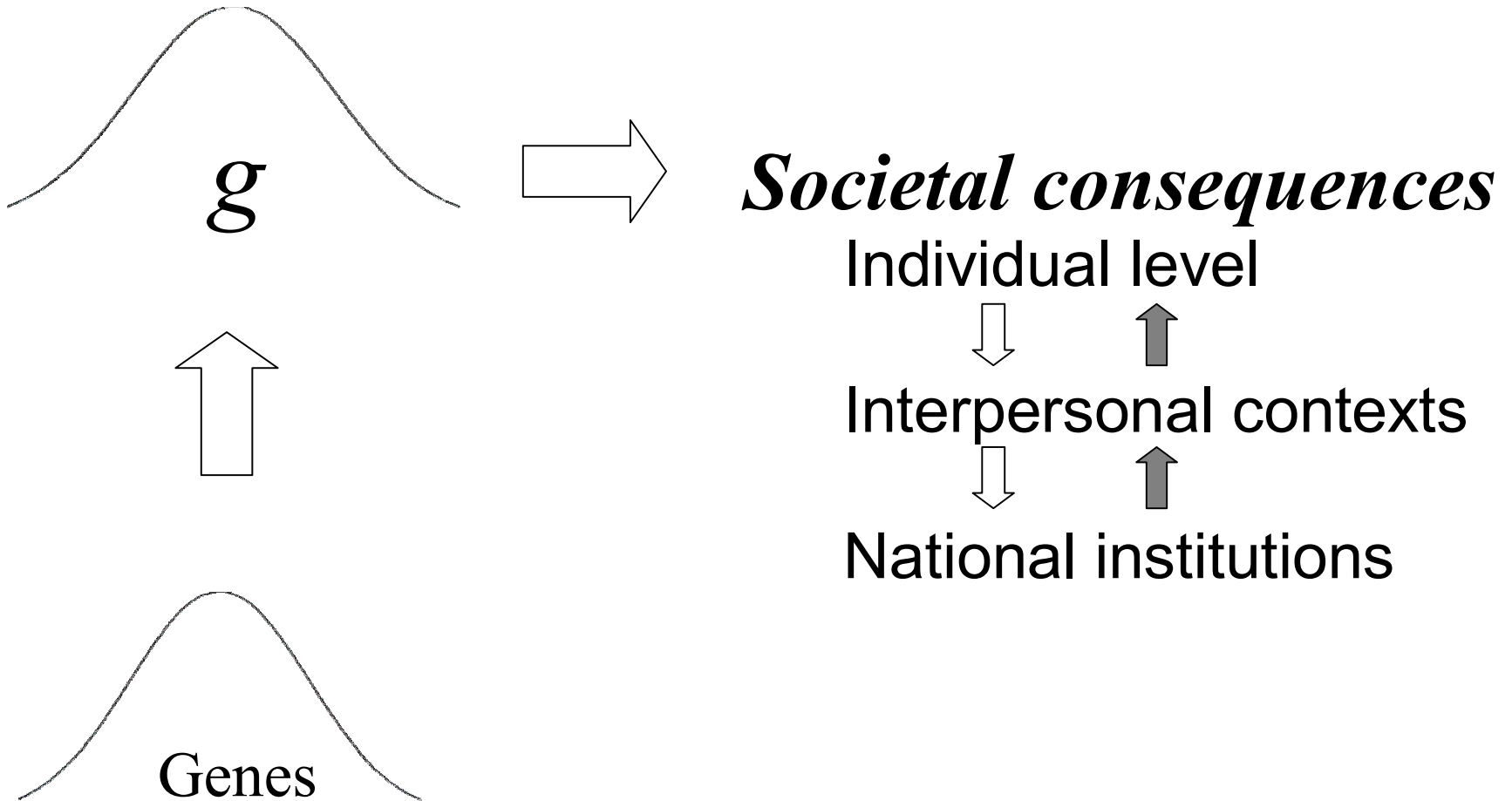# Innovation, Fatal Accidents, and the Evolution of General Intelligence
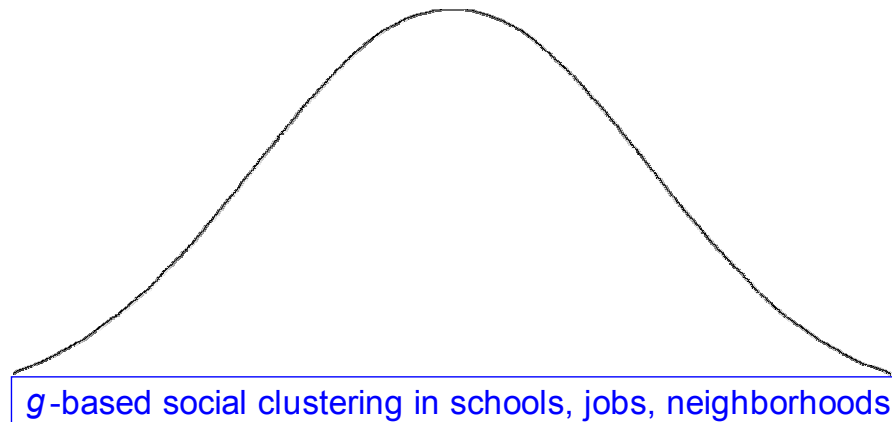
Linda S. Gottfredson

University of Delaware

Lunch seminar at UC Davis

Department of Psychology, Psychobiology Group
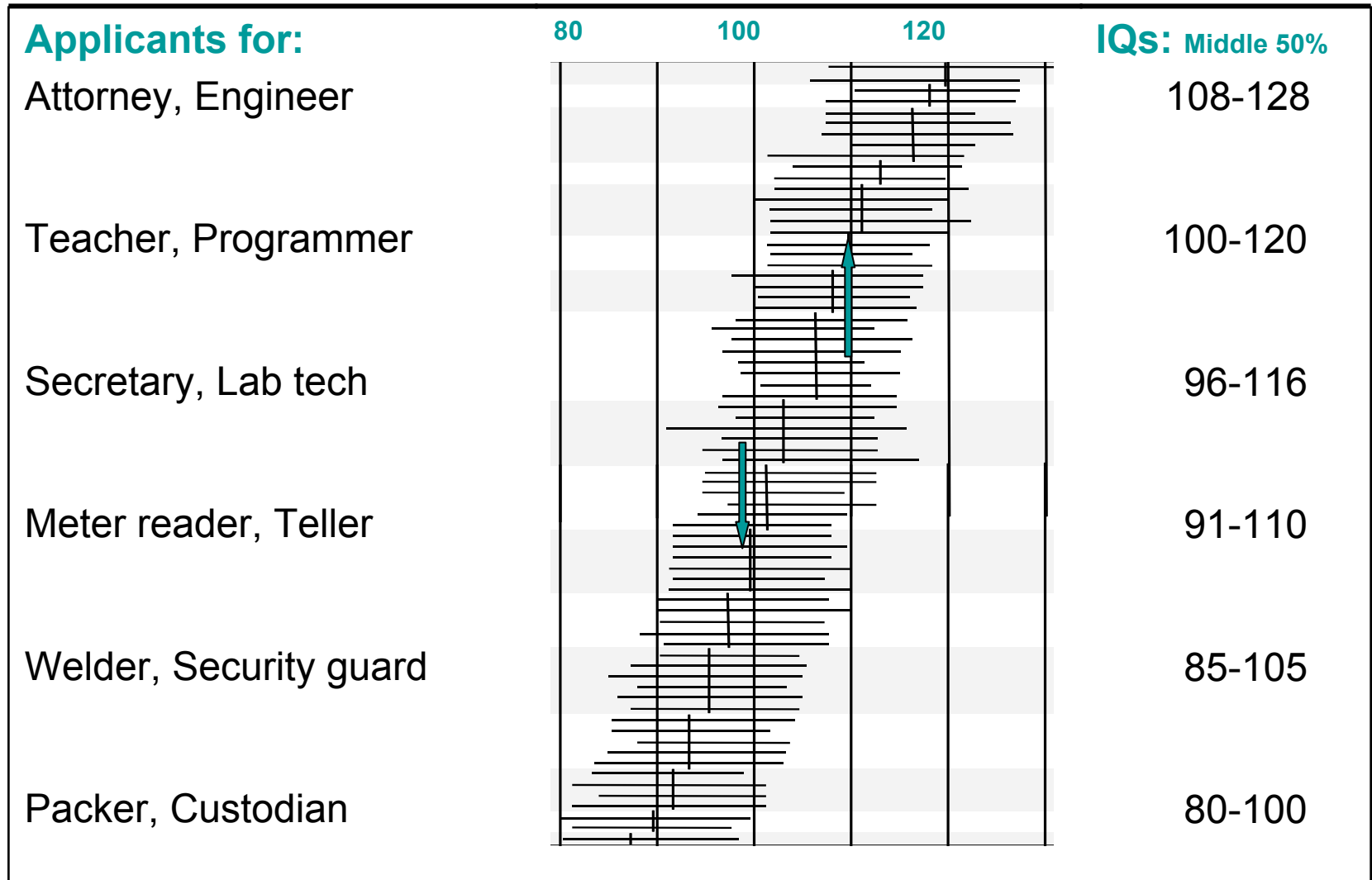
December 6, 2005

