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Dyslexia: the temporal spatial disordering hypothesis and its metrical reflex

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Developmental Dyslexia

- Definition: I.Q.- performance discrepancy

  Failure to acquire age typical reading skills despite adequate intelligence, educational and socioeconomic possibilities

Indicators of Phonological deficit:

(1)rapid naming problems（RAN tasks),
(2)verbal short term memory difficulties,
(3)difficulties in spoonerism tasks

- Rapid Naming problems (RAN tasks)
  – 2, 5, 9, 3, 1, 6
- Verbal Short Term Memory
  Tegdep, retway, molup,
  ……?
- Spoonerism tasks
  – bat pin → pat bin

widely held view in the literature:

- deficit in the use and representation of phonological information (Shankweiler and Liberman 1976, Liberman and Shankweiler 1985, Rack et al. 1992, Goswami and Bryant 1990, and many others).
- The focus has been the notion of phonological awareness usually defined as the ability to identify and manipulate individual phonemes within words.

Phonemic awareness

- Haskins group in the late 1970's note:
  - There is a particular segmental level, the phonemic one, that seems critical to reading an alphabetic language
  - This unit (the phoneme) is particularly difficult for conscious access because it is obscured by coarticulation
- alphabetic principle: A grapheme is a meaningless symbol for a meaningless symbol (a sound). These sounds can be put together in hierarchical combination with other meaningless symbols (i.e., sounds) which constitute the subparticles of meaningful words.

Phonemic awareness is related to orthography

- Opaque orthography: English!
- Subjects with dyslexia do not have problems with phonemic awareness in languages with transparent orthography.
- Transparent orthography: Spanish, Italian, German, Dutch
- Transparent syllabary *Kana*: Japanese

Transparency of the Japanese syllabary: the Kana matrix

ん /N/	わ /wa/	ら /ɾa/	や /ya/	ま /ma/	は /ha/	な /na/	た /ta/	さ /sa/	か /ka/	あ /a/
		り /ɾi/		み /mi/	ひ /hi/	に /ni/	ち /çi/	し /ʃi/	き /ki/	い /i/
		る /ɾɯ/	ゆ /yɯ/	む /mɯ/	ふ /ɸɯ/	ぬ /nɯ/	つ /tˢɯ/	す /sɯ/	く /kɯ/	う /ɯ/
		れ /ɾe/		め /me/	へ /he/	ね /ne/	て /te/	せ /se/	け /ke/	え /e/
	を /wo/	ろ /ɾo/	よ /yo/	も /mo/	ほ /ho/	の /no/	と /to/	そ /so/	こ /ko/	お /o/

Suggestive data to the relevance of orthographical opacity vs. transparency

- English: 10-12%
  Japanese: 4% (cf.: Wydell 2005)

- In Japan dyslexia often surfaces to teachers' attention when a student starts learning English. (cf.:Oishi 2001)

Opacity of English orthography

- Especially vowel graphemes are unpredictable in their pronunciation (Treiman et al 1995, Kessler and Treiman 1997)

Transparency of German

Approximate one to one mapping between grapheme and phoneme

English (opaque) vs. German (transparent)

English graphemes	in words spelled	phonemes (IPA)
a	father, fat, staple	/ɑ/, /æ/, /eɪ/
e	bet, be, Bert	/ɛ/, /i/, /ə/
i	bird, pint, hint	/ə/, /aɪ/, /ɪ/
ou	should, shoulder, foul	/ʊ/, /oʊ/, /aʊ/

German graphemes	in words spelled	phonemes (IPA)
a	Vater, an, nah	/ɑ/, /ɑ/, /ɑ/
e	ersten, ecke, Knecht	/ɛ, ɛ/, /ɛ, ɛ/, /ɛ/
i	ich, finden Birgit	/ɪ/, /ɪ/, /ɪ, ɪ/
au	glauben, August, Traum	/aʊ/, /aʊ/, /aʊ/

