Cognitive Neuroscience for Literacy:

Some provocative viewpoints

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Are you wondering what to do about adult literacy?

Are you worried about the perennially low budgets and low priority?

Do you think something is missing from the explanations about adult literacy?

This presentation will offer some little-known pieces of the puzzle

Caution: Counterintuitive content ahead!
Science has implications for all topics of this conference

Efficient literacy programs:
- teaching letter by letter, attend to visual issues
- Attainment of automaticity

New emergent contents of life skills:
- automatizing low-level chains

Reducing poverty under lifelong learning through CLC
- How the poor make decisions at base of pyramid business
Two important problems underlying adult literacy instruction

Adults face some difficulties in becoming fluent readers
The prevailing teaching philosophies do not help them overcome difficulties

Have you learned a new SCRIPT in adulthood?
The most important concepts that rule our learning are beyond our consciousness

Working memory
(short term memory)
Need to acquire fluency, automaticity
Working memory capacity
Message must be read fast to be understood!

- About 7 items
- 4 pictures
- 12 seconds at most

Cognitive networks

Long-term memory

125 gigs
semantic memory!
Implication of working memory:
Fluency must be the goal of all training

Practice shortens reaction time, we do things without much attention:
- Reading
- Math calculations
- Vocationally related skills, computer operation
- Making good decisions within a few seconds

Time, materials, homework must be used to bring about fluency

How is fluency acquired?
Practice chunks items into pieces for working memory
start small
big chunks require more practice
Analogies facilitate chunking: systematically pair consonants with vowels

<table>
<thead>
<tr>
<th>a e i o u</th>
<th>Letter</th>
<th>Fatha</th>
<th>Qasra</th>
<th>Dhamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>B ba be bi bo bu</td>
<td>Ö Öö öÖ Öö</td>
<td></td>
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<tr>
<td>C ca ce ci co cu</td>
<td>Ö Öö öÖ Öö</td>
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<td>D da de de do du</td>
<td>Ö Öö öÖ Öö</td>
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<td>F fa fe fi fo fu</td>
<td>Ö Öö öÖ Öö</td>
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<td>G ga ge gi go gu</td>
<td>Ö Öö öÖ Öö</td>
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<td></td>
</tr>
<tr>
<td>H ha he hi ho hu</td>
<td>Ö Öö öÖ Öö</td>
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<td>Etc</td>
<td>cte</td>
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</tbody>
</table>
Implications of chunking principle in memory

Start with small bites for better digestion!
In reading, teach single letters at a time
  Join with previous letters
Teach analogies
  People are attuned to pattern detection
To learn new procedures:
  Practice the small chains that make them up
Memorize mental math as basis for more complex calculations
Some bad news….

Some brain circuits related to perception and movement have a “sensitive” period (critical period)

Automaticity of certain tasks may become harder after certain ages
Automatic reading in adulthood is impacted

An integration circuit may be responsible
Adults may take longer to learn new skills involving certain low-level circuits.
The edifice of knowledge when built on top of low-level skills that have sensitive periods

Examples:
chains of movements that must be automatized:
Musical instruments, some athletic skills, typing.
Language from environment, some visual memory aspects, probably high-speed reading.

Skill with sensitive period

Age

decline

Leveled off
After a “sensitive” period ends, learning takes more effort

Children are ‘data sponges’, fast pattern recognition, rote learning, extract trends from large noisy datasets

Adults need explicit rules, more feedback
Early reading consists of low-level neurological skills

To learn reading we need:
To perceive letters within milliseconds, identify them, discriminate them from others.

• Enough language knowledge to match letters and sounds
• A sense of where words start and end (phonological awareness)
• A good enough short-term memory to keep the message that has been read
Cognitive neuroscience guides us to more efficient instruction

• The basic process of learning to read is fairly clear
• There are crucial neglected variables
  – Letters must be large and optimally spaced
  – Need to be taught in small pieces, one by one
  – Speed must build up for comprehension
• cut them into bits
• Blow them up
• speed them up!
• Get tons of practice
As taught usually, neoliterates read haltingly
May misread letters
Read one letter, make up an irrelevant word
may not understand what they read
may lapse back into illiteracy
    the youngest or the brightest ones learn

Children who are not dyslexic need 3-4 months for decoding
    ‘shallow’ orthographies.
instantly recognize many words by the end of grade 1
Adults may need three (?) times longer
Why the modest literacy outcomes?

Literacy methods have relied on the perception of automatic readers

We are automatized, “brainwashed” readers

We overestimate what literacy participants see
Critical spacing:
How to write letters for beginning readers?
24 point font double spaced, 3 spaces

Once upon a time there was a land with a good king named Midas

Efficient books maximize space for reading practice 5000 words in grade 1?
Letters are often small and illegible, new learners cannot learn to distinguish them.

Experienced readers write in small calligraphy, not easily read.
Instead use big letters
the back rows must distinguish them
Burkina Faso 2000
As a result of visual issues and ambitious pacing, learners may be getting much less reading practice than we think!

