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Word Reversing by a Person with Williams Syndrome:  
More Evidence for the Mora as Structural Unit

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## Background

- Hockett (1955) proposed: the mora is conceivable only in the presence of the syllable. Since then this had been a generally accepted view for nearly three decades.
- Hyman (1985) argued: as a primary necessary step to syllabification, languages group segments into “weight units” (= moras).
- Since then, the question of whether moras constitute distinct units has been frequently asked.

- The construct mora has been recognized widely. Hock 1986; Poser 1984; Tateishi 1989 (musician's language), Kubozono 1989 (speech errors), Katada 1990 (language game), Otake et al 1993 (experimental studies).
- However, persuasive evidence for the mora as an autonomous structural unit, together with evidence bearing on its internal structure, is hard to come by.

## Partly because...

- What constitutes linguistic evidence is an arguable issue. The issue is associated with the status of ludling operations accompanying presented evidence (most typically language games) (for summary, see Bagemihl 1995).
- A ludling is defined as a language which meets the following criteria (Bagemihl 1995):
  - (1) its morphological system is limited to one or more operations associated with (a) affixing, (b) templatic operations, (c) reversing operations, or (d) replacement;
  - (2) its affixes (whether fully specified or defined only in prosodic or melodic terms) are limited to one or at most a handful of lexical items; and
  - (3) its morphology is semantically empty.

- The majority of ludling studies divide into two categories:
  - (1) ludlings as descriptive, nontheoretical studies of individual ludling systems themselves.
  - (2) ludlings used as external evidence.
- Ludlings used as external evidence have gained their own right to constitute an integral part of linguistic theory (Ohala 1986; Campbell 1980; Sherzer 1970; Cowan et al 1985; French 1988; Demolin 1991; Treiman 1983; Hombert 1986; Campbell 1986).
- Nowadays, ludlings are considered to have mini-grammars worthy of theoretical investigation in their own right, and used as evidence for certain constructs in phonological theory (Yip 1982; Lefkowitz 1988; Bagemihl 1988; Bao 1990; Plenat 1991; Vago 1985; Bagemihl 1987; Tateishi 1989; Bagemihl 1995 for summary) .

Even so...

- Such studies lose credibility unless ludlings are shown to be orthography-free.
- This credibility issue is relevant especially to languages with transparent orthography (sound:character = 1:1), assuming the possibility in which orthography affects spoken grammar.
- Representative is Japanese!

## Japanese Transparent Syllabary: the Kana Matrix

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

## Proposal and Claim

- I propose, under the model of Baddeley & Hitch (1974) (followed by subsequent models such as Just & Carpenter (1992), Schneider & Detweiler (1988), and others), human auditory working memory is an area which offers reliable (i.e. orthography-free) linguistic evidence.
- I present two cases:
  - Case 1: Word reversing by a person with Williams syndrome.
  - Case 2: Word reversing by a Japanese-English bilingual adult with no cognitive disabilities, kept an exceptional ability of backward reproduction.
- I claim the mora is an autonomous structural unit.

## General overview of “memory”

- Most theoretical models of memory distinguish three types based on duration of use (*Microsoft Encarta 2005*):
- (a) *sensory memory* (lasts fraction of a second) refers to the initial, momentary recording in our sensory systems, which function outside of awareness.
- (b) *working memory* (lasts 1.5 – 2 seconds) is a notion developed from short-term memory; it both stores information temporarily and allows manipulation and use of the stored information; *it is critical to mental work or thinking.*
- (c) *long-term memory* can refer to facts learned a few minutes ago, memories many decades old, or skills learned with practice; generally memories more than one minute old are considered to be in long-term memory.

# Working Memory

Baddeley & Hitch's (1974) notion, developed from Atkinson & Shiffrin's (1968) notion of short-term memory. The notion has been observed by subsequent models developed by Just & Carpenter (1992), Schneider & Detweiler (1988), and others.

- Working memory consists of the central executive system and two slave systems: (a) phonological loop, and (b) visuo-spatial sketch pad.
- Phonological loop consists of: (a) subvocal rehearsal component, and (b) phonological short-term store (which is assumed to be not an empty storage, but stored with distinctive features of language specific phonological items.)
- Subvocal rehearsal is necessary for linguistic inputs to be stored in the phonological short-term storage (Baddeley 1997).

