SES gaps. If educators adopt laissez-faire "children learn through play" approach, children lacking reflective home dialogue will hold mathematical knowledge implicitly, unable to verbalize, generalize, or connect to formal symbols.

Siegler (2009): The Great Race - Targeted Number Line Game

Why Number Line Representation Matters

The **linear mental number line** is the foundational representation for magnitude understanding and arithmetic. It spatializes numerical relationships: adding 3 to 4 means "moving 3 steps from the 4 position."

Intervention Design

Component	Detail
Game Structure	Linear board game numbered 1-10. Spin spinner (lands on 1-4), move token that many spaces
Critical Feature	**Linear spatial layout with numerical labels and colored spaces** - child repeatedly experiences distance ∝ numerical difference
Dosage	Four 15-minute sessions over 2 weeks

Results (2-9 weeks post-intervention)

Measure	Pre-test	Post-test	Interpretation
Number line placement model fit	$R^2 = 0.22$ (logarithmic compression: all numbers cluster at midpoint)	$R^2 = 0.94$ (near-perfect linear fit: $y = 0.78x + 0.67$)	Shift from logarithmic to linear mental representation
Magnitude comparison	65% accuracy	89% accuracy	Improved understanding that 6 is "farther" from 0 than 1
Single-digit arithmetic (with corrective feedback)	Baseline	Significant learning gains	Linear representation supports calculation

Control Conditions (Minimal Improvement: $R^2 \approx 0.26$)

- **Circular game:** Removes linearity - movement around circle doesn't map "larger numbers are farther from zero"
- **Color-only linear game:** Removes numerical labeling - no spatial-numerical integration
- **Counting activities:** Lack spatial integration - no distance ∝ magnitude mapping

Critical Lesson: Effective educational games must embed the target cognitive representation, not merely involve relevant content. The specific representational structure (linear spatial-numerical integration) is critical, not mere play or numerical exposure.

Gentner et al.: Structured Comparison & Language

Stable Construction Principles (Bracing Study)

Condition	Training Structures	Transfer Test (Novel Structure)	Ages 8+ Accuracy
High Alignability	Two structures with diagonal braces (same relational structure: diagonal → triangles → stability, but different positions/colors)	Novel trapezoidal frame (unstable) - can they add appropriate brace?	82% correctly add diagonal brace to form triangles
Low Alignability	One braced structure + one differently-configured structure (different base shapes, harder to align)	Same novel structure	47% correct transfer
No Training	—	Same novel structure	38% correct transfer (baseline)

Language Enhancement (Zheng, Goldwater & Gentner, 2025)

Addition of relational language label "brace" during learning:

- High alignability + language → **85% transfer** (vs. 82% without language)
- Low alignability + language → Improved transfer
- **Mechanism:** Verbal labels help children encode and retrieve abstract relational structures independent of specific objects

Principle: Comparison extracts relational structure (diagonal brace → triangle formation → rigidity); language provides stable encoding; together they enable far transfer to novel configurations.

Intervention Design Framework: 5-Step Process

Step	Goal	Implementation	Example
1. Identify Target Representation	What mental model/schema underlies competent performance?	Research-based identification of cognitive bottleneck	Linear number line, diagonal bracing → triangles → stability, fractions as magnitudes on continuous line
2. Embed in Meaningful Activity	Design motivating game/problem that repeatedly instantiates target representation	Create engaging context that feels like play, not drill	Great Race board game (number line), construction challenge (bracing)
3. Maximize Alignability	For relational principles: show multiple analogous examples	Vary surface features while preserving relational structure	Different braced structures (rectangles, trapezoids), different linear games (different themes/colors)
4. Add Relational Language	Provide verbal handles for encoding/retrieval of abstract relationships	Introduce vocabulary that names the principle, not just objects	"Brace" (structural element), "number line" (representation), "symmetry" (property)
5. Prompt Reflection	Elicit verbalization of strategies and justification of choices	Ask "why/how" questions during and after activity	"Why did you put big blocks on bottom?" "How do you know?" "What would happen if...?"

Common Design Failures

- **Fun but no target representation:** Chutes and Ladders teaches turn-taking but not linear number representation (jumps violate magnitude proportionality)
- **Single examples without comparison:** Children encode specific instances rather than abstract principles
- **Implicit learning without verbalization:** Knowledge remains procedural and context-bound

Competing Educational Approaches

Approach	Advocate	Core Strategy	Advantages	Costs/Limitations
Whole-Curriculum Mathematicization	Clements & Sarama	Observe children's play, identify implicit mathematical behaviors, design curricula that prompt reflection and formalize those activities	• Holistic, child-centered • Builds on intrinsic motivation • Leverages existing competencies • Addresses multiple mathematical domains	• Requires high teacher expertise to recognize math in diverse contexts • Time-intensive • May lack focus on critical bottleneck representations • Harder to scale
Targeted Representational Games	Siegler	Identify key mental representation (linear number line) and design focused game to build it; don't "gamify everything," just target what matters most	• Efficient (four 15-min sessions) • Empirically validated to close SES numeracy gaps • Scalable • Minimal teacher training • Directly addresses cognitive bottleneck	• Narrow focus may miss other competencies • Less intrinsically engaging than open play • Risks instrumentalizing play • Requires research to identify critical representations
Structured Comparison + Language	Gentner	Show multiple alignable examples that share relational structure but vary surface features; add relational language labels to stabilize encoding	• Facilitates abstraction and far transfer • Language provides portable encoding • Effective for relational concepts (bracing → triangles → stability)	• Requires careful design of alignable pairs • May be less effective for concepts lacking clear relational structure • Language labels must be introduced at right time
Reflective Prompting	General scaffolding	Ask "Why did that happen? How do you know? What would happen if...?" during and after play to verbalize strategies	• Low-cost, applicable across domains • Builds metacognitive skills • Provides conversational input that low-SES children often lack at home	• Effectiveness depends on teacher skill in asking productive questions • May interrupt flow of play if poorly timed • Doesn't guarantee correct concept formation

Recommended Decision: Use targeted games for foundational bottleneck representations (number line, fraction magnitudes, geometric transformations) where research identifies specific cognitive bottlenecks, while embedding broader play-based mathematicization for exploratory learning and motivation. Avoid extremes: neither drill-based decontextualized instruction NOR unstructured "discovery learning" without scaffolding.

Theoretical Integration: Vygotsky's Sociocultural Framework

Vygotskian Claim	Evidence from This Lecture	Nuances/Contradictions
Language = cultural tool for higher cognition	• SES gap: same play behaviors, different verbal reasoning (language input differences predict outcomes) • "Imagine if..." prompt enables logical reasoning • Relational language ("brace") improves transfer	Harris contradicts Vygotsky collaborators' Siberian work: logical competence exists pre-school, doesn't require formal schooling—just needs imaginative frame to access
Social interaction builds knowledge	• Reflective questions ("Why?") transform implicit → explicit • High-SES conversational scaffolding provides advantage • Teacher prompts during inquiry-based learning teach COV	Siegler's targeted games work even with minimal social interaction, suggesting representational structure itself matters, not just social mediation
Cultural institutions (e.g., schooling) shape thinking	• Formal COV strategies don't emerge spontaneously—require explicit instruction • Number line representation requires culturally designed games/activities • Verbalized mathematical knowledge requires reflective conversations	However, underlying competencies (hypothesis-testing, logical reasoning, mathematical intuitions) exist pre-school and cross-culturally, suggesting universal cognitive foundations

Resolution: Competence exists universally (against strong Vygotskian cultural determinism), BUT language and cultural practices provide tools to ACCESS, FORMALIZE, and GENERALIZE that competence (supporting Vygotskian emphasis on cultural mediation). The lecture demonstrates that play reveals latent abilities, while education provides the cultural-linguistic scaffolding to make them explicit and transferable.

High-Yield Study Facts

Schultz & Bonawitz (2007): Jack-in-Box Study

- **Confounded condition:** 65% choose old toy (need more play to resolve causal ambiguity)
- **Unconfounded condition:** 62% choose new toy (causal structure complete, prefer novelty)
- **Interpretation:** Play duration ∝ causal uncertainty (information-seeking, not hedonic value)

Harris (2001): Syllogistic Reasoning

- **Standard syllogism ("All cats bark..."):** 4-6yo refuse false premise (reality bias)
- **"Imagine if..." framing:** Same kids succeed (licenses departure from reality)
- **Multiple frames work:** Not frame-specific, but requires explicit counterfactual cue

Buchsbaum et al. (2012): Zando Study

- **40% of 4yo** pass counterfactual task ("What if non-zando were zando?")
- **Correlation:** Counterfactual success → 78% pretense success; failure → 32% pretense success
- **Holds controlling for EF:** Shared representational architecture, not executive function

Siegler (2009): Number Line Results

- **Pre-test:** $R^2 = 0.22$ (logarithmic compression)
- **Post-test:** $R^2 = 0.94$ (linear: $y = 0.78x + 0.67$)
- **Magnitude comparison:** 65% → 89%
- **Controls fail:** Circular game $R^2 \approx 0.26$ (no improvement)

Gentner: Bracing Transfer

- **High alignability:** 82% transfer to novel structure
- **Low alignability:** 47% transfer
- **No training:** 38% transfer (baseline)
- **Language enhancement:** 85% transfer (high align + "brace" label)

Common Exam Confusions & Correct Views

Wrong Assumption	Correct View	Evidence
Play reveals thinking → no teaching needed	Play = implicit competence. Teaching makes it explicit, generalizable, verbal	Kids use symmetry in blocks but can't define it formally; same play behaviors across SES but different verbal reasoning
COV failure = low intelligence or immaturity	Lack of abstract strategy representation + domain knowledge (even scientists fail without theory)	Klahr: kids vary all variables. Joseph & Patel: professional scientists fail to control variables when theory doesn't flag them as confounds
Imaginative framing is "magic" or just motivational	It's a cultural tool (Vygotsky) that licenses departure from reality bias, activating pretense reasoning mode	Harris: same kids fail standard syllogism but succeed with "Imagine if..." - competence exists, needs pragmatic cue
Linear number line game works because it's more fun	Specific representation (distance ∝ magnitude) is critical. Circular/color-only fail despite equal engagement	Siegler: only linear spatial-numerical integration improves number line estimation (R^2 0.22→0.94). Controls R^2 ~0.26
SES gap in math = different play abilities or materials	Same play behaviors, different VERBALIZATION (language input quality/quantity differences)	Seo & Ginsburg: equivalent math play behaviors across SES, but gaps in verbal mathematical reasoning at K entry
Pretense and counterfactual reasoning are separate skills	Shared dual-model architecture: both require maintaining actual vs. hypothetical and reasoning within hypothetical	Buchsbaum: correlation holds controlling for EF (78% vs 32%), indicating representational overlap not capacity limitation

Critical Distinctions (Know These Cold)

Concept A	vs	Concept B	Example/Test
Implicit/Procedural knowledge (knowing-how)	≠	**Explicit/Declarative knowledge** (knowing-that)	Can sort blocks by shape (procedural) but can't explain classification criteria (declarative)
Context-bound competence	≠	**Generalizable, portable skill**	Use symmetry in block-building but not in algebra definitions; classify toys but not animals using same principles
Perceptual/behavioral understanding	≠	**Verbal/symbolic representation**	"I have more" (perceptual magnitude comparison) vs. "6 > 1 because 6 is farther from 0 on the number line" (symbolic)
Spontaneous discovery	≠	**Scaffolded formalization**	Kids spontaneously test hypotheses (discovery) but don't discover COV strategy without explicit instruction (formalization)
Confounded evidence	≠	**Unconfounded evidence**	Both levers pulled → can't tell which causes effect (confounded) vs. levers tested sequentially (unconfounded)
Natural competence (simple, immediate feedback)	≠	**Instructional threshold** (multiple variables, delayed feedback)	Test single causal link (competence) vs. isolate variables in multi-factor ramp experiment (needs instruction)

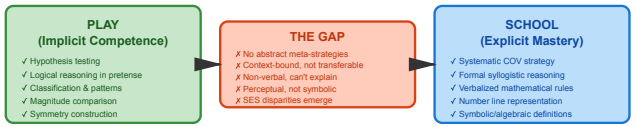
Play → School Pipeline: Integration Across Domains

