On literacy learning: some old and some new constructs

Sonali Nag

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Abstract

Akshara is the symbol unit used in the writing of several Indian languages. Sister disciplines—psychology, education, psycholinguistics, historical linguistics, neuroscience and sociology—each hold promise in unravelling how children become literate in languages that use the akshara. Culturally-embedded constructs like shabda, artha, maatraa and sandhi are core to theorising about akshara-based reading and writing development. But these words hide more than they reveal about the journey from being a novice to an expert in the akshara-based languages. In this talk I draw upon recent work in language, literacy and learning to explore the mechanisms that underpin growing skill and knowledge. I will show how being global, analytic and strategic are all useful. Along the way, the presentation may find resonance with those who wish to introspect about the ebb and flow of constructs in Cognitive Science.

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Brahmi ancestry

Brahmi sample words based on Mauryan edicts from around 250 BCE.

The logic of the Brahmi:
A segmental transcription system organised in symbol blocks

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The symbol blocks are called *akshara*

Individual orthographies in the Indic family are distinct in appearance whilst sharing core principles of architecture and representation.

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Architecture, cognitive-linguistic processes, implications for theorising about writing systems

But first a little detour to familiarise ourselves with the context ....
Reading acquisition processes straddle two systems

- the orthographic system
  - the symbol repertoire
  - the mapping principles

- the linguistic system
  - phonological representations
  - lexical identities
  - meta-linguistic skills

Example of alphabetic English:

bird
Reading acquisition processes straddle two systems

• Akshara knowledge: more than list knowledge

• Oral Language: more than just vocabulary

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Akshara-based research has far reaching social significance

• 150 million learners in primary school age population of South Asia alone (UNESCO, 2014)

Southeast Asia
Older learners
The diaspora
The interested

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Architecture, cognitive-linguistic processes, implications for theorising about writing systems

The writing system

Acquisition and development

Model building

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### Extensive Orthography

The writing system: singleton akshara

<table>
<thead>
<tr>
<th>Primary forms of vowels</th>
<th>अ आ ई इ उ ऊ</th>
</tr>
</thead>
<tbody>
<tr>
<td>/a/ /aa/ /i/ /ii/ /u/ /uu/</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary forms of consonants with the inherent vowel (Ca)</th>
<th>क ख त र ध</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ka/ /kha/ /ta/ /ra/ /da/</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consonant with ligature vowel (CV)</th>
<th>का कि की कु कू</th>
</tr>
</thead>
<tbody>
<tr>
<td>/kaa/ /ki/ /kii/ /ku/ /kuu/</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consonants with inherent vowel (CCa, CCCa)</th>
<th>स्पृ क्ष स्थ त्य</th>
</tr>
</thead>
<tbody>
<tr>
<td>/spa/ /ksha/ /shta/ /tya/</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consonants with ligature vowel (CCV, CCCV)</th>
<th>ककु ख्या र्यी द्या</th>
</tr>
</thead>
<tbody>
<tr>
<td>/kku/ /khyaa/ /strii/ /ddhaa/</td>
<td></td>
</tr>
</tbody>
</table>
Architectural features of surface organisation

Primary & secondary form

Mixed granularity

The writing system: singleton akshara

Ligaturing and non-linearities

̄ू + ू = ू

• Bengali: ̄+ ू = ू
• Hindi: ̄ + ू = ू
• Gurmukhi: ̄ + ू = ू
• Kannada: ̄ + ू = ू
• Sinhala: ̄ + ू = ू
### Characteristics of the akshara writing system

<table>
<thead>
<tr>
<th>Obvious and visible</th>
<th>Implications for learning to read</th>
</tr>
</thead>
<tbody>
<tr>
<td>An akshara can represent consonants, vowels, consonant-vowel pairs and consonant clusters with vowels.</td>
<td>Many symbols have to be recognized.</td>
</tr>
<tr>
<td>Most akshara are constructed by joining individual markers. One important exception is the inherent vowel, which has no marker.</td>
<td>Since symbols are constructed using systematic combinatorial rules, it is efficient to quickly learn these rules.</td>
</tr>
<tr>
<td>Individual markers have a designated place in the akshara. The location may be non-linear but this location is almost entirely predictable.</td>
<td></td>
</tr>
</tbody>
</table>

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Orthographic syllable vs. Phonological syllable

<table>
<thead>
<tr>
<th>Word</th>
<th>Phonological syllable</th>
<th>Orthographic syllable</th>
</tr>
</thead>
<tbody>
<tr>
<td>halva</td>
<td>hal.va</td>
<td>ha.lva</td>
</tr>
<tr>
<td>(a sweetmeat)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mapping of orthographic syllable to phonological syllable:

ha = body of syllable 1, lva = coda of syllable 1 + syllable 2
The inherent vowel & schwa deletion

/пикник/ not /пиканика/

/CVCCV/ sequences written as <CVCaCV>
The writing system: akshara in context

Examples
(a², ma², mā², kla², m¹)