## Visual and Auditory Linguistic Stimuli

- For visual linguistic stimuli: subvocal rehearsal takes place automatically before the stimuli go into the phonological short-term store. This means: visual stimuli (written numbers, characters, and words) are encoded into phonological codes like spoken language once before maintained in the phonological short-term store (since Atkinson & Shiffrin 1968).
- Evidence (Conrad 1964): Experiments using tachistoscope showed normal subjects tend to recall alphabets of similar phonological structure (g → c, b, or p); deaf subjects do not show this tendency.
- For auditory linguistic stimuli: subvocal rehearsal is not necessary. The stimuli go directly into the phonological short-term store, and classified (processed) according to the distinctive phonological features. This means: the moment the auditory stimuli is perceived, their recording takes place automatically.
- For my purpose: this leaves the possibility where performance in working memory associated with auditory stimuli offers orthography-free evidence, regardless of the subject being literate or illiterate.
- Ideal is the case which suffices both conditions: illiterate subject's responses within auditory working memory. This brings us to Case 1: the case in Williams syndrome.

## Williams syndrome

- Born lacking about 20 genes in Chromosome 7, Williams people are marked by low IQ (the average = 58), physical impairment, and having exceptional talent in absolute pitch perception. (Lenhoff et al 2001).
- They also demonstrate normal linguistic competence with no deficit of grammar, vocabulary choice, or fluency (Bellugi et al 1988).
- Because the windows of opportunity (the critical period) for Williams people to develop absolute pitch can extend into adulthood and perhaps indefinitely, studies with people having the syndrome should make it possible to develop new ways of exploring the neurological mechanisms fostering music and language acquisition in the human brain (Lenhoff).

## Case 1

- Case 1 is drawn from linguistic behavior evident on a Japanese television show entitled *Science Mystery* broadcast by Fuji TV, May 17, 2007.
- The subject (Taro, a pseudonym): 15 years old, Japanese-native, male, diagnosed as having Williams at the age 11.
- He has a problem of visual-spatial recognition, is unable to delineate cubic objects integrally, unable to write or read.
- He demonstrates remarkably unique sensitivity to sounds in general; our immediate concern here is his superior auditory working memory in reproducing words backward.
- Because of his illiteracy and performance associated with phonological loop, it is sensible to assume his reversing performance offers highly reliable (orthography-free) evidence.

# Let us listen

Video  
Excerpt  
1



Video  
Excerpt  
2



Video  
Excerpt  
3






Video  
Excerpt  
4



From *Science Mystery* broadcast by Fuji TV  
May 17, 2003

## Transcription of performance

(1)		[yakitori] [ritokiya]	[ya.ki.to.ri.] [ri.to.ki.ya.]
(2)		[toriwasa] [sawarito]	[to.ri.wa.sa.] [sa.wa.ri.to.]
(3)		[sunagimo] [moginatçu]	[su.na.gi.mo.] [mo.gi.na.tçu.]

(1) Note: Fluency and naturalness.

(2) The units Taro manipulates have hierarchical structure beyond that of melody.

(3) What units is he reversing, syllables or moras?

## Evidence in favor of ‘mora’

(4)



[tebagyo:za]

[za:gyobate]

(4 syllables)

[te.ba.gyo:.za.]

\*[za.gyo:.ba.te.]

(5 moras)

[te.ba.gyo.o.za.]

\*[za.o.gyo.ba.te.]

Notes: Neither hypothesized output matches Taro’s actual performance.

Both inputs and outputs are not orthography-based:

\*[て(te)ば(ba)ぎよ(gyo)う(u)ざ(za) → ざ(za)う(u)ぎよ(gyo)ば(ba)て(te)]



## To develop further:

- Kohno (1992, 1993, 2001) has shown that there are two types of rhythm that accord to the holistic sound processing organization of the human being:
  - (1) stress-timed (English)/syllable-timed (French)
  - (2) mora-timed (Japanese)
- Kohno argued: mora and syllables are fundamentally distinct in nature, though the two types of rhythm are both regulated within the fundamental neural clock unit, called “beat” (=330ms). Short-term memory processing accommodates  $7 \pm 2$  units (cf: Miller 1956).
- He has shown: 2 moras = 1 beat, 2 light syllables = 1 beat  
1 heavy syllable = 1 beat