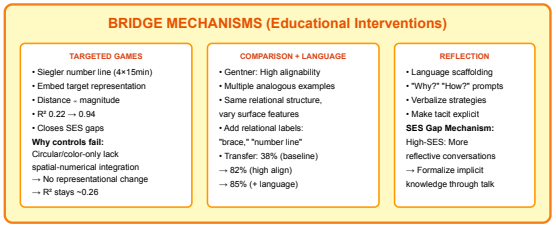
Domain	What Play Shows	What School Teaches	Bridge Mechanism	Common Educational Error
Scientific Thinking	Hypothesis generation, sensitivity to confounded vs. clear evidence, motivation to resolve causal ambiguity (Gopnik, Schultz & Bonawitz)	Control of Variables strategy, systematic testing, domain knowledge to identify relevant variables	Inquiry-based exploration + explicit COV instruction + domain vocabulary + reflective prompting ("What changed? What stayed same?")	Assuming spontaneous hypothesis-testing = scientific method mastery. Omitting explicit strategy naming
Logical Thinking	Counterfactuals in pretense, deduction from imaginary premises, dual-model cognition (Harris, Buchsbaum)	Formal syllogisms, multi-step arguments, validity evaluation independent of content belief	Imaginative framing ("Imagine if...") for young children → Metacognitive training for older children → Formal logic instruction	Assuming imaginative reasoning transfers to formal logic without scaffolding. Conflating pretense competence with generalizable skill
Mathematical Thinking	Classification, patterning, magnitude comparison, symmetry construction, enumeration (Seo & Ginsburg)	Verbalized rules, linear number line representation, fraction reasoning, formal definitions	Targeted representational games (number line) + structured comparison + relational language labels + reflective questioning ("Why sort that way?")	Observing math play and concluding "they're learning math, no teaching needed." Missing language-mediated formalization

Decision Matrix: When Play Suffices vs. When Instruction Required

Task Characteristics	Play Suffices (Implicit Competence Adequate)	Instruction Required (Explicit Formalization Needed)
Number of variables	2-3 variables, simple causal structure	4+ variables, complex interactions
Feedback	Immediate, perceptually salient	Delayed, requires inference
Transfer requirement	Apply skill in same/similar context	Generalize to novel domains/contexts
Communication need	Can demonstrate behaviorally	Must verbalize, explain to others, write about
Representation	Perceptual/action-based understanding adequate	Abstract symbolic representation required (number line, algebraic symbols, formal definitions)
Reasoning depth	Single-step inference, short causal chain	Multi-step deduction, long causal/logical chains
Social context	Individual or peer play discovery	Academic setting requiring formal knowledge demonstration

Visual Summary: The Educational Challenge





L21: Executive Functions Development

Core Definition

Executive Function (EF): Higher-order cognitive control system that regulates thoughts, emotions, and behavior in service of goal-directed action.

- **Metaphor:** "Executive of the brain" coordinating domain-specific regions (language, sensory, motor)
- **Functions:** Goal maintenance, monitoring progress, emotion regulation, impulse control, meta-cognition
- **Localization:** Prefrontal cortex (PFC) + connectivity to other brain regions
- **Critical for:** Planning, learning complex concepts, social appropriateness, school success

Three Core Components

Component	Definition	Gold Standard Task
Response Inhibition	Suppress prepotent/automatic responses; delay gratification	Stroop, Day-Night, Marshmallow
Cognitive Flexibility	Switch between mental sets; reconfigure stimulus-response mappings	DCCS (Dimensional Change Card Sort)
Working Memory	Maintain & manipulate information in parallel; relational complexity	Halford relational tasks, n-back

Note: Highly correlated but dissociable via factor analysis. All improve 3-5yo, continue into mid-20s.

Developmental Timeline

Age	Key Milestone
2-3 years	Poor inhibition, can't switch rules (DCCS 0%), tantrums/impulsivity
3-5 years	**DRAMATIC improvement:** 3yo fail Day-Night (70-90% errors) → 5yo pass (10-20%)
5-6 years	DCCS success (~85-95%), school readiness (sit still, follow rules, sustained attention)
7-11 years	**LARGEST PFC growth period**; WM expands; impulse control strengthens
Adolescence	Intelligence > impulse control; PFC-amygdala connectivity matures slowly
Mid-20s	**Peak EF capacity**; car insurance drops (reduced risk-taking)
30s onward	Gradual decline BUT knowledge compensates (crystallized > fluid reasoning)

Response Inhibition: Tasks & Patterns

Task	Prepotent Response	Required Response	Age Pattern	Theoretical Relevance
Stroop (adults)	Read word automatically	Name ink color (ignore word)	Adults struggle (reading = automatic)	Classic inhibition measure
Day-Night Stroop	Say "day" for sun, "night" for moon	Say OPPOSITE	**3yo: 70-90% errors | 5yo: 10-20% errors**	Can't read yet so use semantic associations
Marshmallow Test	Eat 1 marshmallow NOW	Wait unspecified time for 2 marshmallows	Predicts achievement BUT effect weaker than originally claimed	Delay gratification; see Moffitt study (more robust)

Critical Insight: Task failure ≠ lack of rule knowledge. Children can STATE the rule perfectly but cannot inhibit prepotent response. Performance deficit = weak goal representation in working memory (not comprehension failure).

Theoretical Debates Using Response Inhibition

- **Theory of Mind:** False belief failure = response inhibition deficit? Can't suppress own perspective (competence vs performance)
- **Conservation (Piaget):** Failure = can't inhibit perceptual salience (height of water), not logical reasoning deficit
- **Relational reasoning:** Object similarity more salient than relational similarity; requires inhibition to focus on relations

DCCS Task Procedure

Materials: Cards varying on 2 dimensions: Shape (boats vs rabbits) × Color (red vs blue)

Phase 1: Pre-Switch (Shape Game)

- Rule: Sort by shape (ignore color)
- **3yo performance: 100% accuracy**
- **5yo performance: 100% accuracy**

Phase 2: Rule Check (Verbal Knowledge)

- Experimenter: "Where do RED ones go in color game?"
- **3yo: Points CORRECTLY**
- Experimenter: "Where do BLUE ones go?"
- **3yo: Points CORRECTLY**
- **Conclusion: Verbal knowledge 100% intact**

Phase 3: Post-Switch (Color Game)

- Rule: Sort by color (ignore shape)
- Show red rabbit → **3yo sorts to RABBIT pile (perseverates on shape)**
- Show blue boat → **3yo sorts to BOAT pile**
- **3yo performance: 0% accuracy (despite knowing rule!)**
- **5yo performance: 85-95% accuracy (slight switching cost)**

The DCCS Paradox: Can verbally state rule but cannot execute it. Established stimulus-response mapping (shape → pile) cannot be reconfigured despite intact comprehension, attention, and memory.

DCCS Interpretation

NOT a Failure of:

✓ **Attention:** Can attend to both dimensions (succeeds in pre-switch)
✓ **Memory:** Remembers rule (states it correctly in Phase 2)
✓ **Comprehension:** Understands task (verbal knowledge intact)
✓ **Perception:** Can perceive both color and shape

ACTUAL Failure:

✗ **Cognitive Flexibility:** Cannot disconnect established S-R mapping
✗ **Goal Representation:** Cannot maintain new rule representation to guide behavior
✗ **PFC Maturity:** Immature PFC cannot reconfigure behavior according to new rule

Alternative Interpretations

- **Halford/Andrews view:** Really about **working memory**, not switching per se. Must bind color + shape simultaneously (binary relational complexity). Under-5s fail binary relations.
- **Zelazo view:** Age increase in **hierarchical rule complexity** (if-then-else structures)
- **Goal representation view:** Keeping goal prominent allows inhibition of old mapping

DCCS Task: Visual Process Flow

3-Year-Old DCCS Performance: The Perseveration Pattern

Phase 1: Shape Game

"Sort by SHAPE"

Boats → Boat pile
Rabbits → Rabbit pile
(Ignore color)

✓ 3yo: 100% Accuracy
Perfect sorting

Stimulus-Response Mapping ESTABLISHED:

Boat card → Boat pile
Rabbit card → Rabbit pile

Can attend to shape dimension
Can ignore irrelevant dimension (color)

Phase 2: Rule Check

"Where do RED ones go in color game?"

✓ Points CORRECTLY

"Where do BLUE ones go?"

✓ Points CORRECTLY

VERBAL KNOWLEDGE 100% INTACT
• Remembers rule

NOT a failure of:
Comprehension, Memory, or Attention

Phase 3: Color Game

"Sort by COLOR now"

Show: Red rabbit
↓
Sorts to RABBIT pile
(Should go to RED pile)

Show: Blue boat
↓
Sorts to BOAT pile
(Should go to BLUE pile)

✗ 0% Accuracy
Perseverates on SHAPE

Cannot disconnect established S-R mapping

What's Really Failing?

Cognitive Flexibility Deficit

Cannot RECONFIGURE behavior according to new rule

Knows rule (can state it) but Behavior remains locked to first-learned mapping

Alternative Explanations

Halford:
Working memory limit
(can't bind 2 dimensions)

Goal representation:
Can't keep new goal active to override old habit

Working Memory: Halford Relational Complexity

Key Claim: WM capacity = number of elements considered **in parallel** (not sequential chunking).

Level	Age	Example Task	Success Rate
Unary (1 relation)	2-3 years	Dark squares = A, light squares = B (single dimension)	3yo: ~90%
Binary (2 relations)	5 years	Light-small AND dark-large = A (bind 2 dimensions)	3yo: 20-30%; 5yo: 60-70%
Ternary (3 relations)	11+ years	3-way ANOVA interactions (bakery × fresh/frozen × cake type)	Adults: interpretable with effort
Quaternary (4 relations)	Adult ceiling	4-way interactions; object tracking (max = 4 objects)	Adults: barely interpretable
5+ relations	—	5-way interactions	Humans cannot interpret (must chunk)

Halford's DCCS Reinterpretation: DCCS failure = binary relational complexity failure. Must simultaneously represent: (1) color dimension + (2) shape dimension + (3) which dimension is currently relevant. This exceeds 3yo WM capacity.

Working Memory: Key Studies

Goswami & Brown (1990): Analogies in 3-Year-Olds

- **Piaget's claim:** Analogical reasoning impossible before 6-7 years (operational stage)
- **Finding:** 3yo CAN solve analogies IF familiar relations used
- **Example:** Bread : Slice of bread :: Lemon : ? → 3yo correctly choose slice of lemon
- **Interpretation:** Competence present but masked by WM load. Familiar content = chunked knowledge = reduced WM demand

Elderly Go Experts: Knowledge × WM Interaction

- **Sample:** Go experts aged 60-80 vs younger adults
- **Game-specific WM:** NO age decline (how many Go moves ahead can you think?)
- **Novel game WM:** Significant age decline (new game = no chunking possible)
- **Interpretation:** Expertise = chunked sequences → reduces WM load. Decline only apparent in novel tasks.

Test Anxiety Mechanism

- **Worry consumes WM capacity** → less available for math problems
- Experimental stress induction (e.g., "You'll give a speech after this") → impaired EF performance
- Real-time stress hurts WM more than other EF components

Competence vs Performance Debate

Position	Claim	Evidence
Competence Deficit	Child lacks underlying conceptual understanding	Piaget: Operations emerge at stage transition (qualitative shift)
Performance Deficit	Competence present but masked by EF limits	Infants show ToM via looking time; fail explicit tasks until 4-5

Key Examples

- **False Belief:** Competence in infancy (violation-of-expectation) but performance failure until 5yo (requires inhibiting own perspective)
- **Conservation:** Not logic failure but inability to inhibit perceptual salience (taller glass LOOKS like more)
- **Analogies:** Relational competence present but WM limits prevent demonstration unless familiar content used

Resolution: Both factors matter. EF improvements unlock latent competencies, BUT conceptual development also occurs. Continuous development of EF + knowledge (not discrete stages).

