How intelligence research can guide interventions to reduce error rates in health self-management

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Presented in the symposium, “Causal models that integrate literacy, g, and health outcomes: A practical guide to more effective disease prevention and health promotion?”

International Society for Intelligence Research, Decatur, GA
December 12, 2008
Or, “Levers for Change”

*g* theory* reveals:

- High-use levers are weak—but improvable
- High-promise levers go unrecognized
- Alluring blind alleys to avoid

\*g* = Also called “Spearman’s *g*,” it is the general mental ability factor discovered using factor analysis, confirmed by Carroll (1993) as the core of all specific mental abilities, and shown to be correlated both phenotypically and genetically with a wide array of brain attributes (Deary, 2000; Jensen, 1998; Jung & Haier, 2007). “*g* theory” refers to the set of generalizations gleaned from a century of research on the nature, origins, and educational, employment, health, and other consequences of population dispersion along the *g* continuum (e.g., Batty et al., 2007; Gottfredson, 1998, 2002; Kuncel et al., 2004; Lubinski, 2004).
The view from $g$ theory

- New guys on the block in 1990s, big players by 2000s
  - Health literacy
  - Cognitive epidemiology
- Overlapping concerns & constructs
  - Reading/literacy-health relation
  - IQ/$g$-health relation
- Common methods
  - Atheoretical
  - Throwing a wide net (measures, outcomes)
  - Searching for incremental predictive validity (e.g., net of SES)
- Common results
  - Pervasive connections (knowledge, behavior, morbidity, mortality)
  - Inconsistent findings, unclear patterns
Repeating past mistakes, such as:

The best **definitions** of health literacy will recognize that:
- It is an extremely complex construct
- It is not an attribute of the individual, but the intersection of individuals and environments

Confuses ability and achievement

“Definitions” fallacy*

The best **measures** of health literacy will:
- Be specific to health, not general
- Cover all relevant knowledge and skills

False “specificity theory”

“Marbles” fallacy

The best **interventions** for low health literacy will:
- Create a more health-literate population
- Reduce group disparities

But little generalization

But SD expands when mean rises

The best **estimates** of its effects control for SES

Sociologists’ fallacy

* See Gottfredson (2009) for common misconceptions & logical fallacies about cognitive abilities.
What \textit{g} research \& theory can offer

Large body of evidence on:

- Core construct (\(g\): learning/reasoning ability)
- Predictor domain
- Task domain
- Criterion domain
- Causal relations among them
- Past mistakes \& persisting fallacies

Key sources:

- Research literatures in psychometrics, job analysis, school \& job performance, status attainment, behavior genetics, neuroscience (all represented in this room today)

Yet untapped, especially in health literacy

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A tremendous opportunity cost for patients and providers
Health literacy—its heritage lost?

Cognitive epidemiology next?
Work literacy: Military research in 1970s

“Literacy” is general
- not reading per se, but comprehension
- not content specific
- not modality specific

“Literacy” ≈ “trainability” = AFQT
- Can teach specific knowledge & skills
- Cannot teach “literacy”

Table 22

<table>
<thead>
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<th>Variable</th>
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<td>.12</td>
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<td>.01</td>
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<td>.11</td>
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<td>-.22</td>
<td>-.30</td>
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<td>.12</td>
<td>.11</td>
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aFor computing the correlations with race, Caucasian was assigned the code number of O. and Negro the code number of 1.
On “literacy”:

“Children and young adults have adequate abilities for basic tasks, but are poor problem solvers….Skills can be applied in isolation but not in combination” (p. 28).
National Adult Literacy Survey (NALS)—1990s
Subset of items = Health Adult Literacy Survey (HALS)

See also: Test of Functional Health Literacy in Adults (TOFHLA)

Literacy is not content specific:
• prose, quantitative, & document scales show same results—as if “in triplicate”

Literacy is a general ability:
• “complex information processing skills”
• “verbal comprehension & reasoning”
• “ability to understand, analyze, evaluate”
Literacy sometimes equated with reading ability, but reading ability develops *slowly* (NAEP)

Growth: 8 years older $\approx$ 80-point gain
Variation within age: Interquartile range $\approx$ 54
Achievement gap: White-Black $\approx$ 34
White-Hispanic $\approx$ 27
Health self-care as a job
Diabetes: Patients’ “job description”