Beat:                    b1    b2   b3

Moraic:                m1  m2  m3  m4  m5

Skeletal:              X<sub>1</sub>X<sub>2</sub>X<sub>3</sub>X<sub>4</sub> X<sub>5</sub>X<sub>6</sub>X<sub>7</sub>X<sub>8</sub>X<sub>9</sub>

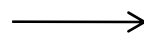
Melodic:              t e    b a g y o    z a

                          b1    b2   b3

                          m5  m4  m3  m2  m1

                          X<sub>8</sub>X<sub>9</sub>X<sub>7</sub>X<sub>5</sub>X<sub>6</sub> X<sub>3</sub>X<sub>4</sub>X<sub>1</sub>X<sub>2</sub>

                          z a    g y o b a t e

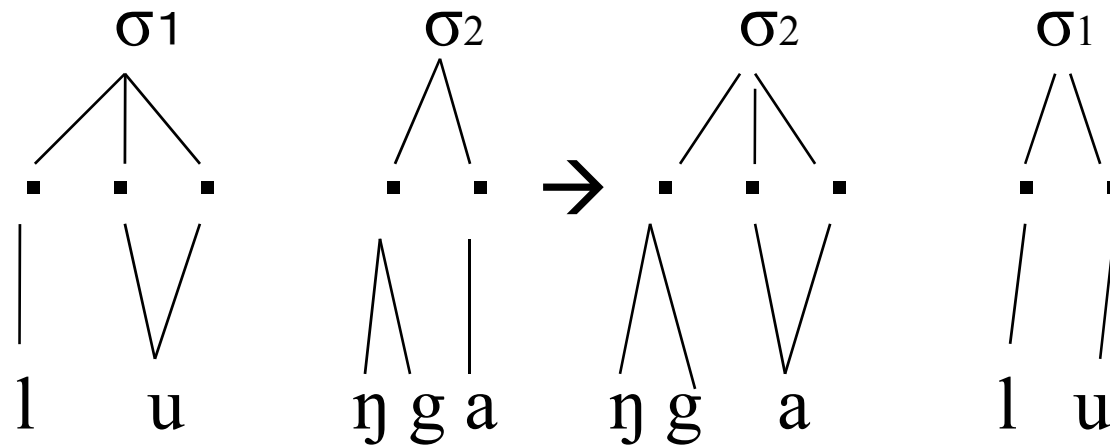


# McCarthy's (1982) treatment of long vowels

## Bakwiri (a Bantu language)

- (a) [moko] → [komo]      (b) [kóndì] → [ndíkò]  
 (c) [lùùṅgá] → [ṅgáálù]      (d) [zééyá] → [yáázé]

- (a) Length is preserved in its original position.  
 (b) Tone maintains its original position.



## Case 2

- The subject (Ziro, a pseudonym): 24 years old, a Japanese-English bilingual, male, spent 7 years (5-12 years old) in the US, a university graduate with no cognitive difficulties.
- At the age 13, he realized he has an exceptional ability for backward reproduction of what he hears. Ever since he kept the ability until the present.
- Pilot experiment: asked Ziro to reproduce words he hears as fast as he can. The experiment was recorded for analysis.
- Ziro's data is more complex than Taro's.

## Ziro's treatment of syllabic nasal

- (a) [nihongo] → [gonhuni]: if syllable [ni.hon.go.] → \*[go.hon.ni.]  
if mora [ni.ho.n.go.] → [go.n.ho.ni]
- (b) [gohan] → [nhago]: if syllable [go.han.] → \*[han.go.]  
if mora [go.ha.n.] → [n.ha.go.]
- (c) [hantai] → [itanha]: if syllable [han.tai.] → \*[tai.han]  
if mora [ha.n.ta.i.] → [i.ta.n.ha]
- (d) [ongaku] → [kugano]: if syllable [on.ga.ku] → \*[ku.ga.on]  
if mora [o.n.ga.ku] → [ku.ga.n.o]  
[お.ん.が.く] → [く.が.ん.お]

# Summary

- I proposed auditory working memory is an area for reliable linguistic evidence.
- I presented two cases of word reversing performance:  
Case 1 by a person with Williams syndrome,  
Case 2 by a person who maintained the reversing ability since his childhood.
- These cases show a long vowel involves 2 units, and a syllabic nasal forms an independent unit. These contribute to the argument for the mora as an autonomous structural unit.
- More data should be collected to secure the claim.

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Thank you.

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