🧬 Brain Development: PFC & Connectivity

Aspect	Details
Prefrontal Cortex (PFC)	Most critical brain region for EF; slow protracted maturation (birth → mid-20s)
Peak growth period	**Ages 7-11 (middle childhood)** = largest PFC volume expansion
White matter connectivity	PFC ↔ other brain regions; strengthens through adolescence into early 20s
PFC-amygdala pathway	Emotion regulation circuit; weaker connectivity = depression risk (Beavers, Schneider, Pacheco)
Individual variability	Huge variation in maturation rate; ADHD at age 12 may resolve by 17 (late maturers)
Broca's area	Frontal language region; also involved in verbal working memory (phonological loop)

Brain-Injured Adults: Dissociations

- **PFC damage:** Socially inappropriate behavior (loss of inhibition) without general cognitive impairment
- **Example (Jenny Beers):** Older male patients with frontal lobe damage making inappropriate comments to young female researcher
- **Pattern:** Language, memory, perception intact BUT impulse control, social appropriateness lost

📈 Lifespan Trajectory: EF × Knowledge

Life Stage	EF Capacity	Knowledge	Net Function
Early childhood (2-5)	Low (PFC immature)	Low (little learned)	Helpless without scaffolding; tantrums; impulsivity
Middle childhood (6-11)	Rapidly improving	Building domain knowledge	**EF enables knowledge acquisition** (school readiness)
Adolescence (12-20)	Improving but incomplete	Substantial expertise emerging	Intelligence > impulse control; risk-taking peaks
Young adulthood (20-30)	**Peak (~age 25)**	High (expertise in domains)	Both systems optimal; complex reasoning at peak
Older adulthood (60+)	Declining (slow decline)	High (crystallized intelligence)	**Knowledge compensates**; expertise = chunking reduces WM load

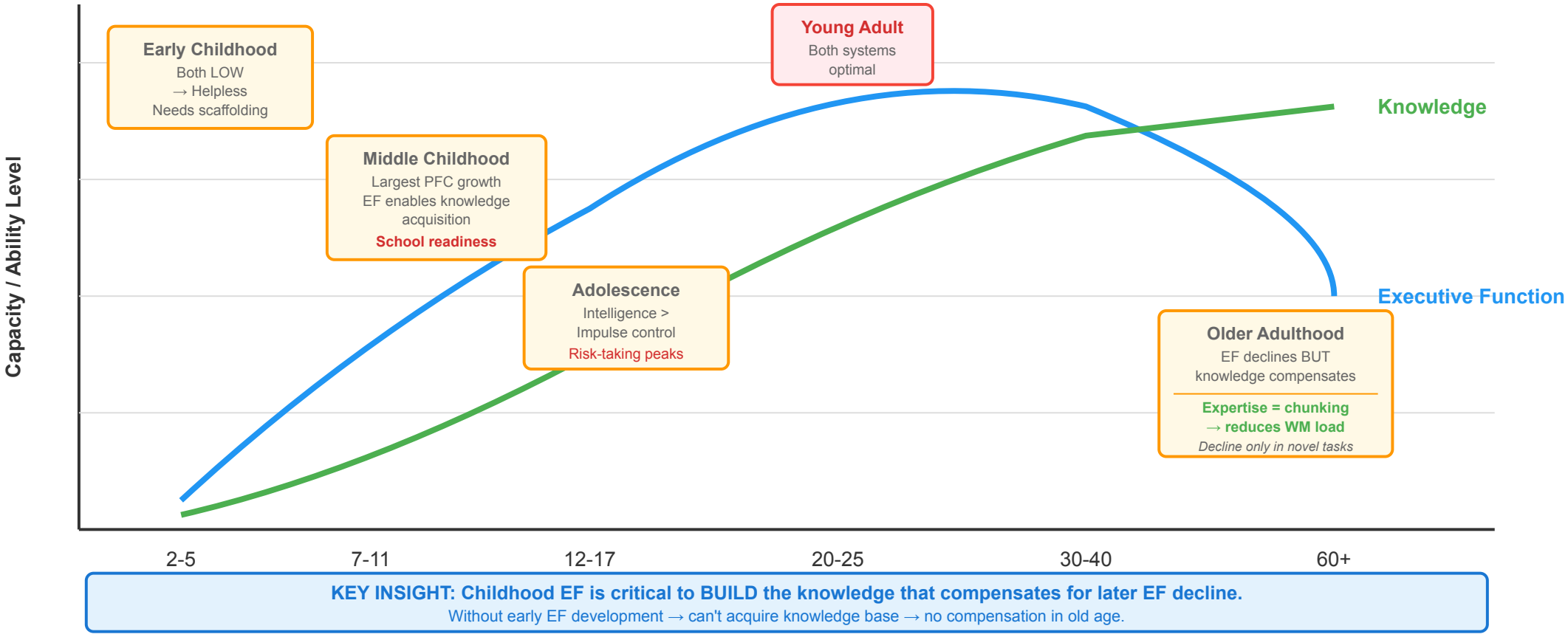
Why childhood EF is critical: Need EF to BUILD the high-quality knowledge that later compensates for age-related EF decline. Without early EF development, can't acquire knowledge base that supports later functioning.

Why Older Adults Don't Become Like 4-Year-Olds

- Decline in **fluid reasoning** (novel problem-solving)
- Intact **crystallized intelligence** (accumulated knowledge)
- Familiar tasks show minimal decline (chunking compensates for WM limits)
- Example: Grandfather discusses 20th-century politics intelligently BUT struggles with new phone interface

🔗 Knowledge × Executive Function Interaction Across Lifespan

Lifespan Trajectories: Executive Function vs Knowledge



KEY INSIGHT: Childhood EF is critical to BUILD the knowledge that compensates for later EF decline.

Without early EF development → can't acquire knowledge base → no compensation in old age.

⚠️ SES, Stress & Risk Factors

Factor	Effect on EF
Low SES	Lower EF across ALL components (inhibition, flexibility, WM); predicts educational outcomes
Mechanism 1: Chronic Stress	Impairs PFC growth (both volume + connectivity) — Hackman & Farah
Mechanism 2: Acute Stress	In-moment stress → WM interference (worry consumes capacity)
Mechanism 3: Lack of Stimulation	Less enrichment activities, less language input (affects PFC + Broca's area)
Brain regions affected	Primarily PFC and language areas (NOT all brain regions equally vulnerable)
Pathways to achievement gap	**EF + language** = primary mediators connecting SES → school outcomes

Hackman & Farah (2009): Stress & PFC

- Reviewed neuroscience evidence linking poverty-related stress to brain development
- Low SES children show **reduced PFC volume** and **weaker PFC connectivity**
- Stress hormones (cortisol) interfere with synapse formation and pruning
- Effect is **specific to PFC** (not global brain impairment)

PFC-Amygdala Connectivity & Depression Risk

- **Study:** Beavers, Schneider, Pacheco
- **Sample:** University students at risk for depression (family history)
- **Finding:** At-risk individuals show **less white matter** in PFC-amygdala pathway
- **Interpretation:** Weaker connectivity → poorer emotion regulation → vulnerability to depressive episodes

🛠️ EF Interventions: Principles

Who Benefits Most?

Biggest benefits for children with biggest deficits (at-risk populations). NOT about creating "super EF" in typically-developing children.

Intervention Requirements

- **Time-intensive:** Must be sustained over months/years (not brief training)
- **Adaptive training:** Increase difficulty as child improves (scaffolding → gradual removal)
- **Ecological validity:** Embed in naturalistic activities (not just computer games)
- **Transferability:** Must generalize to novel tasks (not just task-specific practice effects)

What DOESN'T Work

- **Commercial "brain training" games:** Early excitement but failed to replicate. Task-specific improvements don't transfer.
- **Brief interventions:** Short-term programs show no lasting effects
- **Single-component training:** Must target multiple EF components and real-world contexts

What DOES Show Promise

- **Traditional martial arts:** Small-sample study showed transfer (focus on discipline/self-control traditions, not just fighting)
- **Abecedarian Project:** Not EF-specific but massive IQ gains (EF + fluid intelligence highly correlated)
- **Tools of the Mind:** Most evidence-based preschool curriculum (see next card)

🎓 Tools of the Mind Curriculum

Design Principles

Aspect	Details
Theoretical basis	**Vygotskian:** Language as cultural tool for self-regulation; private speech → internalization
Target population	Low-income urban preschool/kindergarten (at-risk for EF deficits)
Implementation	Can be used by ANY teacher (no special training/equipment); structured play-based
Control condition	Early literacy curriculum (also designed for at-risk kids)
Initial outcome (2007)	Control schools **ABANDONED** literacy curriculum → adopted Tools (behavior so much better)

Core Vygotskian Principle

Self-regulation via language: External speech (saying rules out loud) → private speech (whispering to self) → internal speech (silent self-talk). Language becomes a tool to control impulses and maintain goals.

Assessment Results (Science 2007)

- **Tasks:** Novel computerized EF tasks (never seen before)
- **Hearts & Flowers (dots task):**
  - Congruent (heart → same side): Tools 70%, Control 65%
  - Incongruent (flower → opposite side): Tools 68%, Control 55%
  - **Mixed (switching):** Tools 72%, Control 50% (BIGGEST EFFECT)
- **Flanker task:** Tools advantage on most demanding conditions (reverse flanker, mixed)
- **Pattern:** Bigger Tools advantage as task demands increase (more switching, more inhibition required)
- **Critical:** Generalization from year of turn-taking games to completely novel computerized tasks

Replication History

- **2007:** Initial Science paper → excitement
- **2010s:** Mixed replications (implementation quality issues? Different school contexts?)
- **2017:** Systematic review → "some evidence" but not definitive
- **2018+:** Recent RCTs show benefits in literacy + socio-emotional outcomes (reduced aggression, better classroom behavior)
- **Current status:** Promising but implementation quality matters enormously

📝 Tools Activities: Buddy Reading

Goal: Turn-taking, inhibition, listening skills

Procedure

1. Each child gets a picture book
2. Pairs take turns telling story that goes with their book (point at pictures as story progresses)
3. **Problem:** Initially all want to talk, none want to listen
4. **Scaffold:** One child gets **EAR card** (listen role), other gets **LIPS card** (talk role)
5. Teacher explains: "Ears don't talk, ears listen"
6. With concrete visual symbol, child with ear inhibits talking, waits turn
7. Children trade cards and roles
8. **Outcome:** After a few months, cards no longer needed → internalized turn-taking

EF Components Trained

- **Response inhibition:** Suppress urge to talk when have ear card
- **Working memory:** Remember current role, monitor partner's actions
- **Social norms:** Enacting turn-taking without external enforcement

🔢 Tools Activities: Math Pairs

Goal: Inhibition, meta-cognition, self-reflection

Procedure

1. One child **counts** objects out loud
2. Other child **checks** whether counting was correct
3. Checker waits until counter finishes, then uses check-sheet to verify
4. Roles switch

EF Components Trained

- **Inhibition (checker):** Wait until partner finishes; don't jump in to correct mid-count
- **Working memory (counter):** Maintain count, track which objects already counted
- **Meta-cognition (counter watching checker):** Reflect on own performance; "Did I count correctly?"
- **Self-regulation:** Both roles require managing impulses and monitoring behavior

🎵 Tools Activities: Pattern Movement

Goal: Working memory, cognitive flexibility, rule-following

Procedure

1. Teacher presents visual pattern: A-B-A-B-B-A (e.g., triangle-square-triangle-square-square-triangle)
2. Assign specific movements to each shape:
   - Triangle = wave right hand
   - Square = kick left leg
3. Children perform movement sequence according to pattern
4. Teacher can change movement-shape mappings (cognitive flexibility)

EF Components Trained

- **Working memory:** Hold pattern in mind + movement-shape rules simultaneously
- **Response inhibition:** Suppress urge to continue previous movement; execute correct one
- **Cognitive flexibility:** When mappings change (triangle now = stomp foot), switch to new rule
- **Sequencing:** Track position in pattern, anticipate next move

Scaffolding → Internalization: Start with simple 2-element patterns and 2 movements. Gradually increase pattern complexity, number of shapes, and movement difficulty. Eventually remove visual pattern (work from memory).