English orthography as rime-based

- Pronunciation of the vowel grapheme is contextually influenced.
- VC as more predictable environment than CV; the coda provides more useful information than onset (statistical studies by Kessler & Treiman 1995, 1997)

ea → [ɛ] / _ d (bread, tread, head, dead,)
ea → [i] /_ p (heap, leap, cheap)

Rimes are important in reading English

- (cf.: Goswami 1999, 2001; Wise, Olson & Treiman 1990) Onset-rime segmentation of written words proved more helpful than postvowel segmentation in short-term learning of the words for beginning readers.
- ship/big → sh.ip/b.ig vs shi.p/bi.g

Our case study:
Tara (pseudonym), born in 1988

Demonstrated well above average language abilities in various diagnostic tests such as forward digit repetition, the Peabody Picture Vocabulary, IQ = 131, Boston Diagnostic Aphasic Examination

Had difficulties in learning to read , spell, and write.
Looked atypical on Rapid Naming Task.

Tara's Data: used either non-sense words, Latin words, or words not in her reading vocabulary; ensured no rote forms nor contextual clues available

Observation 1: The avoidance of coda

	presented word	Tara's pronunciation	process
1	regatleb	[ri.ˈgɑ.tɪ.lɛb]	epenthesis
2	bailesbud	[be.ˈlɪ.si.bəd]	epenthesis
3	besaubgant	[bi.ˈsɑ.bɪ.gænt	epenthesis
4	aipcid	[ˈe.pɪ.sɪd]	epenthesis
5	maudlin	[ˈmɑ.du.lɪn]	metathesis
6	leegtab	[le.ˈgɪ.tə.bə]	metathesis
7	weipgan	[ˈwi.pɪ.gæn]	metathesis
8	wepgad	[ˈwe.gæd]	deletion

Observation 2: The presence of complex onsets

	presented word	Tara's pronunciation	notes
1	feestary	[ˈfi.stə.nɑ.ri]	sC
2	reastal	[ˈri.stəl]	sC
3	toispar	[ˈtɔɪ.spɑr]	sC
4	roipsar	[ˈrɔɪ. spɑr]	(*ps* → *sp*)
5	braptor	[ˈbræ.pi.tər]	Cr
6	degatrab	[di.ˈgæ.træb]	Cr

Tara's atypical reading

Tara does *not* exploit the unit *rime*.

Tara *does* exploit a phonological unit: CV.

Tara overproduces CVs, via epenthesis, metathesis, or deletion.

We explore the etiology of this atypicality from the linguistic and cognitive point of view.

temporal spatial abilities affected by dyslexia

semantic difficulties

- Confusion of: before/after; above/below; right/left
- Ex: “Mommy, sit above the blanket.” (Meaning: “Mommy sit oriented to the other side of the blanket.” i.e., under the blanket)
- “above” used as a pure relational term.
- Tara reports confusion in understanding the meaning of instructions that state: Before X, Y; or: After X, Y. Specifically, she is unsure of which temporal sequence is intended.

auditory and motor rhythm awareness

- Thompson et al. (2006), Goswami et al (2002): Children and adults with developmental dyslexia have difficulties with auditory cues to speech rhythm and stress.
  - Both expressive and receptive abilities seem affected.
  - Also non-linguistic areas affected such as :
    - manual tapping to a metronome
    - perception of amplitude modulating tones as having a beat or not.

- Rhythmic periodicity in speech related to the onset of vowels in stressed syllables (P-center cue).

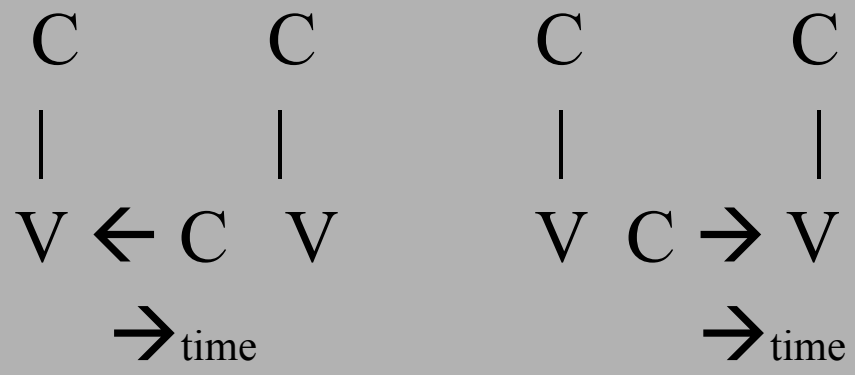
- Researchers suggest that this affects the ability to gain access to segmental organization within syllables.