Sociology of Intelligence

g ⟹ **Societal consequences**

Individual level

Interpersonal contexts

National institutions

Genes

Cascading, Multi-Level Effects

g-based social clustering in schools, jobs, neighborhoods

Unemployed	12	10	7	7	2
Illegitimate child	32	17	8	4	2
Lives in poverty	30	16	6	3	2
Chronic welfare	31	17	8	2	0
HS dropout	55	35	6	0.4	0

Different interpersonal climates, help, risks

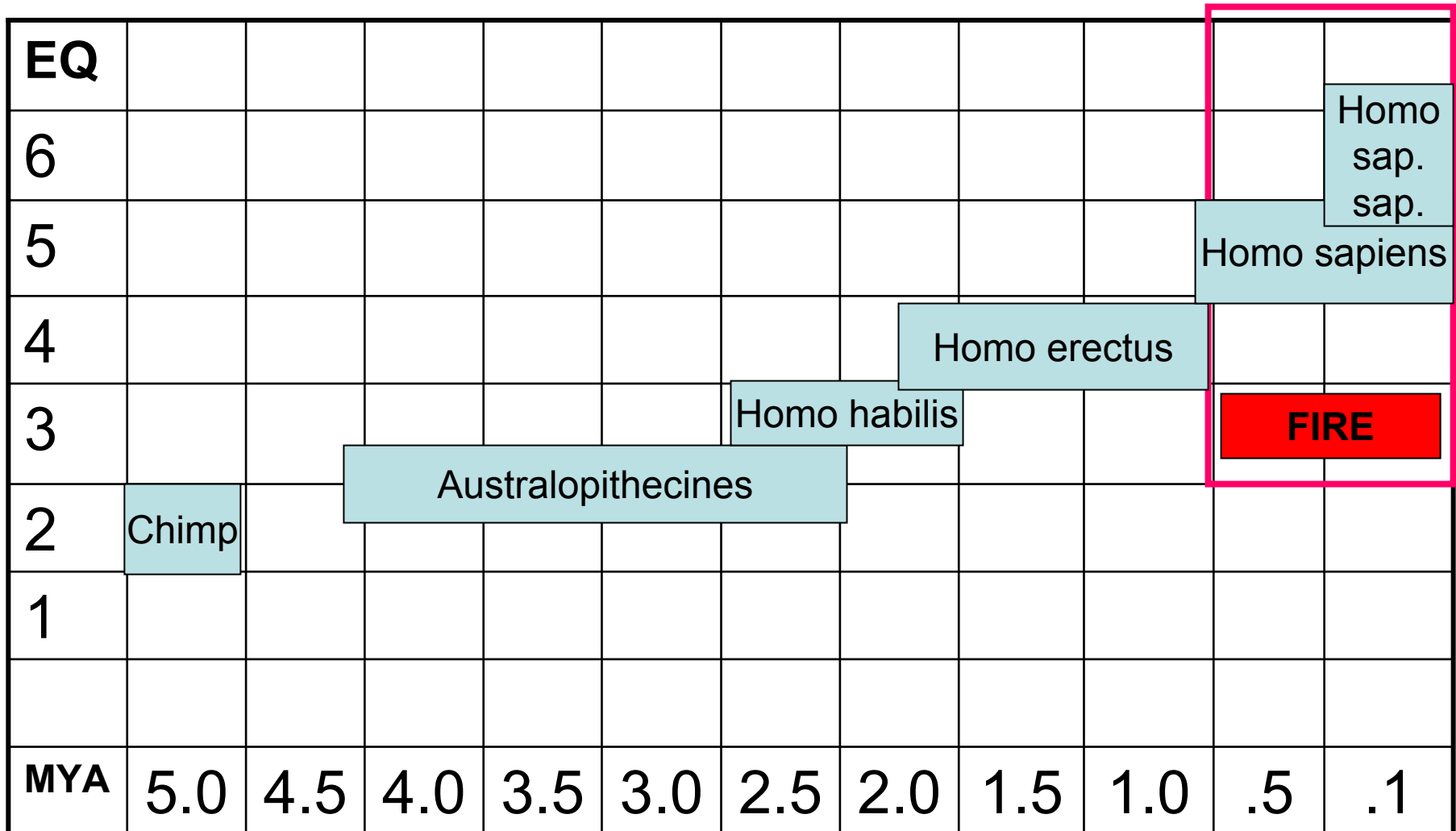g-based sub-cultures; diffusion gradients for information, help, & regard

Social inequality, job hierarchies, intergroup competition, policy responses

Evolution of Division of Labor

Applicants for:	80	100	120	IQs: Middle 50%
Attorney, Engineer				108-128
Teacher, Programmer				100-120
Secretary, Lab tech				96-116
Meter reader, Teller				91-110
Welder, Security guard				85-105
Packer, Custodian				80-100

Humans' "Remarkable" Intellect

Encephalization quotient (EQ) = brain-to-body size compared to the average mammal

EQ											
6											Homo sap. sap.
5										Homo sapiens	
4								Homo erectus			
3							Homo habilis			FIRE	
2	Chimp			Australopithecines							
1											
MYA	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	.5	.1

The Explanadum

Human "Intelligence"

- Psychometric view—*g*
  - General ability to learn & reason
  - General (cross-domain) utility
 - Instrumental (not socioemotional)

E.g., Fitness signaling & survival theories consistent with *g*

- Evo Psych views—varied, but mostly <u>not</u> *g*
  - Modular: Narrow, domain-specific, automated (many fast and frugal heuristics)
  - Social intelligence (not "ecological competence")

So, most Evo Psych theories leave *g* unexplained.

What is *g*?