- **Learn about diabetes in general** *(At “entry’)*
  - Physiological process
  - Interdependence of diet, exercise, meds
  - Symptoms & corrective action
  - Consequences of poor control

- **Apply knowledge to own case** *(Daily, Hourly)*
  - Implement appropriate regimen
  - Continuously monitor physical signs
  - Diagnose problems in timely manner
  - Adjust food, exercise, meds in timely and appropriate manner

- **Coordinate with relevant parties** *(Frequently)*
  - Negotiate changes in activities with family, friends, job
  - Enlist/capitalize on social support
  - Communicate status and needs to HCPs

- **Update knowledge & adjust regimen** *(Occasionally)*
  - When other chronic conditions or disabilities develop
  - When new treatments available
  - When life circumstances change
Good performance requires good judgment*

- **IT IS NOT** mechanically following a recipe
- **IT IS** keeping a complex system under control in often unpredictable circumstances
  - Coordinate a regimen having multiple interacting elements
  - Adjust parts as needed to maintain good control of system buffeted by many other factors
  - Anticipate lag time between (in)action and system response
  - Monitor advance “hidden” indicators (blood glucose) to prevent system veering badly out of control
  - Decide appropriate type and timing of corrective action if system veering off-track
  - Monitor/control other shocks to system (infection, emotional stress)
  - Coordinate regimen with other daily activities
  - Plan ahead (meals, meds, etc.)
    - For the expected
    - For the unexpected and unpredictable
  - Prioritize conflicting demands on time and behavior

* See Gottfredson (1997, 2006)
But little training or supervision

Apply “on the job”
• 24 hours/day
• 7 days/week

Adherence
Self-management

Clinic

Information

Communication

Training

Understand, learn

Not blank slate (misinfo)
Construct domains in job performance research

Predictor domain

Worker traits
- “can do”
- “will do”
- “have done”

Criterion domain

Job knowledges
- Procedural
- Declarative

Job performances
- Technical
- Citizenship

Utilities
- Worker
- Organization
IQ-job performance gradients*

Five “Deep Generalizations”
  - IQ/g enhances performance in all jobs
  - 4 moderators

Two “Muddlers”
  - 2 statistical artifacts

*Based on 90 years of personnel selection research (e.g., Schmidt & Hunter, 1998, 2004)
Causal model of job performance (typical job)*

Conscientiousness
(“will do”)

Experience

Knowledge

Performance

IQ/g
(“can do”)

Generalization: Validity generalization of IQ/g ($r_{g/\text{performance}} > 0$)

*For example, see Hunter (1986), Schmidt & Hunter (1998)
Causal model of job performance (typical job)

Conscientiousness
("will do")

Experience

Knowledge

Performance

IQ/g

Comprehend Reason

Name carbohydrates
Use glucose meter

Adherence
Self-management

Rewards
Health

Work context: Basic tools & training provided—simulates universal health care?

“Health literacy” today—construct lost?
IQ predicts performance in all jobs—but especially higher up

IQs of applicants for:
Attorney, Engineer
Teacher, Programmer
Secretary, Lab tech
Meter reader, Teller
Welder, Security guard
Packer, Custodian

Criterion validity (corrected)

Diabetes?
Two moderators: (1) criterion type and (2) task complexity

<table>
<thead>
<tr>
<th>Predictor domain*</th>
<th>Criterion domain*</th>
<th>Task domain</th>
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</thead>
<tbody>
<tr>
<td>g (IQ)</td>
<td>Technical</td>
<td>Simple to complex jobs</td>
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<td>S Non-g</td>
<td>Citizenship</td>
<td>Orderly Clerk Nurse Physician Diabetes?</td>
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</table>

*On structure of predictor & criterion domains, see Campbell (1990), Campbell & Knapp (2001)
Resulting clockwork-like patterns

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<tr>
<th>Predictor domain</th>
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<td>s</td>
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</table>

Disparate impact—race:
Two more moderators: (1) worker discretion allowed and (2) performance cumulative*.

IQ-performance correlation rises when individuals work more independently and outcomes are more cumulative in nature.