📖 Key Studies Quick Reference

Study	Key Finding
Moffitt et al. (longitudinal)	Self-control in middle childhood → criminality, health, wealth in adulthood. Most robust inhibition-outcomes link.
Halford (2002)	Relational complexity = WM constraint; adults max at 4-way interactions (quaternary relations).
Andrews & Halford (2002)	Under-5s fail binary (2D) categorization; DCCS = WM failure (binding 2 dimensions) not switching per se.
Goswami & Brown (1990)	3yo solve analogies with familiar relations (bread → slice); contra Piaget's stage theory. Knowledge reduces WM load.
Beavers, Schneider, Pacheco	Depression risk linked to weaker PFC-amygdala white matter connectivity (emotion regulation pathway).
Hackman & Farah (2009)	Stress + low SES → impaired PFC growth (both volume and connectivity). Specific to PFC, not global.
Diamond et al. (2007) - Tools	Preschool EF intervention; control schools adopted Tools due to behavior improvements. Bigger effects on more demanding tasks.
Jenny Beers (case studies)	Older male patients with PFC damage: socially inappropriate behavior (loss of inhibition) without general cognitive impairment.

⚡ Exam-Critical Concepts

- **Three components:** Response inhibition, cognitive flexibility, working memory — dissociable but highly correlated; all improve 3-5yo, continue into mid-20s
- **PFC trajectory:** Protracted maturation; peak growth 7-11yo; maturity mid-20s; decline 30s+ (slow, compensated by knowledge)
- **DCCS paradox:** Verbal knowledge intact (can state rule) but behavior locked to first-learned mapping. NOT attention/memory/comprehension failure.
- **Competence vs performance:** EF limits may mask underlying competence (ToM, conservation, analogies). Both factors matter: EF improvements + conceptual development.
- **Halford WM:** Capacity = relations in parallel (not items). 3yo = unary, 5yo = binary, 11yo = ternary, adult = quaternary (max 4 before chunking required).
- **Knowledge × EF bidirectional:** EF enables knowledge acquisition (childhood) → knowledge reduces WM load later (adulthood). Need childhood EF to build compensatory knowledge base.
- **SES mechanisms:** (1) Chronic stress → impaired PFC growth, (2) Acute stress → WM interference, (3) Less stimulation → reduced enrichment
- **Tools of Mind:** Vygotsky-based; scaffolds (ear/lips cards) → internalization (self-regulation). Biggest effects on demanding tasks. Replication mixed (implementation quality matters).
- **Test anxiety mechanism:** Worry consumes WM capacity → less available for math problems (acute stress effect)
- **Adolescent paradox:** High intelligence but poor impulse control (PFC-amygdala connectivity still maturing). Risk-taking peaks, then drops post-25 (car insurance evidence).

? Common Exam Confusions

Wrong Assumption	Correct Understanding
DCCS failure = doesn't know rule	**Can state rule perfectly.** Failure = cannot reconfigure behavior according to known rule (S-R mapping persists).
EF = single unified ability	Three dissociable components (inhibition, flexibility, WM) BUT **highly correlated** (common underlying PFC function).
WM = storage capacity (like STM)	WM = **parallel processing of relations** (Halford). Storage = chunking into LTM. WM about manipulation, not just holding items.
Older adults = like 4-year-olds	**Knowledge compensates.** Decline only in NOVEL tasks. Expertise = chunking reduces WM load. No decline on familiar/practiced tasks.
ToM failure = conceptual deficit	May be **response inhibition deficit** (performance not competence). Infants show competence via looking time; explicit tasks require suppressing own perspective.
Marshmallow test predicts life outcomes strongly	Original claims **overstated**. Effect weaker than thought. **Moffitt study** (self-control scale) more robust predictor.
Tools of the Mind = proven intervention	Promising but **replication mixed**. Implementation quality matters enormously. Recent RCTs show benefits but not universal panacea.
Brain training games improve general EF	**Failed to replicate.** Task-specific improvements don't transfer. Need ecologically valid, sustained, adaptive interventions.
Stress affects all brain regions equally	**Specific to PFC and language areas.** Not global brain impairment. Other regions (visual cortex, etc.) largely unaffected by SES-related stress.
Children willfully defy rules they know	Ability to **connect rule knowledge to behavior** changes dramatically 3-5yo. Can state rule but can't execute = performance deficit, not defiance.

L22: Language Development I: Foundations of Acquisition

Four Levels of Language

Level	What It Governs	Example
Phonology	Sound structure & permissible combinations	/st/ legal onset (stop), /pf/ not in English
Morphology	Internal word structure (inflections, derivations)	-s (plural), -ed (past), -tion (V→N)
Syntax	Word order & phrase structure	"dog bites man" ≠ "man bites dog"
Semantics	Meanings & reference	"Dog" = canine; "bachelor" = unmarried male
Pragmatics	Social conventions & language use	"Could you pass salt?" = request, not question

Exam Focus: "Goed" = morphological error (NOT syntax—order correct). Sarcasm = pragmatic (NOT semantic).

Developmental Timeline

Age	Milestone
0-2 mo	Cooing; prefer speech>non-speech; recognize native prosody (from womb)
6 mo	Canonical babbling ("bababa"); universal phoneme discrimination; gaze following
10 mo	**Perceptual narrowing complete**; language-specific babbling; comprehend ~50 words
12 mo	First words; produce 1-10 words, comprehend ~100
18 mo	Vocabulary explosion (~1 word/day); two-word combos ("Daddy work"); preserve word order
24-36 mo	100-2,000 words; **productive morphology** (wug→wugs); overgeneralization ("tooths")
3-5 yr	5,000-20,000 words (~1 word/hour peak); complex sentences; re-learn irregulars
6-8 yr	Metaphor, irony, sarcasm; non-literal language; register variation

Hierarchical Infinite Productivity

Key Insight: Constraints ENABLE productivity, NOT limit it. No constraints → noise; constraints → contrastive structure → infinite combinations.

Level	Finite Components	Constraints Create Meaning
Phonology	~40 phonemes	/st/ legal → /df/ not → patterns learnable
Morphology	Morphemes	Rule-governed inflection/derivation
Syntax	~20,000 words	Word order changes meaning (SVO)
Discourse	Sentences	Coherence requires pragmatic bridging

Recursion: Sentences embed infinitely: "I think [you believe [she knows [...]]]". Finite rules + recursion = infinite utterances.

Perceptual Narrowing

Stage	Details
6 months	Universal discrimination: English + Hindi + Japanese phonemes ALL distinguished
10 months	Language-specific: lose non-native contrasts (Japanese: no /r/-/l/; English: no Hindi /ɖ/-/d̪/)
Mechanism	**Adaptive specialization**, NOT cognitive loss. Collapse irrelevant variance → free resources for word learning
Bilingual	Maintain BOTH phoneme sets if both statistically frequent. NOT delay—appropriate environmental tuning
Adult L2	Struggle with non-native: tuned categorical boundaries ignore contrasts (NOT sensory loss)

Common Error: Narrowing = regression? NO. It's learned category optimization. Bilingual infants maintain both—no delay.

Categorical Perception (VOT)

Comparison	Acoustic Distance	Percept	Discrimination
0ms vs 20ms	20ms	Both /d/	Poor (within-category)
20ms vs 40ms	20ms	**/d/ → /t/**	**Excellent (boundary!)**
40ms vs 60ms	20ms	Both /t/	Poor (within-category)

Eimas et al. 1971: 2-day-olds show categorical perception. High-amplitude sucking: habituate to 20ms, dishabituate to 40ms (cross-boundary) NOT 0ms (within-category).

Key Formula: Equal acoustic steps (20ms each) → Unequal perceptual distances. Boundary sharpens discrimination. From birth!

Speech Segmentation Cues

Problem: No consistent silences between words in fluent speech. How do infants find word boundaries?

Cue Type	Mechanism
Stress Patterns	English words = 1 primary stress (BAbuy, spaGHETti). Consecutive stressed syllables → boundary
Phonotactics	Legal onset clusters (/st/ OK, /df/ not). Distributional learning of sound sequences
Transitional Probability	Within-word: high P(by|ba). Across boundary: low P. Statistical learning (Saffran et al.)
Language-Specific	English: stress-timed (stress cues). French: syllable-timed (phonotactics + function words)

Age: Sensitive to all cues by 8 months (BEFORE first words).

Word Learning Mechanisms

Mechanism	Function	Example/Context
Mutual Exclusivity	Novel word → novel object (lacks known label)	Fork + garlic press: "Give me dax" → 95% pick garlic press (age 3)
Shape Bias	Extend count nouns by shape (default for solid objects)	"This is a blicket" → generalize to same-shape objects
Whole Object	Assume labels refer to whole objects, not parts/properties	"Rabbit" → whole animal (NOT ears/legs/fur)
Pedagogical Sampling	Infer category level from example diversity	3 Dalmatians → subordinate; 3 breeds → basic; dog+cat+bird → superordinate
Comparison	Override shape bias—identify contrastive feature	2 spongy objects (diff shapes) → generalize by texture NOT shape (Graham et al. 2020)
Gaze Following	Track speaker's referential target (by 12mo)	Speaker looks at rabbit → "gavagai" = rabbit (NOT unattended objects)

Integration: Real word learning combines ALL mechanisms. Mutual exclusivity narrows candidates → comparison identifies features → gaze provides grounding.

Morphosyntax Development

Component	Details
Morphemes	Meaningful units: "dog" (1), "tugboat" (2: tug+boat), "dogs" (2: dog+-s)
Inflectional	Add grammatical info, NO category change: -s (plural), -ed (past), -ing (progressive)
Derivational	CHANGE category: destroy (V) → destruction (N); happy (Adj) → happiness (N)
Wug Test	(Berko 1958) "This is a wug. Two ___?" → "wugs" /wʌgz/. Productive rule + allomorph selection
Allomorphs	/-s/ after voiceless (cats); /-z/ after voiced (dogs, wugs); /-ɪz/ after sibilants (buses)
U-shaped	feet (imitate) → foots (overgeneralize rule) → feet (rule + exceptions). ERROR = LEARNING
18 mo	Two-word combos: "Daddy work" (NOT "work Daddy"). Telegraphic but preserve order
24-36 mo	Productive morphology: apply -s/-ed to novel words. Overgeneralize to irregulars (tooths, goed)

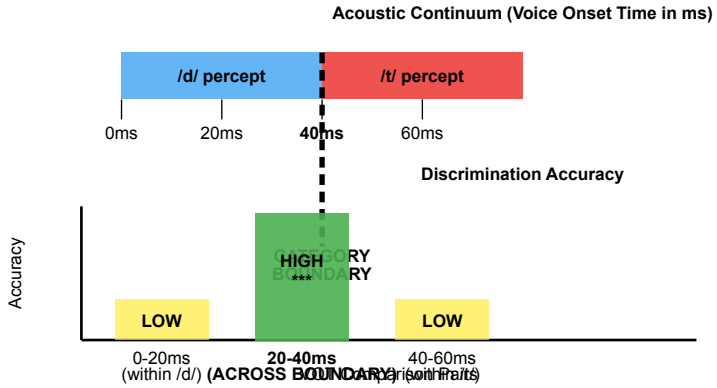
Hinge: Overgeneralization = EVIDENCE of rule extraction (NOT delay). Child has abstract NOUN+-s rule, not memorized forms.

Interpreting Child Errors

Utterance	Type	Correct Interpretation
"I have two mouses"	Morphological overgeneralization	Extracted regular plural rule, overapplied to irregular. NOT vocabulary error
"She goed to park"	Morphological overgeneralization	Learned -ed rule, not yet "went" exception. NOT syntactic (order correct!)
"Want cookie" (18mo)	Telegraphic speech	Omit function words but preserve order. NOT lack of grammar—emerging syntax
"I brushed my tooths"	Productive rule learning	ADVANCED (extracted abstract rule), NOT delayed. U-shaped: teeth→tooths→teeth

Morphology vs Syntax: Morphology = internal word structure. Syntax = how words combine. "Goed" has correct syntax, wrong morphology.

Voice Onset Time: Categorical Perception



Equal acoustic steps (20ms each) → Unequal perceptual distances

Eimas et al. 1971: 2-day-old infants show adult-like categorical perception using high-amplitude sucking paradigm.