In Bengali
ā², m², mā², kla², m¹

In Hindi
ā², m², mā², kla², m¹

In Kannada
න², ಮೆ, ಮಾನೆ, ಕಲೆ, ಮೊೆ

In Tamil
நு, மம, மா, --, மெ

Spoken Units
1. Phoneme
2. Syllable
3. Morpheme
4. Body
5. Coda
6. Coda-Body
7. Coda-Open Syllable

Examples
(Education for All)

In Bengali
অর শিক্ষা
<sa ṛva > <shi kshā >

In Hindi
सर्व शिक्षा
<sa ṛva > <shi kshā >

In Kannada
ಸರ್ವ ಶಿಕ್ಷಾ
<sa ṛva > <shi kshā Na >

In Tamil
அதலாள்சூழ்சி
<a nai va ru .k.ku .m > <ka .l.vi >

Note: For each orthographic example the level of mapping to language is shown in superscript.
I used to write it as शरदचंद्र, which is the common way in Maharashtra. Then I saw a house named शरचंद्र and wondered about it. Then my father pointed out to me that since the name is a sandhi of two nouns: शरत् + चंद्र, then it has to become (using Sanskrit sandhi rules, which also apply to sanskrit-derived words in Marathi I suppose) शरचंद्र (akin to how Shivaji's mudra says प्रतिपचंद्र लेखेव वर्धिष्णु ...).

Whereas (he said) if we use शरत् in standalone mode as a name, then the त् becomes a द (sanskrit again).

that is when I changed my full name spelling to शरचंद्र ....
<table>
<thead>
<tr>
<th>Characteristics of the akshara writing system</th>
<th>Implications for learning to read</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Less obvious and less visible</strong></td>
<td></td>
</tr>
<tr>
<td>1. A consonant that comes after a vowel becomes a new akshara.</td>
<td>Visual word recognition sometimes requires more than straightforward sound-symbol decoding.</td>
</tr>
<tr>
<td>2. The akshara within words map to phonology at different levels.</td>
<td>Since linguistic rules underpin the written word form, it is efficient to widen <strong>lexical knowledge</strong>.</td>
</tr>
<tr>
<td>3. If there is more than one way of re-syllabification, the one to use for a specific word will depend on linguistic rules (e.g., rules about etymology of loan words, legal endings of words, and syllable weight).</td>
<td></td>
</tr>
</tbody>
</table>
The akshara systems must be characterised within a multi-dimensional space.

<table>
<thead>
<tr>
<th>Language</th>
<th>Non-linear arrangements</th>
<th>Re-syllabification of /CVC.CV/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>on CVs</td>
<td>on CCVs</td>
</tr>
<tr>
<td>Bengali</td>
<td>common</td>
<td>common</td>
</tr>
<tr>
<td>Hindi</td>
<td>common</td>
<td>common</td>
</tr>
<tr>
<td>Gujarati</td>
<td>common</td>
<td>common</td>
</tr>
<tr>
<td>Kannada</td>
<td>common</td>
<td>common</td>
</tr>
<tr>
<td>Malayalam</td>
<td>common</td>
<td>common</td>
</tr>
</tbody>
</table>

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The Indic alphasyllabaries

architecture, cognitive-linguistic processes,
implications for theorising about writing systems

The writing system

Acquisition and development

Model building

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The rest of the presentation will focus on symbol learning and single word learning. Time does not permit including a discussion about text level processes.
The phases of Kannada *akshara* knowledge acquisition

- Grade 1: त (T)
- Grade 2: की (Ki)
- Grade 3: धू (Dhu)
- Grade 4: त्य (Ty)

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Not everything is taught

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>Akshara Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implicitly learnt</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Explicitly taught</td>
<td>12</td>
<td>28</td>
</tr>
</tbody>
</table>

based on corpus analysis by Patel, Bapi & Nag, 2013
Factors that may influence symbol learning

Symbol characteristics
- Frequency,
- Acroponicity, consistency
- Visual features, Visuo-motor demands

Child characteristics
- analysing the symbols (visual)
- phonological resources (phonological)
- ‘naming’ the symbols (mapping)
- broader language (e.g. vocabulary)

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Symbol learning: the case of Kannada

What do we know?