Conscientiousness

("will do")

Experience

Knowledge

Performance $ 

IQ/g

("can do")

Examples of increasingly cumulative outcomes:

- Quiz
- Course grade
- GPA
- blood sugar now
- A1c
- retinopathy

*Hunter (1986), Schmidt & Hunter (1992)
Two muddlers—Statistical artifacts  (VG research)

- Test unreliability  
- Sample restriction in range (predictors are highly sensitive to differences in context, task)

Tests’ range of discriminability (e.g., ceilings, floors) → Attenuates prediction

e.g., Mini Mental Status Exam

*The once-reigning theory in both intelligence and job performance fields that was disproved ~1970s by research using new factor-analytic & meta-analytic techniques (e.g., Schmidt & Hunter, 1998).
Structure of “intelligence” — and “literacy”?

- All mental tests measure mostly the same ability: $g$ (it is their common core)
- $g$ is ~content independent
- $g$ carries the freight of prediction
- More general abilities are more heritable & less manipulable
All mental tests measure mostly the same ability: $g$ (it is their common core)

- $g$ is \sim content independent
- $g$ carries the freight of prediction
- More general abilities are more heritable & less manipulable

NOTE: $g$ is unitary as a behavioral phenotype, but not physiologically
Recommendations for intervention I: Avoid past mistakes

The best **definitions** of health literacy will recognize that:
- It is an extremely complex construct
- It is not an attribute of the individual, but the intersection of individuals with environments

The best **measures** of health literacy will:
- Be specific to health, not general
- Cover all relevant knowledge and skills

The best **interventions** for low health literacy will:
- Create a more health-literate population
- Reduce group disparities

Think general: "Definitions" fallacy
Confuses ability and achievement
Think simple (NVS, UD): False “specificity theory”
“Marbles” fallacy
Think error reduction: But little generalization
But SD expands when mean rises
Recommendations for interventions II: Identify & reduce sources of patient error

Can’t change g level, but can use g theory to manipulate worker-job interface to reduce rates of patient error:

1. Worker side—import tools
   - Train providers in individual differences
   - Train patients using learning principles (educ psych)

2. Job side—develop tools (explained shortly)
Points of leverage for error reduction

Worker traits
- “can do”
- “will do”
- “have done”

1. Assess (not change)

Job knowledges
- Procedural
- Declarative

3. Train

Job performances
- Technical
- Citizenship

4. Monitor

Utilities
- Worker
- Organization

2. Focus on critical errors
Error model (human factors approach)

Error

- A cognitive mistake (á la psychometric)
- Commission or omission
- “We all make mistakes”

Ask: What increases error rates in patients’ self-care?

- Patient side
  - Weaker g
  - Weaker KSAs (knowledge, skills & abilities)
  - Impaired deployment of KSAs (e.g., stress, illness)
- Task demand side
  - More complex
Need epidemiology of patient error

1. Cognitive susceptibility (patient’s g level)

2. Cognitive hazards (task’s g loading)

3. Error rates (non-adherence)
   - rise at lower IQ
   - rise with greater complexity
Matrix of cognitive risk (patient error rates on tasks)

Can predict error rates if we know:

Distribution of g in groups of patients:
- race
- age
- locale

Distribution of g loadings in sets of tasks:
- preventive care
- chronic diseases

Some errors more dangerous
But all cumulate

Triage

Task complexity
Error rates increase with age

- fluid g down
- “jobs” more complex (morbidity up)

Average profile only

Basic cultural knowledge ($G_C$)

Basic information processing ($G_F$)
Instructional needs differ by IQ level (adults)

- **IQ 70**
  - Slow, simple, concrete, one-on-one instruction
  - Written materials & experience

- **IQ 110**
  - Mastery learning, hands-on
  - Can gather, infer information on own

- **IQ 120**
  - Learns well in college format

- **IQ 130**
  - Very explicit, structured, hands-on

**NALS level**
- IQ 70: NALS level 1
- IQ 80: NALS level 2
- IQ 90: NALS level 3
- IQ 100: NALS level 4
- IQ 110: NALS level 5
Distribution of your clinic population?

Instructional needs differ by IQ level (adults)

- IQ 70 - 80: Slow, simple, concrete, one-on-one instruction
- IQ 90: Mastery learning, hands-on
- IQ 100 - 110: Very explicit, structured, hands-on
- IQ 120 - 130: Learns well in college format
- IQ 130: Can gather, infer information on own

Written materials & experience

- Black: IQ MR (retarded)
- White: IQ MG (gifted)

IQ NALS level

- IQ 70: NALS level 1
- IQ 80 - 90: NALS level 2
- IQ 90 - 100: NALS level 3
- IQ 100 - 120: NALS level 4
- IQ 120 - 130: NALS level 5
Distribution of cognitive hazards?