Pedagogical Sampling: Category Inference from Examples

How Example Diversity Determines Category Level

3 Dalmatians → "dax"
LOW variety within examples
Inference: dax = Dalmatian
(SUBORDINATE)

3 Dog Breeds → "dax"
MEDIUM variety (all dogs)
Inference: dax = dog
(BASIC LEVEL)

Dog+Cat+Bird → "dax"
HIGH variety (cross-species)
Inference: dax = animal
(SUPERORDINATE)

Bayesian Pedagogical Inference Formula

Level of Generality ∝ (Variation WITHIN examples) / (Variation OUTSIDE examples)

Children assume teachers choose maximally informative examples about category boundaries

If speaker meant broad category, why show such similar examples? (Pragmatic reasoning)

Test Phase: Does This New Object Get the Label?

Show a Poodle:
Subordinate learner REJECTS
("Not a Dalmatian")

Show a Cat:
Basic learner REJECTS
("Not a dog")

Show a Fish:
Superordinate learner ACCEPTS
("It's an animal")

Age 3-4: Children show sensitivity to example diversity for inferring word meanings

Pragmatic Development & Theory of Mind

Age	Pragmatic Skills
18-24 mo	Adjust speech to listener (simpler to baby vs adult); early conversational turn-taking
3-5 yr	Begin understanding indirect speech acts BUT literal interpretation still dominates
6-8 yr	Metaphor, idiom, irony, sarcasm comprehension emerges; non-literal language mastery

Requirement: Metarepresentational Theory of Mind—represent that speaker meaning ≠ literal sentence meaning.
Example: "Could you pass salt?" = REQUEST (pragmatic), NOT yes/no question (literal form).

ASD Profile: Often intact phonology, vocabulary, syntax BUT pragmatic deficits (miss sarcasm, conversational norms, register). Social-cognitive deficit, NOT linguistic.

Language Creation & Regularization

Phenomenon	Details
Home-sign	Deaf children (no sign exposure) spontaneously create gestural systems. Limited grammar without community
Nicaraguan Sign Language	1980s: deaf students brought together → CHILDREN create full systematic grammar in 1 generation
Singleton & Newport 2004	Deaf child of late-learning parents: parents 70% correct ASL morphology → child 80%+. EXCEEDS input quality!
Hudson Kam & Newport 2005	Artificial language: determiner appears 60% (probabilistic). Adults match 60%; CHILDREN regularize to 100% or 0%
Children vs Adults	Children impose categorical structure on probabilistic input. Prefer P=1.0 or P=0 over matching P=0.6
Creole Genesis	Pidgins (variable adult L2, inconsistent) → children regularize morphology/syntax → Creoles (full grammar)

Key Insight: Children are active STRUCTURE-SEEKERS, not passive input-matchers. Filter noise, amplify signal, regularize variation.

Clinical Dissociations & Bilingualism

Selective Language Impairments

Condition	Pattern
Dyslexia	Phonological processing deficits (weak phoneme awareness). Intact syntax/semantics
Semantic Dementia	Loss of word meanings. Preserved syntax/phonology
SLI	Syntactic deficits. Intact nonverbal IQ, preserved other domains
ASD	Pragmatic deficits (miss sarcasm, turn-taking). Often intact syntax/vocabulary

Bilingualism Myths vs Reality

Myth	Reality
Bilingualism delays language	FALSE. No overall delay. Total vocabulary comparable. Per-language may appear smaller
Should avoid multiple languages	FALSE. No evidence of harm. Advantages to multilingualism. Maintain both phoneme sets
Baby sign accelerates language	UNPROVEN. No harm but no strong evidence for acceleration

Landmark Studies - Citation Ready

Study	Method & Finding
Eimas et al. 1971	2-day-olds: categorical perception of VOT. High-amplitude sucking: dishabituate to cross-boundary, NOT within-category
Vouloumanos & Werker 2004	Newborns prefer speech to acoustically complex non-speech. Recognize native prosody from womb exposure
Berko 1958 (Wug Test)	Children (2.5-3yr) productively apply plural -s to novel "wug" → "wugs". Rule extraction, NOT memorization
Markman; Wilson & Katsos 2021	Mutual exclusivity: 95% of 3-year-olds select unfamiliar object for novel word "dax" (fork+garlic press task)
Graham et al. 2020	Comparison overrides shape bias: 2 same-texture objects (diff shapes) → children generalize by texture
Gambell & Yang 2003	English words typically have 1 primary stressed syllable. Infants use stress patterns to segment speech (8mo)
Singleton & Newport 2004	Deaf child of late-learning ASL parents: parents 70% correct morphology → child 80%+. Active regularization
Hudson Kam & Newport 2005	Artificial language: determiner 60% probabilistic. Adults match input; children regularize to categorical (100%/0%)

Exam Focus: Critical Distinctions & Common Errors

Morphology vs Syntax

- **Morphology:** Internal word structure (goed, tooths). Order is CORRECT
- **Syntax:** How words combine into phrases (*dog the chased cat the). Structure is WRONG
- **Error:** Labeling "goed" as syntax error when syntax is perfect (I-verb-location-time)

Inflectional vs Derivational

- **Inflectional:** NO category change. -s (plural), -ed (past), -ing (progressive). dog/dogs both nouns
- **Derivational:** CHANGES category. destroy (V) → destruction (N), happy (Adj) → happiness (N)

Perceptual Narrowing

- **NOT cognitive loss/regression:** Adaptive specialization. Collapse irrelevant variance → optimize for native language
- **Bilingual:** Maintain BOTH phoneme sets. NOT delay—appropriate tuning to BOTH statistical environments
- **Adult L2:** Difficulty NOT sensory damage but learned categorical boundaries ignoring non-native contrasts

Overgeneralization

- **Evidence of rule learning:** "Tooths" shows child extracted abstract NOUN+-s rule (NOT memorization)
- **U-shaped = NORMAL:** feet (imitate) → foots (rule) → feet (rule+exceptions)
- **NOT delay/error:** Systematically applying productive rule is ADVANCED cognition

Word Learning Mechanisms (Complementary, NOT Competing)

- **Mutual Exclusivity:** Which object? (Novel word → novel object lacking label)
- **Shape Bias:** Which feature? (Default: generalize by shape for count nouns)
- **Comparison:** Override shape when 2+ examples highlight different feature (texture)
- **Pedagogical Sampling:** What abstraction level? (Diversity determines subordinate/basic/superordinate)

Pragmatics vs Other Levels

- **Pragmatics = Language USE:** Appropriateness in context (sarcasm, indirect speech acts)
- **Can dissociate from form:** ASD shows intact syntax/semantics BUT pragmatic deficits
- **Requires Theory of Mind:** Metarepresentational reasoning (speaker meaning ≠ literal meaning)

Hierarchical Productivity

- **Constraints ENABLE infinity:** No constraints → no contrastive structure → noise
- **Constraints create meaning:** Word order matters ("dog bites man" ≠ "man bites dog")
- **Recursion:** Finite rules + embedding = infinite novel utterances

HIGHEST YIELD: Children as active structure-seekers (regularize probabilistic input), overgeneralization as evidence (NOT error), pragmatic dissociations in ASD, perceptual narrowing as optimization (NOT loss).

Prescriptivism vs Descriptivism

Aspect	Prescriptivism	Descriptivism (Our Approach)
Question	How SHOULD people speak correctly?	How DO people actually use/process language?
Stance on "Errors"	Deviations from norms are incorrect, should be corrected	Systematic "errors" reveal rule learning. All native productions reflect grammatical knowledge
Example	"Don't say 'ain't'—it's wrong"	"AAVE 'ain't' is systematic & grammatical within that dialect"
Development	Errors = failures to learn proper forms	Overgeneralization = evidence of abstract rule extraction (COGNITIVE ACHIEVEMENT)
Domain	Stylistic writing, formal register, professional communication	Scientific study of mental representations, cognitive processes, developmental trajectories

Analogy: Like studying bird song—you wouldn't say "that bird sang wrong." We describe WHAT happens, not judge correctness.

Componentiality & Compositionality

Language = Hierarchical System: Finite primitives + finite rules → infinite productivity

Level	Components (Finite)	Composition Rules (Finite)	Output (Infinite)
Phonology	~40 phonemes	Phonotactic constraints (/st/ OK, /df/ not)	→ Syllables
Morphology	Syllables, morphemes	Inflection/derivation rules	→ Words
Syntax	~20,000 words	Word order, phrase structure, recursion	→ Sentences (infinite)
Discourse	Sentences	Pragmatic coherence, bridging	→ Conversations

Why constraints enable productivity: Without constraints, any sound could follow any sound → no learnable patterns → noise. Constraints create CONTRASTIVE STRUCTURE → meaning differences → infinite interpretable combinations.

Allomorph Selection Rules

English Plural: One morpheme {-s}, three phonological realizations (allomorphs)

Allomorph	Context	Examples
/-s/	After voiceless consonants (/p, t, k, f, θ/)	cat → cats /kæts/, cup → cups /kʌps/
/-z/	After voiced consonants (/b, d, g, v, ð/) & vowels	dog → dogs /dɔgz/, **wug → wugs /wʌgz/**, bee → bees /biz/
/-ɪz/	After sibilants (/s, z, ʃ, ʒ, tʃ, dʒ/)	bus → buses /bʌsɪz/, church → churches /tʃɜrtʃɪz/

Evidence of productivity: Children who say "wugs" (never heard before) demonstrate BOTH morphological rule (NOUN+-s) AND phonological rule (select /-z/ after voiced /g/). Double generalization!

L23-24: Language Development II & III: Nativist vs. Constructionist Approaches

Nativist vs Constructionist Overview

Aspect	Nativist (UG)	Constructionist
What is innate?	Language-SPECIFIC constraints: phrase structure (VP=V+NP), structural dependence, recursion	Domain-GENERAL mechanisms: statistical learning, analogical abstraction, social cognition
Initial state	Abstract & verb-general from start (18mo+)	Concrete & item-specific; gradually abstracted (36mo+)
Input quality	IMPOVERISHED - insufficient for learning (poverty of stimulus)	RICH - contains learnable statistical patterns
Key evidence	No SD errors; NSL emergence; sensitive periods	Verb islands; TP-based segmentation; priming confounds

Central Question: Is language a specialized cognitive MODULE or EMERGENT from general cognition applied to linguistic input?

Universal Grammar (UG) - Chomsky's Claims

What UG Specifies (Innate)

- **Hierarchical phrase structure:** S = NP + VP; VP = V + NP
- **Structural dependence:** Syntactic operations reference phrase structure, NOT linear order
- **Recursion:** Clause embedding infinitely: "I think [you believe [she knows [...]]]"
- **Island constraints:** Rules on wh-movement extraction

What Must Be Learned

- Word order parameters (English: V+NP; Turkish: NP+V)
- Specific vocabulary and morphemes
- Phonological patterns

Key Claim: Children NEVER make structure-independent errors because UG prohibits even considering such rules. "Innate schematism" - Chomsky (1971)

Poverty of Stimulus Argument

The Logic

1. Children acquire syntactic knowledge that appears NOWHERE in input
2. No NEGATIVE EVIDENCE available (no one produces ungrammatical sentences to show what's wrong)
3. If learning from input alone, children should overgeneralize then correct from feedback
4. BUT children never make certain error types (e.g., island violations)
5. THEREFORE constraints must be INNATE

Example: Wh-Movement

"Which movie does Susan imagine that Sarah saw *t*?" - wh-word moves respecting phrase boundaries

No child ever produces: "*What did Beth eat peanut butter and *t*?" (coordinate structure island)

Constructionist Counter: Input is RICHER than nativists claim; statistical patterns + distributional cues provide sufficient information

Structural Dependence - "A Parade Case"

Principle: Syntactic operations reference HIERARCHICAL phrase structure, NOT linear word order.

Question Formation Example

Type	Rule	Output
Declarative	--	"The boy who is smoking is crazy"
CORRECT Question	Move MAIN CLAUSE auxiliary	"Is the boy who is smoking crazy?"
***LINEAR Error**	Move FIRST auxiliary	"*Is the boy who smoking is crazy?"