And not learning letter values
The Arabic script can greatly benefit from spacing and larger size

هَيَّا َأَحْسَنْ نَصَّنَعْ طُوِّبَاً
هَشَوِيّاً اَحْسَنْ نَصَّنَعْ طُوِّبَاً

More legible font for beginner textbooks – lines between letters rise higher

Arial Unicode MS

النظير لا مير اشا فتي

بولد جميع الناس أحراراً متساوين في الكرامة والحقوق. وقد وُهبوا عقولاً وضميراً وعليهم أن يعامل بعضهم ببعضًا بروح الإخاء.
Contrasts potentially confusable letters

Dudak - durak

Variance between print and handwriting can mislead beginners
Moroccan literacy book, 2005
Small fonts for the low letters, potential crowding for neoliterates
Many complex shapes taught at once
Imagine that you are an illiterate and your script looks like this..
Captivating learners with useful material on day 1, but method teaches 5 syllabic letters!
Page 1 of the Nepalese Naya Goreto used for about 20 years

Freirean philosophy

Kaam = work

But are the letters memorable for this reason?
Naya Goreto day 2
“water”
Difficult methods for teaching adult literacy

REFLECT – whole language approach

Important for group dynamics
groups often “decide” they don’t want literacy

Yo si puedo – Cuba

Short, sparse text, multiple letters to words
Pairs letters with numbers, irrelevant words
Political appeal
Textbooks of Wolof, Gambia

Textbook 1984

Textbook 2010

Ndaje 1

Arafi ngalaw yi

A E É Ê I O Ó U
A e é ê i o ó u

A Ami e et é éen

ë ëkka o os

i indé

ó òom

u uppukaay

laa la aal al
laa mala laal alal

laala laam am mala mala alal la alal la laala am.
Synthetic phonics are simpler visual patterns
See both in this Senegalese adult education book
Gambia readers developed on this basis

Jola fony adult literacy, Summer Institute of Linguistics, Senegal
Reading letter by letter can’t allow the processing of much text

If humans only read letter by letter, however fast, they would be unable to read much text.

To read volumes, a different function is needed

With practice, a part in the brain takes over that is involved in face recognition

To read fluently and effortlessly, this must be sufficiently activated
Automaticity:
Reading words as if they were faces!
When people become fluent, a special area in the brain gets activated called visual word form: fusiform gyrus, occipitotemporal gyrus. It recognizes faces!!

3 primary reading areas in the brain:
2 for single letters, slow reading
1 for automatic reading

All 3 are used simultaneously

Instructional goal: by the end of the literacy course, this brain area should get sufficiently activated
Automaticity! Fluency!
A miracle state
When the ‘face recognition’ mode of reading gets activated
The brain identifies entire words while seeing single letters as well
As if you saw a face and its features at the same time
Words, letters are recognized within milliseconds
Distortions ok up to a point, just face recognition
Speed easily rises to 200+ words per minute
People can’t help but read
Pay attention to message rather than the print
Automatized reading is not normally forgotten
Neoliterate adults show less activation of the visual word form (Dehaene and Cohen 2010)
Adults learning to read seem to have difficulty attaining automaticity.

The brain “prunes” unneeded circuits at various times until maturity, "critical" periods for acquiring low-level visual and motor skills.

Problem seems to be in integration of visual features, ventral channel.

Issue not well researched.

We may all become dyslexic as adults!
Examples of perceiving components

Devanagari

Ba e
b M h
Q d

• Arabic

ح خ ج
Letter by letter readers:
just see jumbles of letters
make mistakes

Working memory filled with letters
The good students study many hours
Los cinco burros

Don Tomás compró cuatro burros. Montó en uno y volvió a su casa.

Por el camino los contó: uno, dos y tres. No contaba el que montaba.

Ya en su casa dijo a su mujer:
-Mira, he comprado cuatro burros y traigo sólo tres. Me han robado uno.

-¡Qué raro! -dijo la mujer-.
Tu no ves más que tres, pero yo veo cinco.
Learners in Indonesia - 2006

Do these learners understand what they read?
Best learner vs. Infrequent reader, who learned in childhood Bangladesh literacy program 1994

Bangladesh 1993-94
A halting Greek adult vs. a fluent childhood reader
But how much teaching and practice do adults really get?

Class cancellations

Teacher absenteeism
  Late arrivals, early departures

Student absenteeism
  Dropout and re-enrollment

Limited engagement in reading practice in class
  Learners may only spend a few minutes practicing every hour!
Goal of literacy courses should be

To make learners attain a speed of a word per second

60 words per minute (45 at least)

Read a sentence within the limits of their working memory

Comprehend it

Thus they may feel encouraged

Keep reading rather than abandon it

Even without full automaticity, people can make fast letter-by-letter decisions and process rather brief texts
Practice:
Rapid reading of small units
What methods help illiterates more efficiently

Huge emphasis on spacing, size
Use “extreme phonics”, 1 letter at a time
analogies
Use time well – practice in pairs rather than whole class
Explain utility early on
Increase instructional hours to 3-4 times the current levels
Ask the adults which letters they confuse, how they would want to see them
Research on improving contrast sensitivity of the optics of the eye can change through action video games (Green...
Improving contrast sensitivity
visual discrimination

inexpensive computers, e.g. $100 computer

Running well thought literacy software

Action videos: medal of honor, unreal tournament, call of duty

(Daphne Bavalier)
Contrast sensitivity improvement after videogame training
(Bavalier et al.)
Example: Minute Visual Discrimination
How fast can you find all the Js?