■ All mental tests measure mostly the same ability: *g*

■ *g* is the spine or core of all mental abilities
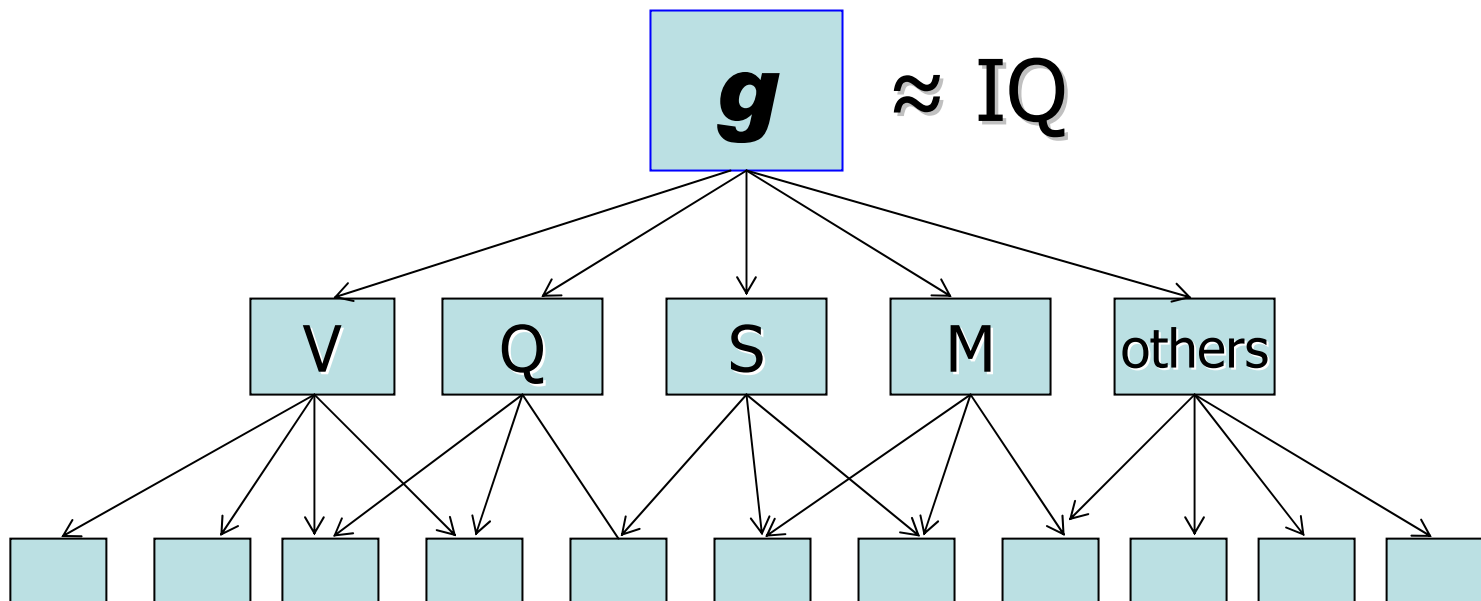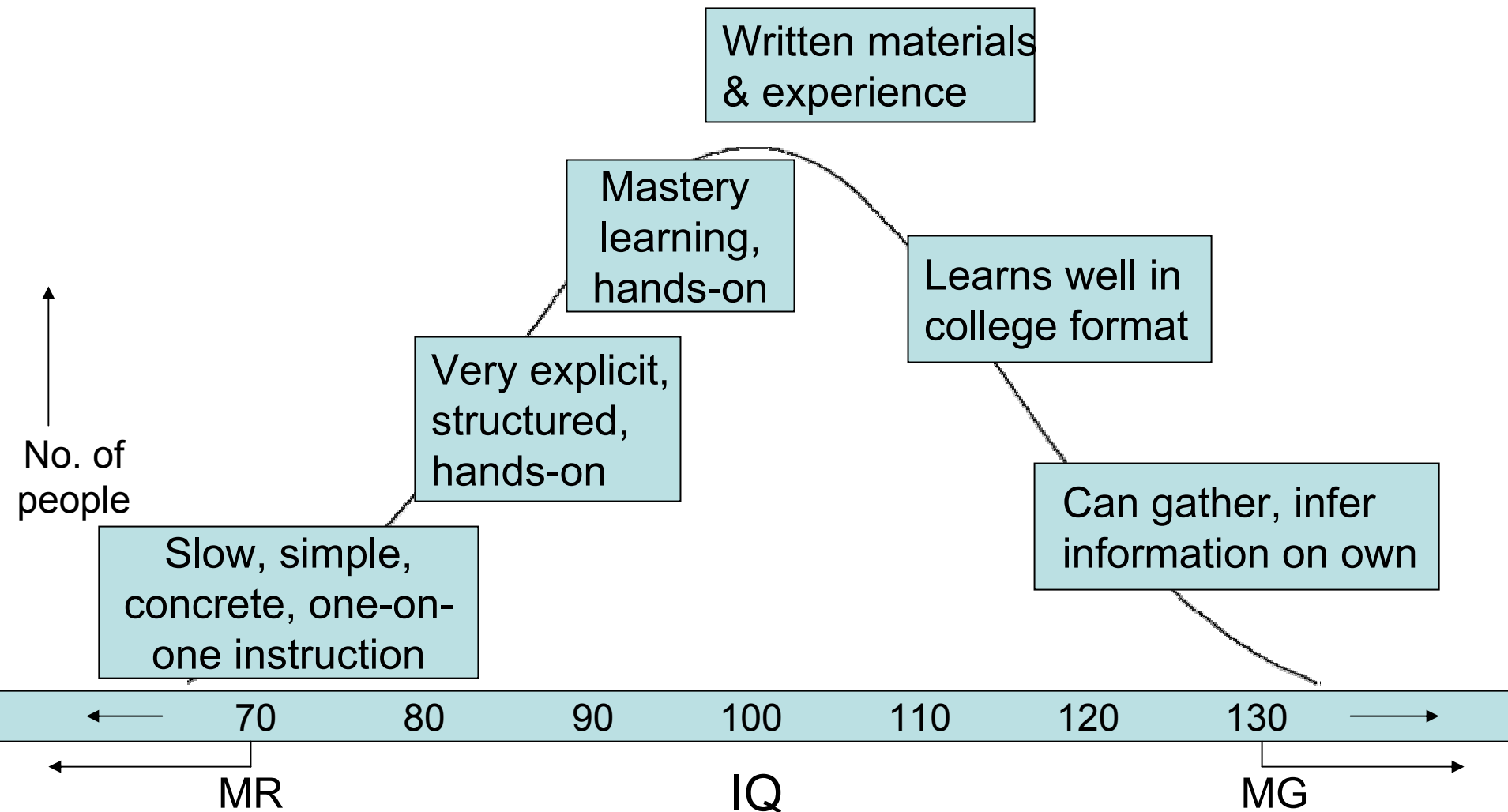
g = Mental Manipulation
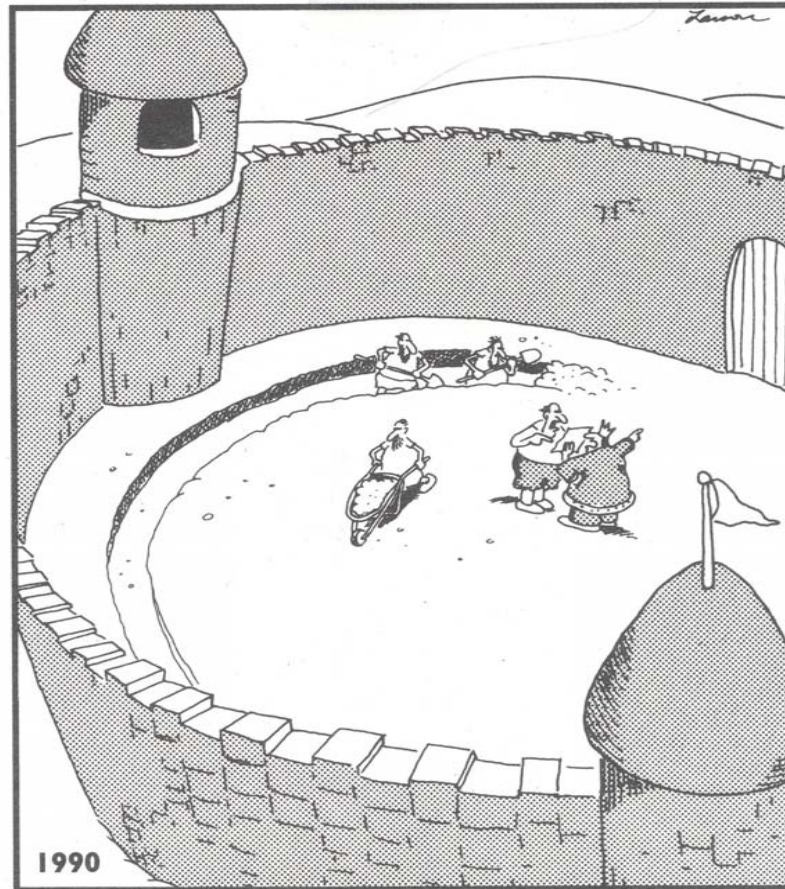
Concrete Example

Digits Subtests:

Forward vs. Backward

Illustrates differences in task complexity
More complex = more "*g* loaded"

g=Learning Ability (Typical Learning Needs at Different IQs)

Written materials & experience

Mastery learning, hands-on

Learns well in college format

Very explicit, structured, hands-on

Can gather, infer information on own

No. of people

Slow, simple, concrete, one-on-one instruction

70   80   90   100   110   120   130
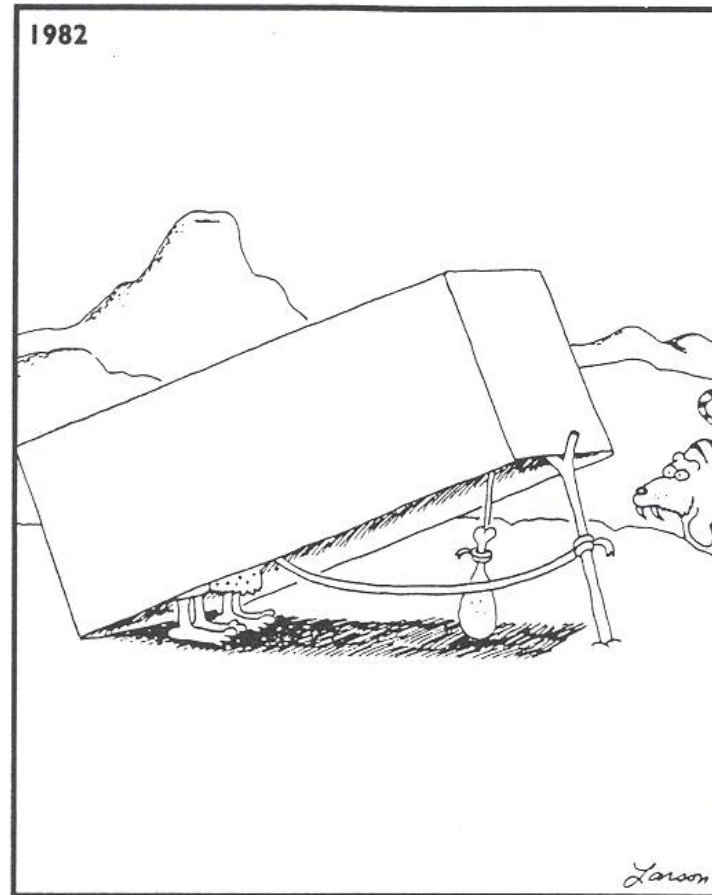
MR   IQ   MG
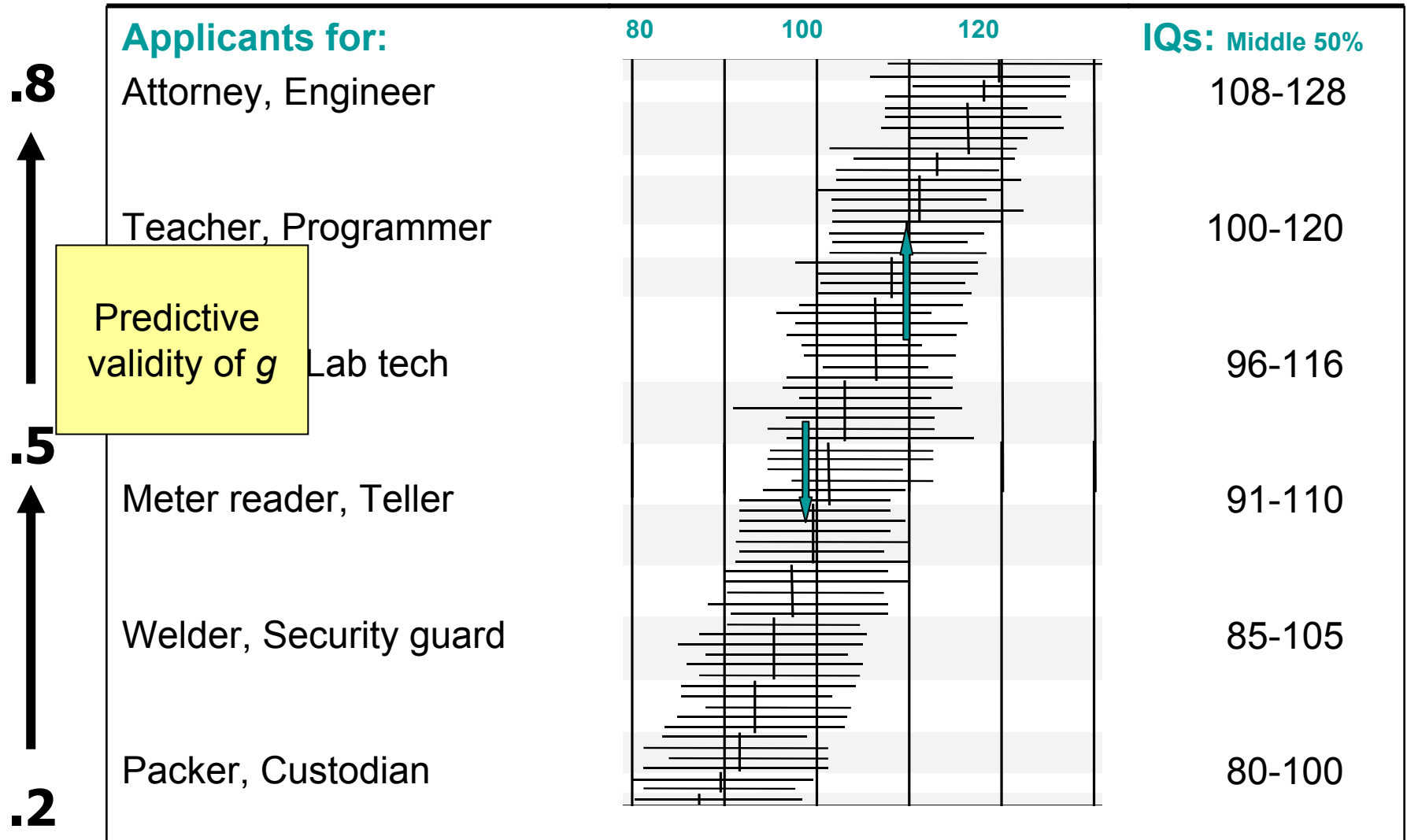
g = Problem Solving

Suddenly, a heated exchange took place between
the king and the moat contractor.

g = Plan, Anticipate Problems

"Shhhh, Zog! ... Here come one now!"

Performance More Dependent on *g* in More Complex Jobs

		80	100	120	IQs: Middle 50%
Applicants for:					
Attorney, Engineer					108-128
Teacher, Programmer					100-120
Lab tech					96-116
Meter reader, Teller					91-110
Welder, Security guard					85-105
Packer, Custodian					80-100

.8

.5

.2

Predictive validity of *g*

Even simple jobs too complex for some people

Urban hospital outpatients: % diabetics _**not**_ knowing that:	Health literacy level		
	V-low	Low	OK
Signal: Thirsty/tired/weak usually means blood sugar too high	40	31	25
Action: Exercise lowers blood sugar	60	54	35
Signal: Suddenly sweaty/shaky/hungry usually means blood sugar too low	50	15	6
Action: Eat some form of sugar	62	46	27

What Must an Explanation of *g* Specify?

1. **Cross-domain value** (<u>common</u> cognitive demands across *different* task domains in *Homo* ecology)

2. **Differential impact on survival** (*g*-related differences in task performance must create *g*-related differences in survival/reproduction)

> Need to lay out a "nitty-gritty selection walk"

3. **Ecological demands that are <u>unique</u> to genus *Homo***

4. **Conditions that <u>accelerated</u> selection for *g* in *Homo sapiens***

Natural Selection, or Sexual Selection?

- My focus here on natural selection
    - I.e., external, physical environment matters
- Sexual selection for *g* may also operate, but is not plausibly the whole answer:
    - Why would it select so strongly for *g* <u>only</u> among humans?
    - What would trigger runaway selection for *g*?
    - What about all those individuals who die before reproductive age?