Key Point: Linear rule is SIMPLER but children NEVER produce it. Why? Nativists: UG prohibits structure-independent rules. Constructionists: "who smoking" never occurs in input (TP = 0).

Crain & Nakayama (1987)

Method

- **Participants:** Children ages 3-5
- **Task:** Elicited production of yes/no questions from complex declaratives
- **Sentences:** Contained relative clauses with auxiliary verbs

Results

0% structural dependence errors across 600+ questions

Interpretation (Nativist)

- Perfect performance despite minimal exposure to complex embeddings in CDS
- Supports innate UG constraint - structural dependence is "parade case of innate schematism"
- Children NEVER consider linear-order rules

Crain's Claim: "Structural dependence is a parade case of an innate constraint"

Ambridge et al. (2008) - Counter-Evidence

Critical Finding

Auxiliary	Error Rate	Why?
"is" questions	0%	"who smoking" NEVER occurs (TP = 0)
"can" questions	**7%**	"who smoke" IS grammatical elsewhere!

Example Error

"Can the boy who smoke can drive?" - SD error occurs because "who smoke" is a legal bigram (e.g., "people who smoke")

Challenge to UG: If structural dependence were UNIVERSAL INNATE CONSTRAINT, it should NOT show word-specific variation. The 7% error rate with "can" suggests transitional probability (statistical learning), NOT innate constraint!

Sensitive Periods for Language

Exposure Age	Outcome
Before age 7	No exposure to sign = permanent deficits in complex syntax
Before puberty	First exposure after puberty = never achieve native fluency in grammatical morphology
After puberty	Second language learners struggle with inflectional morphology despite fluent vocabulary

Evidence for Biological Timing

- Cannot be explained by general cognitive decline - adults learn chess, math, music
- Suggests LANGUAGE-SPECIFIC neural windows
- Strongest evidence: children GENERATE language beyond input

Nativist Interpretation: Genetically-driven maturation of UG-related neural circuits

Nicaraguan Sign Language (NSL) - Senghas, Kita & Ozyurek (2004)

Natural Experiment

1980s Nicaragua: Deaf children with no prior language brought together in schools. First cohort invented home signs; second cohort (exposed during sensitive period) SYSTEMATICALLY COMPLEXIFIED the language.

Componentiality Data

Group	% Componential (Sequential)
Spanish gesturers	~35% (65% simultaneous)
NSL Cohort 1 (adults)	~25%
NSL Cohort 2 (children)	**~75%**
NSL Cohort 3	~73%

Key Finding: Children generated compositional structure BEYOND their input! Cohort 2 children had Cohort 1 adults as models but produced MORE linguistic structure. Evidence for innate drive to impose language structure during sensitive period.

Compositional Structure

Definition

Language splits meaning into COMPONENTS that can be RECOMBINED. Hallmark of true linguistic structure vs. holistic gesture.

Motion Event Example

Type	Expression	Structure
Simultaneous	Rolling-down (one gesture)	Holistic: manner+path fused
Sequential	Roll, then down (two gestures)	Compositional: manner separate from path

Why Compositionality Matters

- Allows RECOMBINATION: "roll down" + "roll up" + "slide down" etc.
- Productive syntax requires separable components
- NSL Cohort 2's sequential structure = TRUE linguistic compositionality

Exam Point: Cohort 2 children RESTRUCTURED input according to linguistic principles despite impoverished models - supports UG-driven acquisition

Statistical Learning - Saffran et al. (1996)

Transitional Probability (TP)

Formula: TP(B|A) = P(B follows A) = frequency(AB) / frequency(A)

Word Segmentation Experiment

- **Participants:** 8-month-old infants
- **Exposure:** 2 min continuous speech: bidaku-padoti-golabu...
- **NO pauses** between "words"

Transition	TP	Location
bi -> da	**1.0**	WITHIN word
ku -> pa	**0.33**	ACROSS boundary

Result

Infants preferred novel "non-words" (kupado) over "words" (bidaku) - extracted word boundaries from TP dips alone!

Implication: Domain-general statistical learning can solve segmentation problem - challenges poverty of stimulus claim

Distributional Learning - Mintz (2003)

Grammatical Categories from Context

Words appearing in SIMILAR syntactic contexts share category membership.

Frequent Frames

Frame	Words That Fit	Category
"the ___ is"	dog, cat, ball, baby	NOUNS (87% accuracy)
"is ___ing"	running, eating, sleeping	VERBS
"you ___ it"	kick, throw, want	VERBS

Bootstrap: Children can cluster words by co-occurrence patterns WITHOUT requiring pre-specified category labels

Key Claim: This explains how children generalize novel words. "The toma is red" --> "I want toma" because toma patterns with other nouns.

Constructionist Operating Assumptions

Three Core Claims

Claim	Detail
1. No pre-specified categories	Children do NOT start with abstract NP, VP, SUBJECT, OBJECT - these EMERGE from learning
2. Input is RICH	Millions of utterances with systematic distributional patterns; statistical learning extracts structure
3. Domain-general mechanisms	Statistical learning, analogical abstraction, social reasoning - same mechanisms for language AND other domains

Not "No Innate Endowment"

Humans DO have genetic adaptations (vocal tract, auditory processing, memory, social cognition) - but these are domain-GENERAL, not language-SPECIFIC

LLM Evidence: GPT and similar models acquire syntactically complex language from distributional statistics alone - proves statistical learning can, in principle, acquire syntax

Verb Islands to Abstract Constructions - Tomasello (2003)

Developmental Trajectory

Stage	Age	Example	Representation
Wholly Concrete	18-24mo	"I kick it," "I kick ball"	Rote-learned exemplars (no slots)
Item-Specific	24-30mo	"I kick [OBJECT]"	Verb island: slot for objects with THIS verb
Partially Abstract	30-36mo	"I [ACTION] [OBJECT]"	Extends within action-verb class
Fully Abstract	36mo+	"[SUBJECT] [VERB] [OBJECT]"	Full productivity - any verb

Mechanism: Schematization through ANALOGICAL COMPARISON across item-based schemas. Children extract common relational structure by noticing "I kick X," "I hit Y," "I throw Z" share [AGENT][ACTION][PATIENT] pattern.

Novel Verb Studies - Tomasello & Brooks (1998)

Method

- Teach 2-year-olds novel verb "tamming" in INTRANSITIVE frame: "The sock is tamming"
- Elicit TRANSITIVE production: "Make Big Bird tam the sock"

Results

Age	Transitive Production
2;0 (2 years)	**3/16 children** (19%)
2;6 (2.5 years)	7/16 children (44%)
4 years	Success - readily produce transitive

Interpretation

Children do NOT initially possess abstract transitive syntax - verb knowledge is ITEM-SPECIFIC (verb islands). Abstraction develops GRADUALLY through exemplar accumulation.

Key Evidence: Age-graded performance contradicts nativist claim that abstract syntax is present from start. If UG provides transitive schema, why can't 2-year-olds extend novel verbs?

Noun vs Verb Generalization

Asymmetric Productivity

Word Type	Generalization Pattern
Novel NOUNS	Children READILY generalize: "toma" --> "I want toma," "I see toma," "Give me toma"
Novel VERBS	Children DO NOT generalize across constructions (intransitive --> transitive)

What This Suggests

- Noun slots are more ABSTRACT early (fit any noun)
- Verb schemas are ITEM-SPECIFIC (verb islands)
- NOT general shyness/task difficulty - same children succeed with nouns

Against UG: If children have abstract [SUBJECT][VERB][OBJECT] from start, why doesn't it work equally for nouns AND verbs? Item-specific verb schemas explain the asymmetry.

Early Abstraction Claims

Position (Fisher, Gertner)

- Children possess INNATE agent-patient linking to noun positions
- Syntactic knowledge is VERB-GENERAL from start (not item-specific)
- Each SEMANTIC ROLE needs a noun; each NOUN needs a semantic role (one-to-one mapping)

Key Distinction

Account	Initial State	Development
Early Abstraction	Abstract syntax present	Performance improves; competence constant
Gradual Abstraction	Item-specific schemas	Competence develops through learning

Why Production Fails: Early abstraction accounts claim 2-year-olds HAVE abstract syntax but show PERFORMANCE limitations (retrieval difficulty, lexical gaps, communicative caution)

Gertner, Fisher & Eisengart (2006)

Method

- **Participants:** 21-month-olds
- **Task:** Preferential looking (comprehension, not production)
- **Stimuli:** "The frog is gorping the bear" (novel verb)
- **Test scenes:** Frog-acts-on-bear vs. Mutual interaction

Results

Children looked LONGER at frog-as-agent scene when hearing transitive syntax

Interpretation

- 21-month-olds map transitive syntax to agent-patient semantics
- WITHOUT knowing "gorp" - must be using ABSTRACT syntactic knowledge
- Evidence for verb-GENERAL syntax at 21 months

Nativist Claim: This shows abstract competence exists BEFORE Tomasello's verb islands dissolve. Production conservatism masks underlying abstract knowledge.

Dittmar et al. (2008) - Critical Reply

The Confound

Fisher et al. "warmed up" children with TRANSITIVE frames using SAME NOUNS as test trials: "The frog is washing the bear"

Dittmar's Manipulation

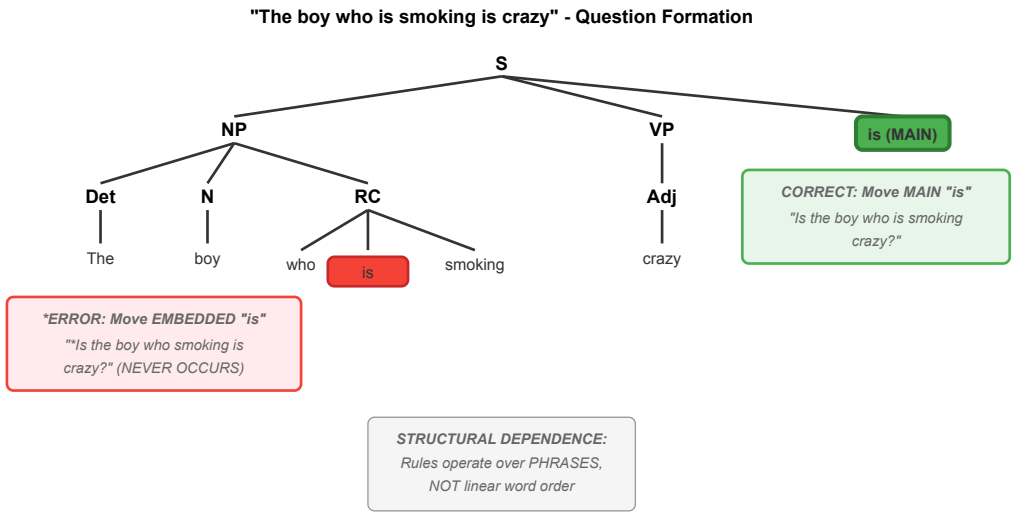
Condition	Warm-up	Result
Fisher's (transitive warm-up)	"The frog is washing the bear"	SUCCESS
Dittmar's (generic warm-up)	"This is called washing"	**FAIL**

Interpretation

When transitive priming REMOVED, children FAIL! Fisher's evidence depends on EXEMPLAR PRIMING (recent exposure to transitive + same nouns), NOT abstract syntax.

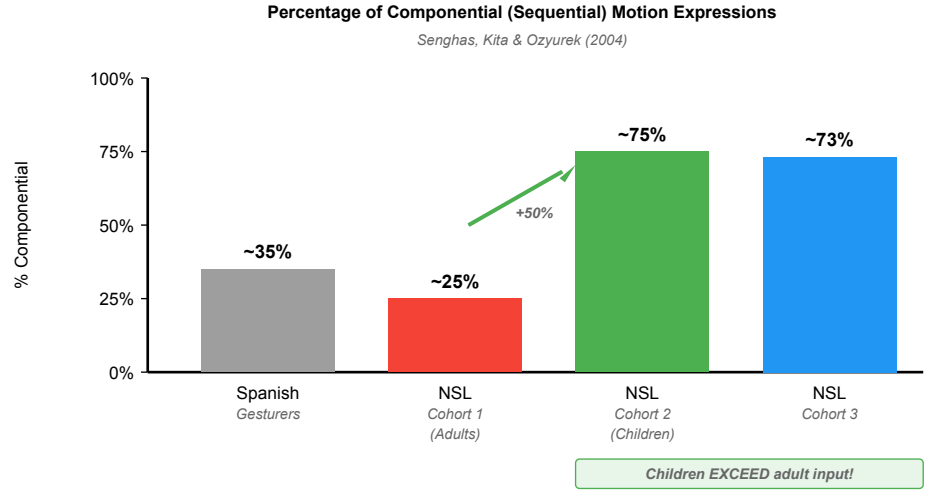
Critical Question: If knowledge were truly ABSTRACT and verb-general, why does it require specific exemplar priming to manifest? This supports ITEM-SPECIFIC knowledge that requires structural priming.