FNTLTLTLTLTLIIIIIIITITLTIFITLILK
TKLILTRILLTLILJLFLFLILILI
ILTITLIJILTLHILITIHLTLILJLTIHIT
LINNTLLILNELILITJI
Action game play: unprecedented transfer of learning
Could it help with automaticity acquisition and other neurological issues of adult illiterates?

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**Claim 2: Changing Cognition**

- Multi-tasking (Green and Bavelier, 2006, JEP)
- Task Switching (Sugarman, Green and Bavelier, in prep.)
- Approximate Mathematics (ongoing; with J. Halberda)
- Statistical Language Learning (ongoing; with R. Aslin, E. Newport and P. Reeder)
- General Fluid Intelligence (ongoing)

D. Bavalier, Sept. 24 2011
Strobe Eyewear Training Improves Visual Memory

Importance of neurocognitive variables!
Videos of same-language subtitling
How to measure literacy?
In words per minute
45-60 wpm likely sufficient activation
Relationship between reading and comprehension

Early Grade Reading Assessment
RTI data
Example from Ghana

Students respond on average to 80%
Correct questions at 53-60 words per min
Much more research is needed

More on visual word form activation for adult learners
How to increase instructional time
How often to present letters, what to do
Means to increase exposure
  - Stare for a long time, see instantly for 3000 trials
  - Action videogames
  - Some of this transmitted through cellphones
Training teachers effectively through
Neurocognitive research is little known among adult educators
Adult education departments don’t teach it
It’s viewed as controversial
Some professors teach the exact opposite philosophies
Young students graduate with outdated knowledge
How to introduce more cognitive science to adult literacy and lifelong learning?

To get more funding and attention, better efficiency is imperative
Modest outcomes create a vicious circle

3-5% of World Bank education budget for literacy in 2001, almost no literacy being financed at this time

Governments and aid agencies - 1.5% of government budgets

Yet, there is a need for courses that are 3-4 times longer than currently

Would cost 3-4 times
If Paulo Freire were alive, what would he say?

Would he take up the science?

We can do much better than the 1970s or 80s

Adult literacy can become viable
Thank you for listening!

What are your thoughts?
Extra slides
Lifelong learning requires ability to learn new skills efficiently

The **good news** from cognitive neuroscience:

Brain plasticity is a fact
- we make new neurons even into old age
- may learn later what we did not learn earlier

The **bad news** from cognitive neuroscience:
What could adults learn easily?

Topics involving higher-order thinking
Topics involving transfer of learning from existing skills
  
  Transfer happens rather rarely, specifically

New languages – through the higher-order route

Execution speed may be lower than skills learned in earlier ages
What would adults learn less easily?

Skills built on motor or perceptual skills with sensitive periods

They drag down higher-level chains

Ex. Imagine learning to type at age 50

How easily will you be able to touch-type a book?

Learning to read music and play the piano

Thinking counts more rather than actual movements

Flying airplane, driving car, etc?

Multiple fast automatic movements in long sequences

Learning complex math?

Unknown

How does the Weber fraction develop in adulthood, sensitivity to symmetry?

Mechanical skills, rotating objects mentally?

Unknown
Conclusions

How could we enhance the efficiency and effectiveness of literacy programmes in terms of learning retention?

2. How could we effectively advocate on literacy and lifelong learning?

3. What kinds of learning contents could be useful and needed for 21st century and how about the delivery system?

4. What are new potentials of Community Learning Centers by looking into social entrepreneurship, BoP business and reasonable technology advancement/ availability?
Problem: How to increase funding and attention to adult literacy?
EFA Goal of a 50% reduction in adult illiteracy by 2015 unmet
2009 GRALE – no data, outcomes unclear
The limited outcomes create a vicious circle of ever-lower budgets.

Few activities, mainly CONFINTEA

New and effective ideas urgently needed!
Phonological awareness

Insight that words are made up of large sounds (syllables: tha –la, gaan) and tiny sounds (phonemes: th-a-l-a, g-aa-n).

Word segmentation exercises

Strong phonological skills make it easier time to learn reading and spelling
In some languages “tonological awareness” is needed

Many East Asian and African languages are tonal

Textbooks of tonal languages must mark them
Some African languages don’t and students have problems
  e.g. Hausa, Mandinka, Moore

Lao – Thai tone marking from sanskrit numbers
Direct student attention to the letter taught maximize long-term potentiation

To combat the usual mindless verbal repetition, use:
- Very few words
- Pointing gestures that learners learn
  - Point: “look at this letter”
  - People told to point as they repeat
  - Thumbs up if you understand, fist closed if you did not

Then: I do, we do, you do
Reading legal nonsense words
Aim of instructional activities

The goal is to reduce reaction time to letters down to a few milliseconds
Until the visual word form is sufficiently activated.
Students probably read 45-60 words per minute when activation is sufficient