1. Ecological Demands—How General?

- Clues from analyzing modern jobs
  - Cognitive complexity is major distinction
  - Example: "Judgment & Reasoning Factor"
    - Deal with unexpected situations
    - Learn & recall job-related information
    - Reason & make judgments
    - Identify problem situations quickly
    - React swiftly when unexpected problems occur
    - Apply common sense to solve problems

None of these is domain-specific.

But wasn't life simpler in the early human EEA?

- Yes, but it was never *g*-proof
- Opportunity to learn & reason **+** within-group *variation* in *g* **=** opportunity for selection
- Tiny effect size **+** many generations **=** big shift in distribution

2. *g*-Related Mortality During Reproductive Years (15-44)?

Major cause of death today: Fatal injuries

- Mostly unintentional (not homicide or suicide)
  - Burns, drowning, vehicle collisions, cuts, crushing, falls, poisons, animal bites, exposure, etc.
- Many males killed in work-related activities
- True worldwide
- Accident prevention is highly cognitive process.
  - Spotting and managing hazards makes same demands as do complex jobs (e.g., dealing with the unexpected)
- Absolute risk of accidental death is low but *relative* risk is high for lower-*g* populations

  Imagine death rate is .001 overall, but .003 for low *g*

Accident Prevention Also Resembles Complex Jobs

Complex jobs require you to:	*r* with complexity
▪ Learn and recall relevant information	.75
▪ Reason and make judgments	.71
▪ Deal with unexpected situations	.69
▪ Identify problem situations quickly	.69
▪ React swiftly when unexpected problems occur	.67
▪ Apply common sense to solve problems	.66
▪ Learn new procedures quickly	.66
▪ Be alert & quick to understand things	.55

Example: Motor Vehicle Deaths

Australian veterans followed to age 40	Death rate per 10,000	
IQ: above 115	51.3	
100-115	51.5	
85-100	92.2	**2x**
80- 85	146.7	**3x**

"People with lower IQ may have a poorer ability to assess risks and, consequently

But in the EEA too?

% Non-Warfare Deaths: USA vs. Pre-Contact Hunter-Gatherers

	USA (1986)				Ache (<1971)
Age:	15-24	25-34	35-44	45-64	15-59
Illness	22	44	72	93	49
Accident	51	31	15	4	37
Suicide	13	12	7	2	0
Homicide	14	13	6	1	14

Cause of Ache Deaths (N, <1971)

Age:	0-3		4-14		15-59		60+	
Sex:	F	M	F	M	F	M	F	M
Illness					9	26	2	3
Congenital/degenerative					1		2	4
Childbirth					3			
Accident					6	23	4	3
jaguar/snake					4	19	1	3
lightning					1	2		
lost						1	3	
drowned/falls/other					1	1		
Homicide					4	7	1	4
sacrificed with adult								
homicide/neglect								
buried alive/left behind					2		1	2
ritual club fights						6		2
non-sanctioned murder					2	1		

Cause of Ache Deaths (N, <1971)

	Age:	0-3		4-14		15-59		60+	
	Sex:	F	M	F	M	F	M	F	M
Illness				8	7	9	26	2	3
Congenital/degenerative						1		2	4
Childbirth						3			
Accident				1	10	6	23	4	3
jaguar/snake					3	4	19	1	3
lightning					3	1	2		
lost					3		1	3	
drowned/falls/other				1	1	1	1		
Homicide				14	3	4	7	1	4
sacrificed with adult				10	1				
homicide/neglect				3					
buried alive/left behind				1	2	2		1	2
ritual club fights							6		2
non-sanctioned murder						2	1		

Most are "mistakes" (faulty mind's eye) during provisioning

Mistakes reverberate

Cause of Ache Deaths (N, <1971)

Age:	0-3		4-14		15-59		60+	
Sex:	F	M	F	M	F	M	F	M
Illness	19	17	8	7	9	26	2	3
Congenital/degenerative	8	11			1		2	4
Childbirth					3			
Accident	1	2	1	10	6	23	4	3
jaguar/snake				3	4	19	1	3
lightning		1		3	1	2		
lost				3		1	3	
drowned/falls/other	1	1	1	1	1	1		
Homicide	26	26	14	3	4	7	1	4
sacrificed with adult	7	4	10	1				
homicide/neglect	17	18	3					
buried alive/left behind	2	4	1	2	2		1	2
ritual club fights						6		2
non-sanctioned murder					2	1		

Cause of Ache Deaths (N, <1971)

Age:	0-3		4-14		15-59		60+
Sex:	F	M	F	M	F	M	
Illness	19	17	8	7	9	26	
Congenital/degenerative	8	11			1		
Childbirth					3		
Accident	1	2	1	10	6	23	
jaguar/snake				3	4	19	
lightning		1		3	1	2	
lost				3		1	
drowned/falls/other	1	1		1	1	1	
Homicide	26	26	14	3	4	7	
sacrificed with adult	7	4	10	1			
homicide/neglect	17	18	3				
buried alive/left behind	2	4	1	2	2		
ritual club fights						6	
non-sanctioned murder					2	1	

NOTE:

Many Ache died before mating age

Many evolutionary "two-fers": child killed after parent dies

What Killed Differentially by *g* Level?

- **Not the obvious**
  - Not high-interest, high-probability threats to band's survival (e.g., starvation, harsh climate)
  - Because the fruits of competence are shared (e.g., meat from hunting)

- **But the "minor" side-effects of core tasks**
  - Myriad low-probability, chance-laden, oft-ignored risks in daily chores (e.g., "accidental" injury)
  - Costs of injury not shared widely

Recall Spearman-Brown Formula for test reliability:
Low-*g* items can yield high-*g* test when many items cumulated (here: across tasks, individuals, generations)

3. What Unique to Human EEA?

Not

- – Tool use
- – Hunting
- – Being hunted
- – Climate
- – Social living

3. What Unique to Human EEA?

Human Innovation

- Changed physical environment or how humans interacted with it (e.g., fire, weapons)

- Improved average well-being but created novel risks (e.g., burns/scalds, inattention to snakes)

- Put a premium on independent learning and foresight,
  - especially for recognizing hazards and preventing "accidental" injury and death during core activities

Innovation & hazards require a mind's eye—imagination, foresight

4. How Did Innovation Accelerate Selection for *g*?

Five possible accelerators

- – Double jeopardy
- – Spearman-Brown pump
- – Spiraling complexity
- – Contagion of error
- – Migration ratchet

Double Jeopardy
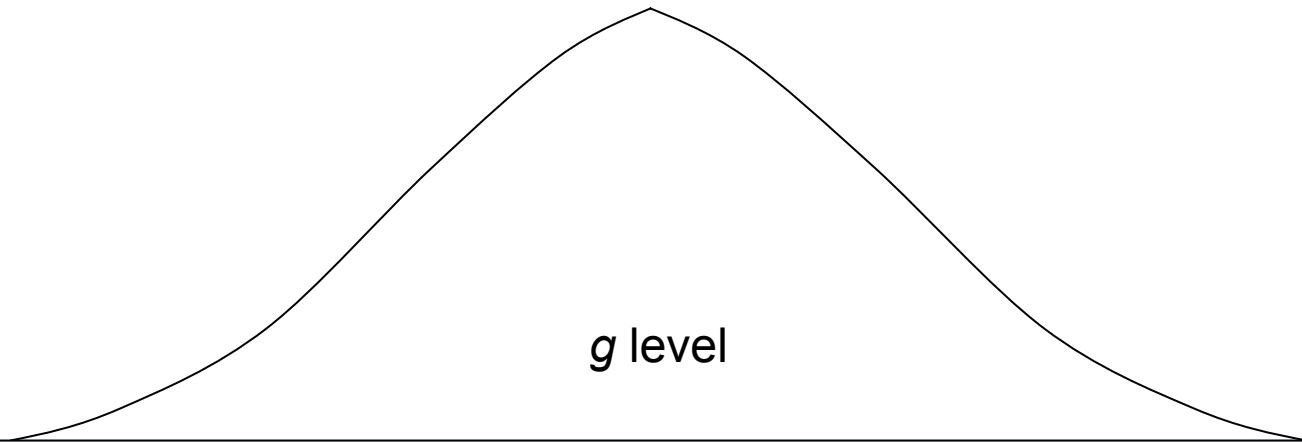
g level
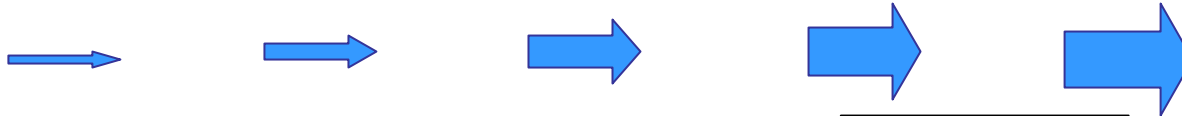
Risk of benefit