Easy is unlikely—broad range is more likely

Medical advances increase complexity

<table>
<thead>
<tr>
<th>IQ</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
<th>130</th>
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<td>NALS level</td>
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<td>2</td>
<td>3</td>
<td>4</td>
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</tr>
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</table>

MR (retarded) → MG (gifted)
Distribution of cognitive hazards?

Aging lowers our ability to deal with them

Raw mental power (scores not age-normed)
Distribution of cognitive hurdles?

Some complexity unnecessary, but much inherent

1 | 2 | 3 | 4 | 5
---|---|---|---|---
IQ  | 70 | 80 | 90 | 100 | 110 | 120 | 130
NALS level  | 1 | 2 | 3 | 4 | 5
Interventions in job complexity: Develop tools

1. Identify distribution of cognitive hurdles
   - Identify/classify building blocks of complexity
     - Elements of tasks (cognitive task analysis—*functional* level)
     - Constellations of tasks (cognitive job analysis—SMEs, focus groups)
     - Scoring system
   - Estimate expected error rates/task (human factors analysis)
   - Estimate error criticalities (critical incidents analysis, SMEs, focus groups)
Common building blocks of job complexity?

- **Individual tasks**
  - Abstract, unseen processes; cause-effect relations
  - Incomplete or conflicting information; much information to integrate; relevance unclear
  - Inferences required; operations not specified
  - Ambiguous, uncertain, unpredictable conditions
  - Distracting information or events
  - Problem not obvious, feedback ambiguous, standards change

- **Task constellation** *(Often neglected, even in job analyses)*
  - Multi-tasking, prioritizing
  - Sequencing, timing, coordinating
  - Evolving mix of tasks
  - Little supervision; need for independent judgment
1. **Identify distribution of cognitive hurdles**
   - Identify/classify building blocks of complexity
     - Elements of tasks (cognitive task analysis—*functional* level)
     - Constellations of tasks (cognitive job analysis—MSEs, focus groups)
   - Estimate expected error rates/task (human factors analysis)
   - Estimate error criticalities (*critical incidents analysis*, SMEs, focus groups)

2. **Where possible, eliminate/lower hurdles**
   - Focus on essentials
   - Then simplify

3. **Train, contingent on *g* stratum of patients:**
   - Narrow task domain (*triage*, job stripping)
   - Individualize training (more scaffolding)
   - Increase supervision (monitoring, feedback)
Complexity of self-management: The neglected lever in health care

Patient error rates (non-adherence) increase when:
- Tasks are more complex
- Constellations of tasks (e.g., the “job” of diabetes) are large, diverse, ambiguous, poorly organized, unsupervised, etc.

Patient error increases morbidity, mortality, & costs
But we know virtually nothing about task-based patterns of cognitive error
- How much, and why, do self-care tasks differ in complexity level (cognitive risk)?
- How are these risks are sequenced across days, weeks, years?
  - In preventing illness & injury
  - In managing illness & injury
- What are the likely points of preventable cognitive overload & critical error?

Cognitive analyses of self-care “jobs” could yield large returns via
- Better “job” design
- Better “job” training
- Better supervision
Preview of cognitive demands in job training for diabetes

Bloom's taxonomy of educational objectives (cognitive domain)

**Simplest tasks**

1. **Remember**
   - recognize, recall, Identify, retrieve

2. **Understand**
   - paraphrase, summarize, compare, predict, infer,

3. **Apply**
   - execute familiar task,, apply procedure to unfamiliar task

4. **Analyze**
   - distinguish, focus, select, integrate, coordinate

5. **Evaluate**
   - check, monitor, detect inconsistencies, judge effectiveness

6. **Create**
   - hypothesize, plan, invent, devise, design

**Most complex tasks**

- Anticipate effect of various exercise on blood sugar
- Coordinate meds, diet, and exercise in timely & appropriate manner
- Determine when & why blood sugar tends to veer out of control
- Monitor signs; assess whether need to act, impact of actions, & how effective they were
- Create lifestyle and contingency plans that minimize swings in blood sugar
- Recall effects of exercise on sugar
- “Diabetes 101”

Citations

Thank you.

For more information:

- gottfred@udel.edu
- http://www.udel.edu/educ/gottfredson/reprints/