Metrical correlate

- the overproduction of CV units is the reflex of a problem with the temporal-spatial ordering of salient items (vowels) versus non-salient items (consonants).
- Onset as co-articulation on vowel (cf. Goldstein and co. as developed by Vergnaud)
- Cf. also Katada (1990) for evidence that onsets form a tight unit with a following vowel (in Japanese mora based system)

- C
  |
  V
- Therefore, the ordering of CV is essentially for free.

- Coda, a nonsalient item which is not a co-articulation of the vowel, cannot as easily be integrated into the syllable and requires a temporal-spatial ordering decision

- 

- A solution where Tara can avoid any temporal-spatial ordering decision is to interpret a potential coda as the coarticulation of a different syllable (or to delete it altogether)

Right word margin

- The one environment where Tara is not faced with a temporal spatial ordering decision about how to integrate the consonant into the word allows a consonant that appears to be a coda:

- Word final C is possible
  - *regatleb → [ri.ˈgɑ.tɪ.lɛb]

- Not necessarily knowledge of coda

- Goad and Brannen (2003) present phonetic evidence that in English, word final consonants in early stages of child language acquisition are actually syllabified as onsets.

Left Word Margin

- Sequences of vowels are also not allowed:
- *patior → patitor
- *diurnal → du.ri.nal
- *deviate → dɛ.lə.vet
- *scio → si.ko
- *celo → kledo (*kleo)
- Sequences broken up by intervening C's (overproduction of CV)

Temporal spatial ordering decision required

- C C
  | |
  V ← V V . → V
  →time →time

- Here, a temporal spatial decision has to be made about the two vowels—are they part of a heavy syllable or two distinct syllables?

- At left word margin, there is no ambiguity involving a temporal spatial ordering decision, so V can occur without an onset.

- Ex: aipcid → [e.pɪ.sɪd]

Proposal

- Metrical construct FOOT (at least moraic trochee) lacking for Tara could explain why she has difficulties syllabifying post vocalic C's as codas.
- Would account for reading difficulty in an orthographically opaque language that requires a reliance on rime to decode: metrical structure is required for decoding

Language acquisition implications

- parallels with early child language (lack of foot) suggest immature readers and readers with dyslexia will have similar behavior– specifically, also an over-reliance on CV

Early Readers

- blending skills in beginning readers
  - (Cassady, J. and L. Smith 2004) where nascent readers blend CVC words more efficiently as: CV+C than C+VC.
  - ca+t preferred to c+at
- Geuden and Saunders (2002), discussed in Yip (in press):
  - study of phonemic awareness in Dutch children,
  - young readers were reluctant to split apart a single syllable word at the so-called onset-rime division.
  - Ex:.….c/at. (dispreferred)
  - Ex:….ca/t (preferred)
- a(n initial) lack of FOOT.

Some interpretations of our finding with respect to language acquisition and UG

one interpretation

- Tara does not completely lack feet. She attempts to implement a more manageable (least marked) metrical structure: quantity insensitive syllabic feet. Solved by allowing only light syllables. Allows her to avoid facing temporal spatial ordering decisions

A different interpretation:

- What we are calling a moraic trochee is actually a constituent headed by a functional category
- The role of functional categories in language acquisition is well established
- Vergnaud's (2007) claim that the prosodic structure (stress) of words can be interpreted as functional structure is supported by our findings in this light, given he includes footlike structures among the relevant prosodic structure—

References available upon request

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