Sharing

Risk of injury

Social Intelligence View?
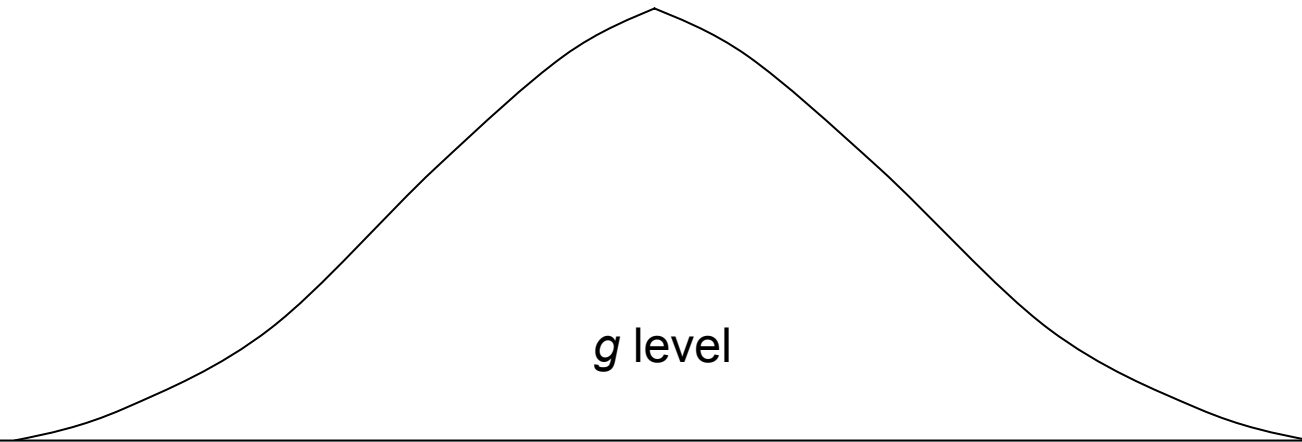
g level

Risk of benefit
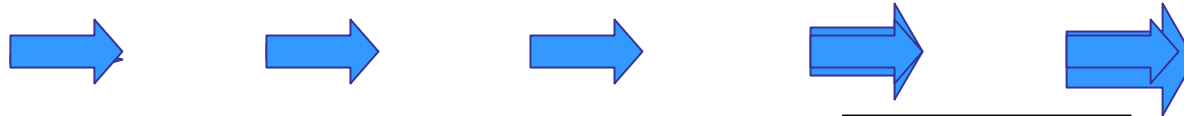
Sharing

Machiavellian exploitation

Risk of injury

High-*g* innovators make like difficult for everyone else

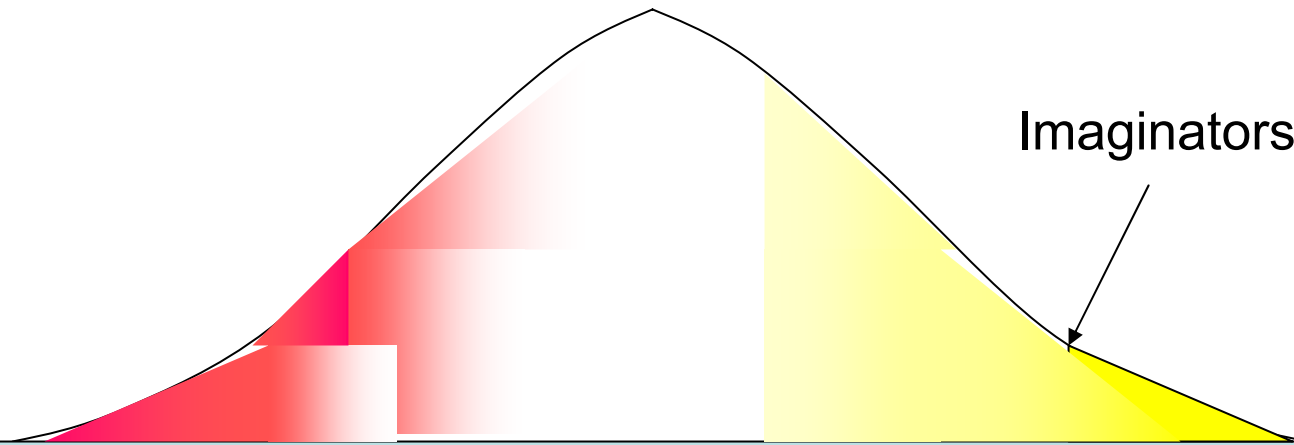# Migration Ratchet

Imaginators
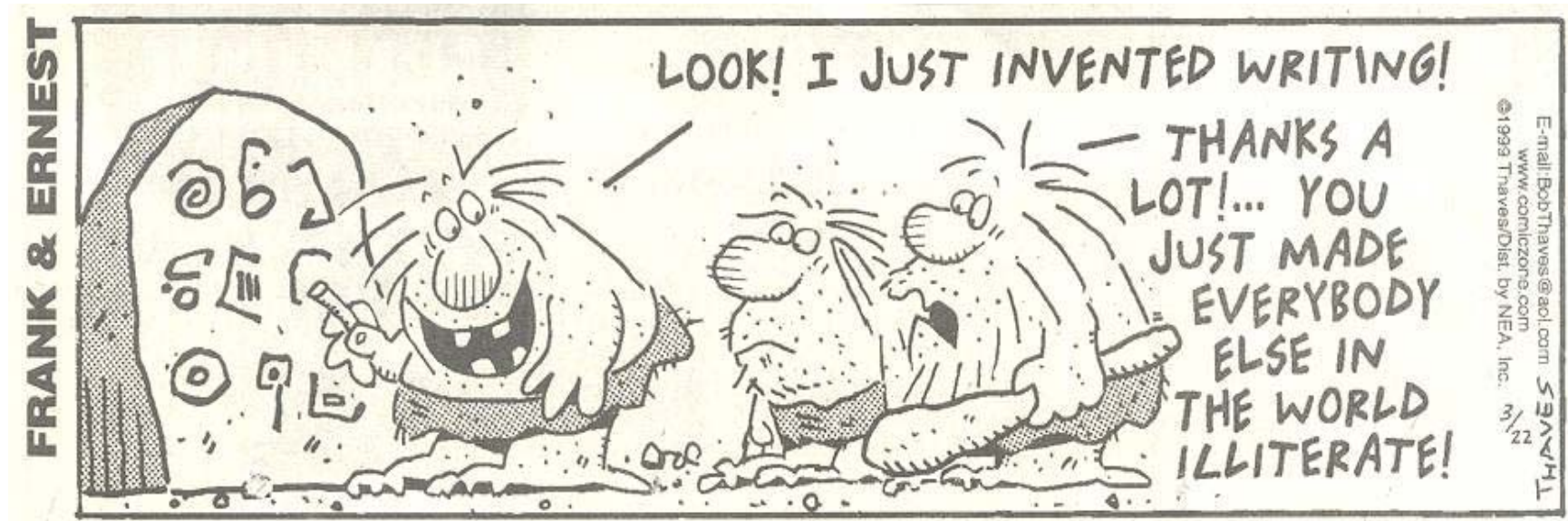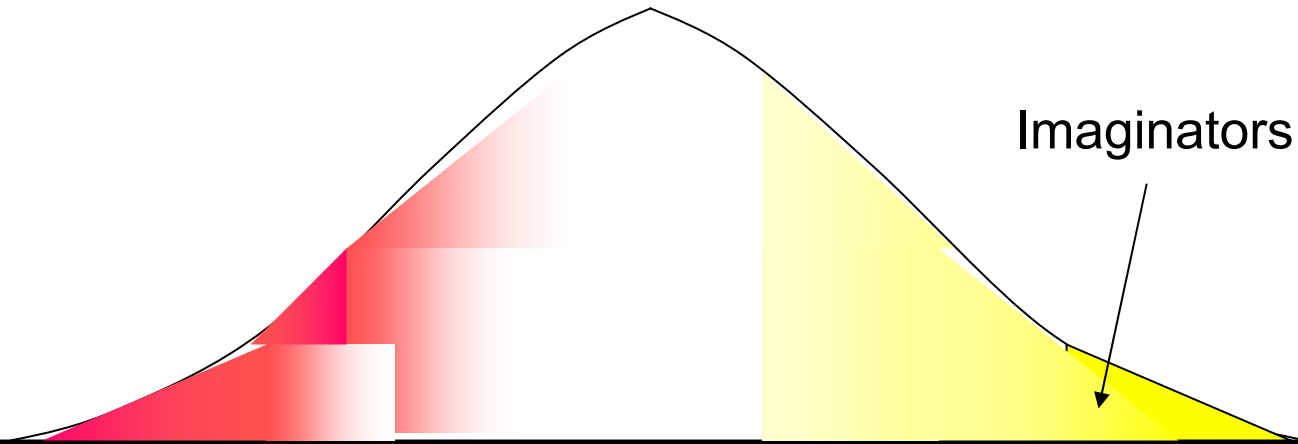
Mean IQ rises