Structural Dependence: Phrase Structure Tree



Linear rule would move FIRST "is" (embedded) but correct rule moves MAIN CLAUSE "is". Children NEVER make this error with "is" (TP of "who smoking" = 0).

NSL Componentiality Across Cohorts



Key Finding: Cohort 2 children learned from Cohort 1 adults BUT produced MORE linguistic structure. Evidence that children GENERATE language beyond input during sensitive period.

Landmark Studies - Citation Ready

Study	Finding	Supports
Chomsky (1971)	Structural dependence as "innate schematism"	Nativist/UG
Crain & Nakayama (1987)	0% SD errors in elicited production (600+ Qs)	Nativist/UG
Saffran et al. (1996)	8-mo-olds segment words using transitional probabilities	Constructionist
Tomasello & Brooks (1998)	Only 3/16 2-year-olds extend novel verb to transitive	Constructionist
Mintz (2003)	Frequent frames reveal grammatical categories	Constructionist
Senghas et al. (2004)	NSL children generate compositional structure beyond input	Nativist
Gertner, Fisher & Eisengart (2006)	21-mo-olds interpret novel verbs using abstract transitive syntax	Nativist/Early Abstraction
Ambridge et al. (2008)	7% SD errors with "can" vs 0% with "is" - word-specific!	Constructionist
Dittmar et al. (2008)	Fisher's result disappears when transitive priming removed	Constructionist

Exam Focus: Critical Distinctions

UG vs Constructionism

- **UG:** Language-specific innate constraints (phrase structure, recursion, structural dependence)
- **Constructionism:** Domain-general mechanisms (statistical learning, analogical abstraction)

Verb-General vs Item-Specific

- **Early Abstraction:** Abstract from START - production limitations mask competence
- **Gradual Abstraction:** Item-specific verb islands - slowly abstracted through comparison

Structural Dependence Key Points

- "*Is the boy who smoking is crazy?" = SD ERROR (never occurs with "is" because "who smoking" TP = 0)
- "Can the boy who smoke can drive?" = SD errors DO occur (7%) because "who smoke" is grammatical elsewhere
- **Challenge to UG:** Word-specific variation contradicts universal innate constraint

Competence vs Performance

- **Production fails, comprehension succeeds:** Nativists claim abstract knowledge exists but performance masks it
- **Dittmar's counter:** Comprehension depends on PRIMING - not truly abstract?

HIGHEST YIELD: Ambridge's 7% vs 0% SD errors (challenges UG); Dittmar's priming confound (challenges early abstraction); NSL cohort 2 exceeds input (supports innate capacity); verb-noun generalization asymmetry (supports item-specific verbs)

Transitional Probability: Quick Reference

Formula

$$TP(B|A) = \frac{freq(AB)}{freq(A)}$$

Word Segmentation Rule

- **High TP** (close to 1.0) = WITHIN word
- **Low TP** (e.g., 0.33) = Word BOUNDARY

Structural Dependence Application

- **"who smoking"** TP approx 0 --> never produces SD error with "is"
- **"who smoke"** grammatical elsewhere --> 7% SD errors with "can"

Key Insight: Statistical patterns in input can explain BOTH error absence (TP=0) AND error presence (TP>0 in other contexts)

Sensitive Period Summary

Age Window	If Missed	Evidence
0-7 years	No sign exposure = permanent complex syntax deficits	Deaf late learners
Before puberty	First L2 after puberty = never native morphology	Immigration studies
During sensitive period	Children GENERATE beyond input (NSL Cohort 2)	Senghas et al. 2004

Competing Interpretations

- **Nativist:** Language-specific critical period tied to UG maturation
- **Constructionist:** Domain-general neural plasticity decline

Evidence Summary by Position

FOR Nativism	FOR Constructionism
0% SD errors with "is" questions	7% SD errors with "can" (word-specific!)
NSL Cohort 2 exceeds Cohort 1 input	8-mo-olds segment using TPs (Saffran)
Sensitive periods for grammar acquisition	Verb islands in 2-year-olds (Tomasello)
Fisher: 21-mo-olds use abstract transitive	Dittmar: Fisher's result needs priming
No negative evidence for island constraints	LLMs acquire syntax from statistics alone
Recursion unique to humans	Noun vs verb generalization asymmetry

Exam Strategy: Know evidence for BOTH sides. Best answers discuss how same data can be interpreted differently (e.g., SD errors: innate constraint vs TP-based avoidance).

L25-26: Culture & Conceptual Development

Core Thesis & Central Principle

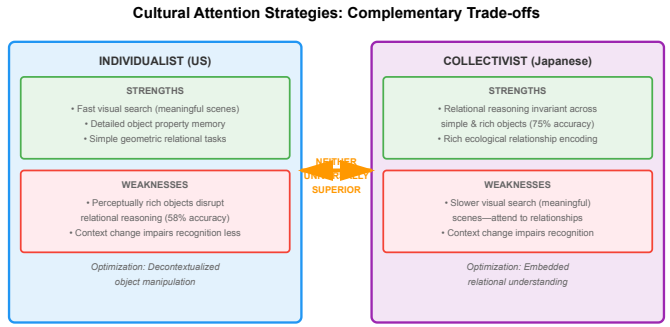
ATTENTION IS THE KEY COGNITIVE MEDIATOR: Cultural values shape attention strategies → attention determines what's learned/remembered → creates complementary cognitive architectures

- **Not universal trajectory:** Western theories misapplied cross-culturally → misdiagnose cultural differences as deficits
- **Complementary trade-offs NOT deficits:** Each culture optimizes for different ecological/social demands
- **Values realized as strategies:** Individualism/collectivism aren't abstract beliefs—they're moment-to-moment cognitive operations
- **Self-determination principle:** When Indigenous communities control design, "gaps" disappear

Individualism vs Collectivism Dimension

Aspect	Individualist	Collectivist
Self-construal	Independent (autonomous self)	Interdependent (embedded in group)
Core values	Independence, competition, uniqueness, self-sufficiency	Harmony, duty, group belonging, context-sensitivity
Attention strategy	Selective focus on isolated objects	Distributed across relationships/context
Memory encoding	Object properties (context-free)	Object-context bindings
Eye-tracking	Narrow fixation on focal object	Broad scanning of entire scene
Development	Detectable by age 4 in preschoolers	
Countries	USA, Canada, Australia, UK, N. Europe	East Asia, Central America, Indigenous communities

Attention & Memory Trade-offs



Kuwabara & Smith (2012): Relational Reasoning

Task Condition	US Children (4yr)	Japanese Children (4yr)
Simple geometric shapes	75% correct	75% correct
Perceptually rich objects (clocks, keys, chairs)	58% correct (↓17%)	75% correct (no drop)
Visual search (meaningful)	Faster (ignore context)	Slower (attend to relationships)
Visual search (random)	Equal speed	

- **Interpretation:** US object-focus → vulnerable to perceptual distraction when relations matter
- **Japanese relational focus:** Automatically filters surface features to extract abstract patterns
- **NOT deficit:** US would excel at detailed object property memory tasks

Memory Encoding: American vs Hong Kong Chinese

- **Task:** Remember animals shown against background scenes; later test with same/swapped backgrounds
- **Instructions:** "Remember the animal" (explicit object focus)
- **Americans:** Equivalent recognition regardless of background match (object-only encoding)
- **Asians:** Impaired recognition when backgrounds swapped (object-context binding)
- **Eye-tracking:** Americans fixate narrowly on object; Asians distribute across scene
- **Key insight:** Cultural training overrides explicit task demands—relational encoding is default

Parental language input: US parents: more object labeling ("that's a duck"); Asian parents: more event descriptions ("duck swimming to eat") → creates feedback loops reinforcing attention strategies

Intent Participation vs Assembly-Line Instruction

Feature	Intent Participation	Assembly-Line
Physical context	Children present during authentic adult work; multi-age	Age-segregated classrooms; learning decontextualized from application
Attention structure	**Simultaneous:** monitor model + execute own + track environment	**Alternating:** must pause to attend model OR work
Collaboration	Spontaneous mutual help; complementary skills valued	Requires permission; goal = individual ranking
Learning from others	High (62% sustained attention to others)	Low (31% sustained attention—tune out non-directed info)
Historical origin	Pre-industrial apprenticeship; current indigenous	Factory metaphor explicit (~1900): children = raw products

Correa-Chávez et al. (2005): Origami Attention Patterns

Group	Simultaneous Attention	Alternating Attention
Traditional Mayan (basic schooling)	**48%**	Lower
Mixed Mayan (more Western schooling)	**35%**	Moderate
European American (high schooling)	**27%**	Higher

- **Simultaneous attention:** Fold own paper WHILE monitoring adult + other children + environment
- **Correlation:** Simultaneous attention negatively correlated with question-asking (extract info via observation)
- **Western schooling effect:** More schooling → less simultaneous attention capacity

Toy-Building Study: Peripheral Learning

- **Design:** Child A taught mouse toy; Child B taught frog toy. Later swap: A must build frog, B must build mouse
- **Easy toy (mouse):** No group differences—all succeed
- **Difficult toy (frog):** Traditional Mayan children need **43.5%** help; European American need **58.8%** help
- **Sustained attention to others' instruction:** Traditional Mayan 62%, Mixed 55%, European 31%

Efficiency calculation: Mayan child during own mouse instruction allocates 40% attention to sibling's frog = 1.2 min prior learning. European child allocates 5% = 0.15 min. When building frog: Mayan needs 1.5 min help (total 2.7 min); European needs 4 min help (total 4.15 min). Ratio: 0.37 (Mayan need only 37% as much help due to observational learning)

Factory Model: Explicit Design Principles

- **1916 Stanford Dean of Education:** "Schools are factories in which raw products (children) are shaped...to meet demands of life"
- **Not retrospective metaphor:** Conscious institutional design principle
- **Modularization:** Math, reading, history as separate "production lines" (like car doors, seats, engines)
- **Teacher role:** Manager delivering pre-specified information; students = receptacles
- **Quizzing:** Teacher asks questions she knows to test information receipt (not authentic inquiry)
- **No rationale:** Teacher directs actions without explanation (workers don't need factory logic)
- **Cultural mismatch:** Indigenous children punished for collaboration (seen as "cheating" vs normative problem-solving)
- **Assessment mandate:** Must rank high vs low performers → collaborative learning incompatible even if enhances outcomes

Folkbiology: Human-Nature Mental Models

Aspect	European American	Native American (Menominee)
Parental goals	"Learn to respect nature" (external relationship)	"Understand they are part of nature" (embedded identity)
Children's books	3rd person ("I Spy an Ecosystem"—human outside)	1st person from animal perspective (see through deer's eyes)
Perspective-taking (age 4)	Urban 41%, rural 41% (embodying animals in play)	Rural 67%, urban 88% (embodying animals)
Ecological knowledge	Limited food chains; categorical responses ("both in nature")	Rich food chains; utility for people; mimic animal sounds
Adult gestures	Gesture ABOUT animal (depict as external object)	Gesture AS animal (embody its perspective)

- **Key distinction:** "Respect" implies external relationship (can respect something distant); "part of" implies embedded identity
- **Rural vs urban:** Rural European kids hunt/fish extensively but still show external model—exposure insufficient without conceptual framework

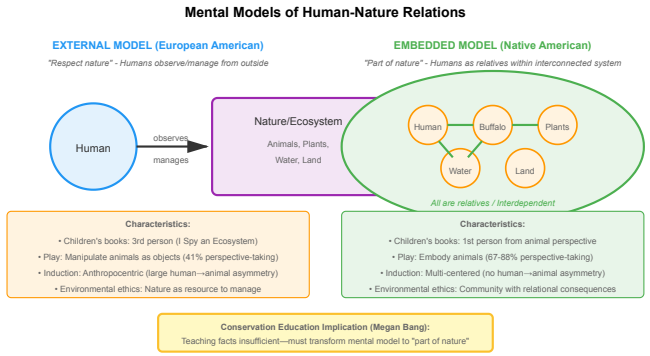
Category-Based Induction: Carey (1985) vs Medin et al.