• Some symbols are learnt faster than others
• Some segments in a symbol is more prone to spelling errors
Symbol recognition

Visual complexity [pixel count]

Visuo-motor complexity [number of confusible points]

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Associations between symbol characteristics

<table>
<thead>
<tr>
<th></th>
<th>Visual Complexity</th>
<th>Visuo-motor Complexity</th>
<th>Phon. Confusability</th>
<th>Symbol Frequency</th>
<th>t1 Symbol Recognition</th>
<th>t2 Symbol Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Complexity</td>
<td>.711 (.000)</td>
<td>.610 (.004)</td>
<td>.254 (.280)</td>
<td>-.437 (.054)</td>
<td>-.630 (.003)</td>
<td>-.637 (.003)</td>
</tr>
<tr>
<td>Visuo-motor Complexity</td>
<td></td>
<td></td>
<td></td>
<td>-.453 (.045)</td>
<td>.598 (.005)</td>
<td>.585 (.007)</td>
</tr>
<tr>
<td>Phonological Confusability</td>
<td></td>
<td></td>
<td>-.160 (.500)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbol Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.829 (.000)</td>
<td>.834 (.000)</td>
</tr>
</tbody>
</table>

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### Cognitive Bases of Visual Word Recognition

<table>
<thead>
<tr>
<th>Cognitive Bases</th>
<th>Reading accuracy</th>
<th>Fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td>akshara knowledge</td>
<td>✓✓</td>
<td>✓</td>
</tr>
<tr>
<td>syllable awareness</td>
<td>✓✓✓</td>
<td>ns</td>
</tr>
<tr>
<td>phoneme awareness</td>
<td>✓✓✓</td>
<td>✓</td>
</tr>
<tr>
<td>RAN</td>
<td>✓✓</td>
<td></td>
</tr>
<tr>
<td>phonological memory</td>
<td>✓</td>
<td>NA</td>
</tr>
<tr>
<td>oral language</td>
<td>✓✓</td>
<td>NA</td>
</tr>
</tbody>
</table>

L1: Bengali, Hindi, Kannada, Marathi, Gujarati, Tamil, Telugu, Thai, Sinhala;  
L2

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Word reading
when there is ambiguity in akshara-syllable mapping

/ piknik / not / pikanika /  
/ thukte / not / thukate /

/CVCCV/ sequences written as <CVCaCV>
Nonword reading (Grades 2 - 4):

**DaTakA**

*maTka* ‘pot’, *paTka* ‘firecrackers’

*jhaTka* ‘a bolt’

**piraShA**

*DhArana* ‘assumption’, *prerana* ‘inspiration’, *ShiranA* ‘title’

Skilled readers: /datk:a/ /piraʃa: /
Less skilled: faithful to orthographic information

Potentially influential factors in the processing of akshara-syllable mappings:
phonological analogies, frequency and phonotactics

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Setting up the reading system

Appears to entail (at least) three layers:

– The surface forms
– The rules for encoding segmental transcription into symbol blocks
– The apparent oddities
  • schwa deletion
  • coda representation
### Dyslexia as a Language Deficit (Phonology)

- Difficulties with syllable level processing
- Difficulties with phoneme level processing
- Difficulties with morpho-phonological boundaries in multimorphemic words

### Dyslexia as a Mapping Problem (Learning)

- Slow pace of akshara learning
- Poor spelling particularly when phonology-akshara mapping is ambiguous
- Deficits in Rapid Automatized Naming (RAN)
The Indic alphasyllabaries

architecture, cognitive-linguistic processes,
implications for theorising about writing systems

The writing system
Symbol, words, sentences
Model building

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The Extensive – Contained Continuum
(the orthographic breadth hypothesis)

(24 – 35 units)
Alphabet languages
(e.g., Arabic, Kiswahili, Spanish)

(400+ units)
Akshara languages
(e.g., Bengali, Hindi, Tamil)

(1200+ units)
Chinese
(e.g., Mandarin)

Contained orthographies

A conceptual framework to capture the basic idea that learning demands will differ depending on where along the continuum the orthography falls

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Nag, 2007; 2011; in press
Parameters to consider

• Visual information that must be attended to
  – Early stage perceptual processes
    • Visual feature density
    • Visual confusability

• Instances of complexity and confusability placing constraints on decoding
  – Role of semantic bootstrapping

• Weight of incidental learning to advance reading skills
Orthographic learning

• Use of intra-symbol cues

• Large symbol inventory

• Variability of akshara-phonology mapping
Phases of akshara learning

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Phases of akshara learning

• Evidence for analytic approaches
  – responses from phonological manipulations, spelling and reading errors
  - cost of symbol-internal details (non-linearity effects, signature neural network, instruction regime)

• Important to note that in this proposal
  – Transitions are not viewed as unidirectional
  – Early years appears to focus on global and analytic and later years on analytic and strategic
  – Global is not seen a primitive approach. Global can be efficient when automaticity is needed.

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Phases of akshara learning

• Mechanisms of influences
  – Insights when print differs from expectation
  – Use of analogies
  – Regularities (statistical learning paradigms)
  – Contextual processes (orthotactics, phonotactics, and morphophonology)

Item level insights and meta-linguistic awareness

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This presentation is based on three forthcoming book chapters


2. S. Nag, in *Learning to read Kannada and other languages of South Asia* in *Learning to Read across Languages and Writing Systems*, Ed. Ludo Verhoeven & Charles Perfetti. Cambridge University Press

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The children in the study
The school teachers and Heads
The families in the study
The research assistants

and

my collaborators

Thank you!

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