Relative risk steepens

Innovate to adapt to harsher climates:
- clothing, shelter
- storage, preservation

Bigger consequences ⬅ More hazards ⬅ More complexity ⬅ More innovations

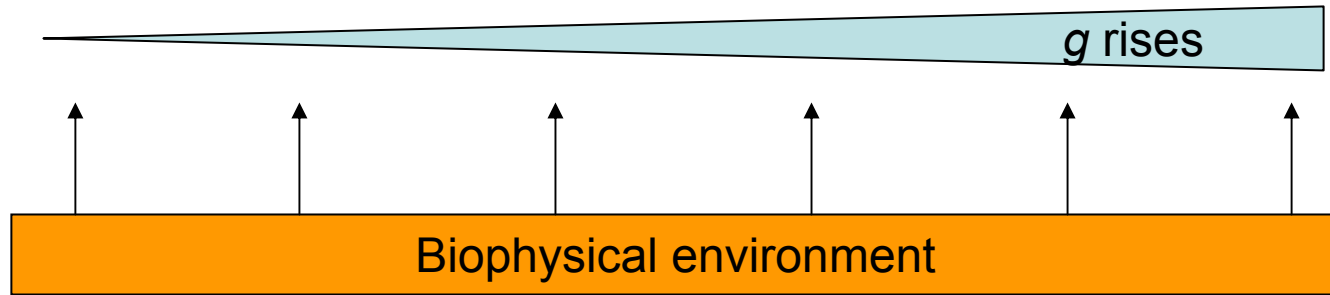# Migration Ratchet

Imaginators

Consistent with mean differences in IQ,
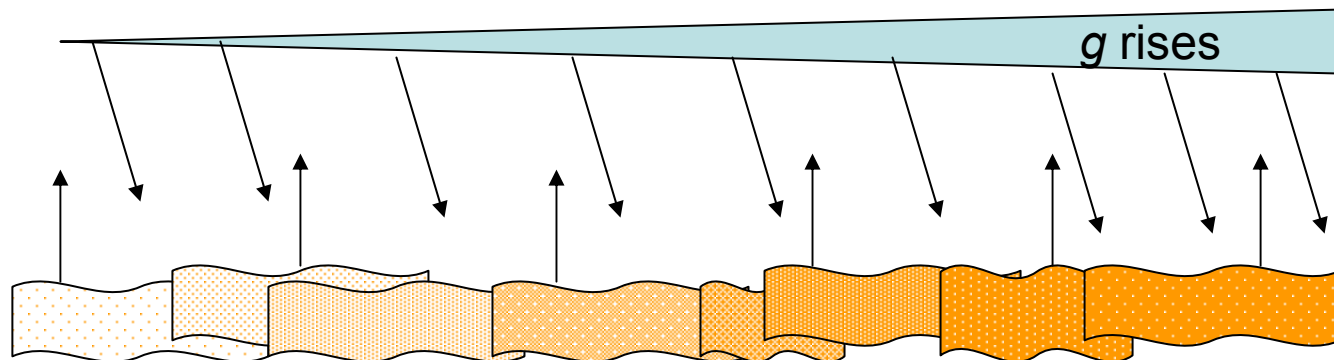brain size, and skeletal robustness by race/latitude

Bigger consequences ⬅ More hazards ⬅ More complexity ⬅ More innovations

Gene-Culture Co-Evolution of *g*

Not this:

g rises

Biophysical environment

But this:

g rises

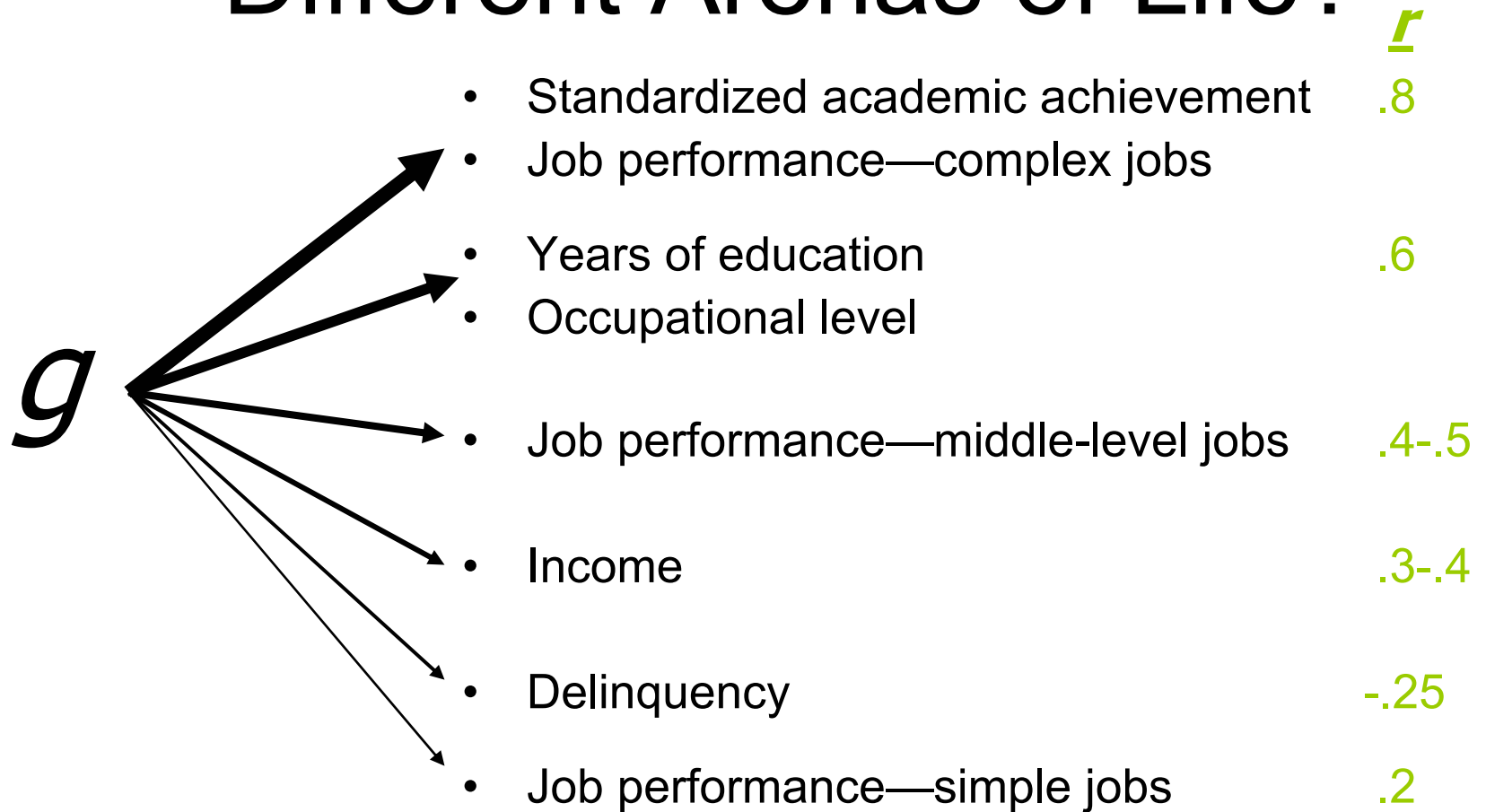Humans modified their EEA, which modified them.