- **Carey's claim:** 4-year-olds privilege humans as inductive base (developmental universal)
- **Method:** Tell child "humans/dogs have omanitum in bones" → test generalization to other species
- **Carey's sample:** Urban white middle-class (near Harvard)—limited nature exposure

Group (age 4-5)	Human-base	Dog-base	Asymmetry
Urban European	75% to 9/12 species	42% to 5/12 species	**Large (33%)**
Rural European	56%	78%	Moderate (dog ownership)
Menominee	67% to 8/12	67% to 8/12	**None (0%)**
All groups (age 6+)	Use similarity among animals; dogs > humans (ecological validity)		

- **Interpretation:** European = anthropocentric (human privileged); Menominee = multi-centered (symmetric)
- **Psychological distance:** Nature as external (visit) vs embedded (belong to as community)

Visual: Human-Nature Mental Models



Indigenous Australian: SEWB Framework

- **Social-Emotional Wellbeing (SEWB):** Self intrinsically connected to family, kinship, community, culture, land, spirituality, ancestors
- **Holistic model:** Reject partitioning mind into isolated components (working memory, inhibition, etc.)
- **Disconnection predicts ill-being:** Health requires harmony of interrelations with land/culture/spiritual health
- **Self-determination central:** Aboriginal/Torres Strait Islander services must be designed/controlled by communities (not externally imposed)
- **Contrast with Western:** Western psychology partitions cognition to maximize subcomponents; SEWB emphasizes embedded connections

Deficit vs Strength-Based Framing

Aspect	Deficit Model	Strength-Based Model
Framing	"Close the gap" (NAPLAN scores)	"Achieve excellence" via cultural integration
Mechanism	Indigenous lack skills; need remediation	Indigenous have cultural strengths; need institutional alignment
Self-concept	Deficit messaging damages → negative loop	Cultural integration builds → positive loop
Self-determination	Programs designed externally, imposed	Programs designed/controlled by Indigenous communities

Google search test: "Excellence in Indigenous education" yields minimal results vs "excellence" in other education contexts—systemic framing asymmetry

- **Self-concept ↔ Achievement reciprocal (Marsh et al.):** Equivalent in Indigenous & non-Indigenous Australians (~500 each, longitudinal)
- **Mechanism:** High self-concept → achievement → higher self-concept (positive loop); damage self-concept → negative spiral

Gawura School: Self-Determination Eliminates Gap

- **Design:** Indigenous-run school-within-school (NSW); integrates cultural identity + practices with standard Australian curriculum
- **Not separate curriculum:** Standard content but Indigenous control over delivery/integration of cultural practices
- **NAPLAN Reading (Year 5):** Gawura scores equal to or frequently exceed state average
- **Growth (Year 3-5):** Grammar, numeracy, reading, spelling, writing—Gawura equal/superior to state; consistently exceeds similar-demographic schools
- **Volatility:** Small sample causes year-to-year jumps, but overall no achievement gap

Interpretation: Not superior innate ability—institutional alignment with cultural strengths protects self-concept, triggering positive reciprocal loop. Deficit framing in other schools damages self-concept → negative loop

Misapplication: Attachment Theory Severe Harm

- **Context:** Years after 2008 Stolen Generations apology, Aboriginal children still separated from families at higher rates
- **Problem:** Attachment Theory (developed in individualistic cultures) misapplied to Aboriginal contexts

Mismatch	Attachment Theory	Aboriginal Cultural Practice	Coded As
Caregiving structure	Evaluate single primary caregiver	Communal caregiving (multiple adults share responsibility)	"Insufficient attachment"
Child agency/autonomy	Expect immediate intervention for falls/distress	Assess injury severity; allow self-soothing if minor (respect child's autonomy/capability)	"Neglect"

Example: Child falls, cries briefly. Aboriginal mother observes, assesses not serious, allows child to stand up independently (respecting autonomy). Caseworker codes as "delayed response to distress" → contributes to removal evidence

- **Harm:** Culturally appropriate parenting pathologized → family separation (ongoing policy-driven harm)
- **Solution:** Assessment tools must be co-designed with Aboriginal communities (self-determination), not adapted from Western frameworks

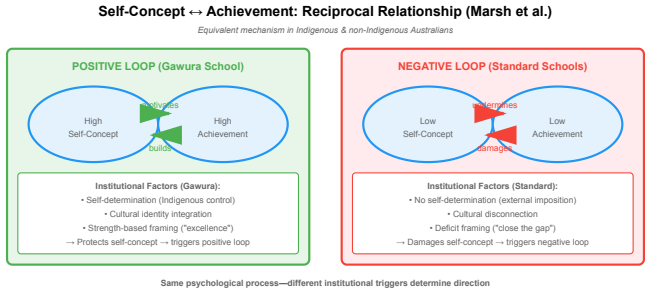
Aboriginal Memory Method (Reser et al. 2021)

- **Sample:** Medical students memorizing butterfly names
- **Task:** Memorize 15 butterfly species names

Method	Perfect Recall	Description
Untrained baseline	24%	No strategy instruction
Memory Palace (Western)	46%	Visualize familiar room; associate items with imagined objects/locations (based on ancient techniques, modern competition method)
Aboriginal method	**64%**	Physically walk real rock garden; construct narrative connecting names to landscape features; practice with Aboriginal educator

- **Three key elements:** (1) Actual physical movement through space (not just visualization), (2) Narrative structure connecting items in story, (3) Connection to land (real ecological features, not imagined furniture)
- **Interpretation:** Aboriginal knowledge transmission practices measurably superior for some tasks—not "different but equal" but actually superior in this context
- **Two-way influence:** All learners benefit (not just Indigenous)—instead of "improving Indigenous cognition to match Western," improve outcomes for everyone by incorporating Indigenous methods
- **Ecological validity:** Method enabled 60,000+ years of knowledge transmission in oral cultures

Self-Concept ↔ Achievement Reciprocal Loop



Critical Decision Rules: Interpreting Cultural Differences

- **Rule 1: Describe trade-offs, not rankings**
  - Japanese slower visual search in meaningful scenes = relational engagement (strength in ecological contexts), NOT attention deficit
  - Ask: What is optimized? What is sacrificed? Neither universally superior
- **Rule 2: Task-culture mismatch ≠ cognitive deficit**
  - Mayan child struggles with individualized worksheets but excels at group projects = system mismatch, not dependency
  - Diagnostic: Does task penalize or reward cultural strategy?
- **Rule 3: Universal claim requires universal sampling**
  - Carey's human-centered folkbiology = artifact of urban sample, not developmental universal
  - Menominee show no asymmetry → different mental model, not delayed development
- **Rule 4: Strategic adaptation ≠ ability difference**
  - Mayan children need less help after observation = culturally-trained simultaneous attention, not innate superiority
  - European children efficient at individualized instruction but miss peripheral information
- **Rule 5: System-level vs individual-level explanation**
  - Indigenous "achievement gap" disappears at Gawura → problem is institutional, not cognitive
  - When self-determination + cultural integration present, gap eliminated

Key Study Results Quick Reference

Study	Key Numerical Finding	Interpretation
Kuwabara & Smith 2012	US: 75%→58% with rich objects Japanese: 75%→75% (invariant)	Object-focus vulnerable to perceptual distraction when relations matter
Correa-Chávez et al. 2005	Simultaneous attention: Traditional Mayan 48%, Mixed 35%, European 27%	More Western schooling → less simultaneous attention capacity
Toy-building study	Difficult toy help needed: Mayan 43.5%, European 58.8%	Peripheral learning from observation (62% vs 31% sustained attention)
Medin et al. (folkbiology)	Asymmetry: Urban European 33%, Menominee 0%	Anthropocentric vs multi-centered mental models
Bang et al. (perspective)	Perspective-taking: Native 67-88%, European 41%	Embodied vs external relationship with nature
Gawura School NAPLAN	Year 3-5 growth equals/exceeds state average across all domains	Self-determination + cultural integration eliminates gap
Reser et al. 2021	Perfect recall: Baseline 24%, Memory Palace 46%, Aboriginal 64%	Indigenous methods measurably superior (two-way influence)

Exam-Focused Comparisons Matrix

Dimension	Pattern A	Pattern B	Key Distinction
Attention	Individualist: Selective (narrow object focus)	Collectivist: Distributed (broad relational)	What information extracted from environment
Learning	Assembly-line: Alternating; individual rank	Intent participation: Simultaneous; collaborative	Observational learning vs individualized instruction
Folkbiology	European: Anthropocentric (human privileged)	Native: Multi-centered (symmetric)	Inductive asymmetry vs symmetry
Nature relation	External: "Respect" (observe/manage)	Embedded: "Part of" (relatives/interconnected)	Psychological distance to nature
Education	Deficit: "Close gap" (damages self-concept)	Strength: "Excellence" (builds self-concept)	Institutional framing triggers reciprocal loop direction
Self	Western: Isolated (partition into components)	Aboriginal SEWB: Holistic (connected to land/culture)	Unit of analysis: individual vs embedded system

Common Interpretation Errors to Avoid

- **Error 1: Deficit interpretation**
  - Wrong: "Japanese children slower at visual search = attention problems"
  - Right: "Relational attention strategy trades object isolation speed for ecological relationship encoding"
- **Error 2: Ability attribution**
  - Wrong: "Mayan children have better working memory capacity"
  - Right: "Culturally-trained simultaneous attention strategies enable peripheral learning"
- **Error 3: Universal developmental claim without universal sampling**
  - Wrong: "4-year-olds universally privilege humans in biological reasoning (Carey)"
  - Right: "Urban Western children show anthropocentric pattern; Menominee show multi-centered pattern"
- **Error 4: Misattributing institutional problems to individuals**
  - Wrong: "Indigenous children have lower achievement → need remediation"
  - Right: "Deficit framing damages self-concept; self-determined education eliminates gap"
- **Error 5: One-directional cultural influence**
  - Wrong: "Indigenous students need to learn Western cognitive strategies"
  - Right: "Two-way influence—Indigenous methods (e.g., memory) benefit all learners"
- **Error 6: Confusing exposure with mental model**
  - Wrong: "More nature exposure → better folk biology"
  - Right: "Rural European children hunt/fish but still show anthropocentric pattern—conceptual framework matters, not just exposure"

Key Researchers & Concepts

- **Kuwabara & Smith (2012):** Relational reasoning with rich vs simple objects; visual search trade-offs
- **Rogoff et al.; Correa-Chávez et al.:** Intent participation; simultaneous vs alternating attention; peripheral learning
- **Susan Carey (1985):** Category-based induction; claimed universal human-centered folkbiology (challenged by Medin)
- **Medin, Waxman, & colleagues:** Cross-cultural folkbiology; inductive asymmetry; psychological distance to nature
- **Megan Bang:** Indigenous science education; transforming mental models of human-nature relations; outdoor education
- **Marsh et al. (2023):** Self-concept ↔ achievement reciprocal relationship; ~500 Indigenous & non-Indigenous longitudinal
- **Gawura School:** Indigenous-run school-within-school; self-determination eliminates achievement gap
- **Reser et al. (2021):** Aboriginal narrative-place memory method superior to Western memory palace
- **1916 Stanford Dean of Education:** Factory model explicit design ("children are raw products to be shaped")

SEWB Framework: Social-Emotional Wellbeing—self connected to family, kinship, community, culture, land, spirituality, ancestors. Disconnection predicts ill-being. Self-determination central to service provision.

Learning System Comparison Flowchart