Thank you.

- In press

- Available at:

    www.udel.edu/educ/gottfredson

Everyday Literacy (NALS)

NALS Level	% pop. (white)	Simulated Everyday Tasks
5	4%	• Use calculator to determine cost of carpet for a room • Use table of information to compare 2 credit cards
4	21%	• Use eligibility pamphlet to calculate SSI benefits • Explain difference between 2 types of employee benefits
3	36%	• Calculate miles per gallon from mileage record chart • Write brief letter explaining error on credit card bill
2	25%	• Determine difference in price between 2 show tickets • Locate intersection on street map
1	14%	• Total bank deposit entry • Locate expiration date on driver's license

1. How *g* Loaded Are Different Arenas of Life?

__r__

- Standardized academic achievement   .8
- Job performance—complex jobs

- Years of education   .6
- Occupational level

- Job performance—middle-level jobs   .4-.5

- Income   .3-.4

- Delinquency   -.25

- Job performance—simple jobs   .2
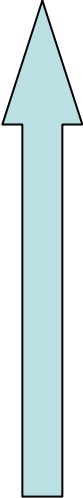
g

Non-Work **Accidental** Death Rates Higher in Lower Classes

Relative risk for poor vs. middle $

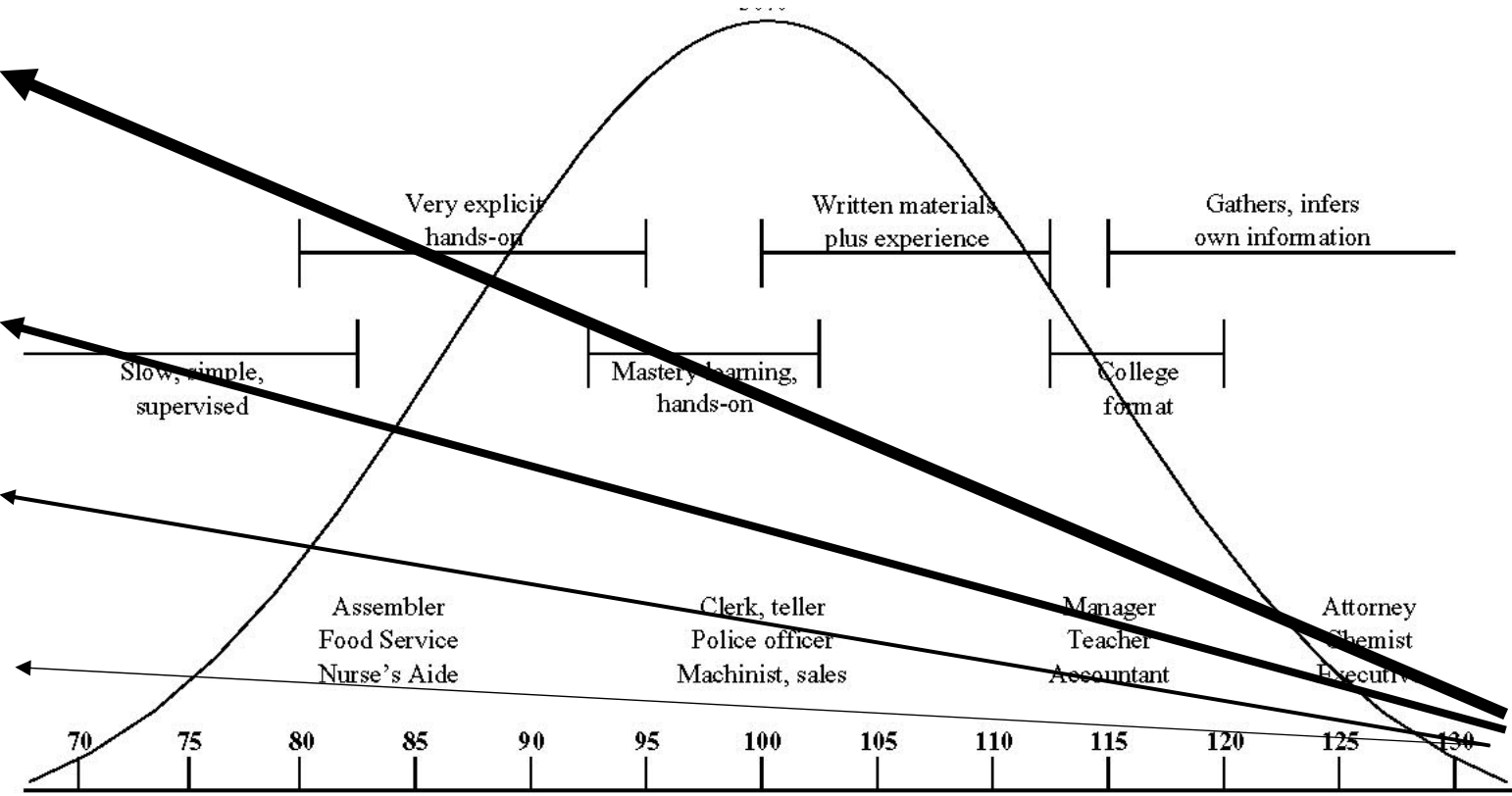- Suffocation (infants)   1.3
- Choking on food (infants & elderly)   1.5
- Drowning (young males)   2.0
- Motor vehicle (young males)   2.4
- Fires/burns (children & elderly)   2.5
- Lightning (young males)   3.4
- Firearms (young males)   4.4
- Natural disasters (all ages, sexes)   5.0
- Exposure/neglect (infants & elderly)   7.4

g-Related Relative Risk Varies by Kind of Outcome

Complex Cumulative

Simple Episodic

Very explicit hands-on

Written materials plus experience

Gathers, infers own information

Slow, simple, supervised

Mastery learning, hands-on

College format

Assembler
Food Service
Nurse's Aide

Clerk, teller
Police officer
Machinist, sales

Manager
Teacher
Accountant

Attorney
Chemist
Executive

70   75   80   85   90   95   100   105   110   115   120   125   130

Sample IQ Items: Active Ingredient Is Complexity

	Easy	**Moderate**	**Hard**
Fill in the next two numbers	3, 5, 7, 9,___, ___	3, 5, 6, 8, 9, ___, ___	10, 9, 8, 9, 8, 7, ___, ___
Name one similarity	orange—banana (93%)	table-chair (55%)	fly-tree (18%)
Define the word	breakfast (99%)	reluctant (50%)	encumber (19%)

% = % of 16-65 year-olds getting at least partial credit for answer, WAIS, 1955

Everyday Literacy (NALS)

NALS Level	% pop. (white)	Simulat
5	4%	▪ Use calculator to ▪ Use table of infor
4	25%	▪ Use eligibility pam ▪ Explain difference
3	36%	▪ Calculate miles pe ▪ Write brief letter
2	25%	▪ Determine differe ▪ Locate intersectio
1	14%	▪Total bank deposit ▪ Locate expiration

Difficulty based on "process complexity"

- level of inference
- abstractness of info
- distracting information