From Theory to Practice: theory, assessment and treatment in Apraxia of speech

Ingrid Aichert

Clinical Neuropsychology Research Group
Neuropsychological Department,
City Hospital München, Germany

Ingrid.Aichert@extern.lrz-muenchen.de

Outline

I. Introduction

- Definition & functional neuroanatomy
- Symptoms
- Assessment

II. Theoretical aspects and clinical implications

What are the units of speech motor programming?
Which units should be chosen for treatment to obtain optimized learning and transfer effects in patients with Apraxia of Speech?

- Segments vs. Syllables
- Suprasyllabic aspects (prosody)

Definition

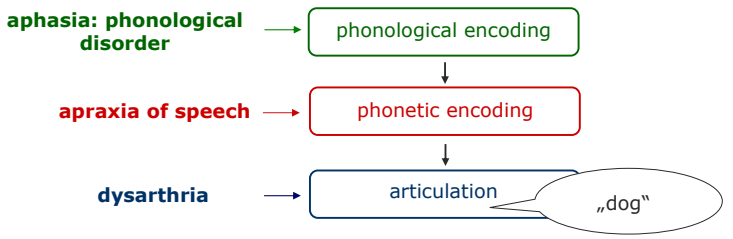
Apraxia of Speech

„…is defined as an articulatory disorder resulting from impairment, due to brain damage, of the capacity to program the positioning of speech musculature for the volitional production of phonemes and the sequencing of muscle movements for the production of words."

(Darley, Aronson & Brown, 1975: 255)

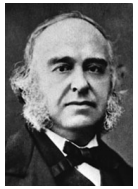
Definition

"[the patient´s] problem is to transform the more abstract representations of word forms into the motor commands that guide the articulators." (Ziegler, 2008: 270)



e.g., Levelt, Roelofs & Meyer, 1999

History: terminological confusions & theoretical disputes



Broca, 1861: Aphémie

loss of the „... faculty to coordinate the movements pertaining to the articulation of words"

perte de „...la faculté de coordonner les mouvements propre au langage des mots"

loss of the „...memory for the movements required for the articulation of words"

perte de „la mémoire des mouvements nécessaires á l´articulation des mots"

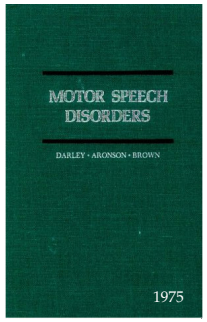
History: terminological confusions & theoretical disputes

Liepmann (1900): "Apraxie der Sprachmuskeln"
(apraxia of the language muscles)

Wernicke, 1874	subcortical motor aphasia
Kussmaul, 1877	atactic aphasia
Déjerine, 1901	pure motor aphasia
Bay, 1957	cortical dysarthria
Martin, 1974	aphasic phonological impairment

History: terminological confusions & theoretical disputes

The contribution of Frederic L. Darley



- Darley, 1968 (talk to ASHA audience):
  „Apraxia of speech: 107 years of terminological confusion."
  → he coined the term "Apraxia of speech"
- he differentiated AOS from dysarthria and aphasia by providing the conceptual underpinnings and a definition, description, and explanation for all three conditions.
- his understanding of AOS comprised a specific management for speech apraxic patients:

> *"The goal of therapy is to help the apraxic patient regain voluntary accurate control in programming the position of his articulators to produce phonemes and phoneme sequences"*
> (Darley et al., 1975: 279)

Etiologies & Localization

Etiologies

- primary cause: left hemisphere stroke with an infarction or hemorrhage of the left middle cerebral artery (Ziegler, 2008)
- other causes:
  - "crossed apraxia of speech": right hemisphere strokes in right-handers (Balasubramanian and Max, 2004)
  - traumatic brain injury (Pellat et al., 1991)
  - brain tumor (Mori et al., 1989)
  - neurodegenerative disease (primary progressive aphasia, Nestor et al., 2003)

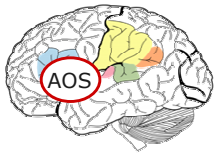
Etiologies & Localization

Localization / Functional Neuroanatomy

- Several regions are discussed, e.g.:
  - left anterior insular cortex (Dronkers, 1996)
  - left inferior motor cortex (Tanji et al., 2001)
  - subcortical white matter (Peach & Tonkovich, 2004)
  - left inferior frontal gyrus: Broca´s area (Hillis et al., 2004)

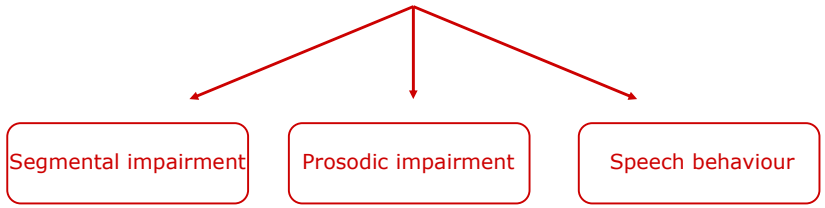
→ inconsistency of the neuroanatomical findings

→ consensus: AOS occurs after lesions to the *anterior perisylvian region* in the dominant (left) hemisphere



"…diverse processes, supported by diverse areas of brain, contribute and interact to produce speech movements. The answer will not be found by focusing on one site, nor is it an isolated process." (N. Miller, 2002: 226)

Symptoms



Symptoms

Segmental impairment

- phonological errors
  = "wellformed" sound errors
  - substitutions (e.g., *nail → dail*)
    → often the reaction is phonemically close to the intended word
  - elisions (e.g., *frog → fog*)
  - additions (e.g., *room → broom*)
  - sequencing errors: anticipations, perseverations, transpositions
    (e.g., *playback → bayback / playpack / bayplack*)

Symptoms

Segmental impairment

→ sequencing errors: a matter of debate

„CONS"

- *"Good acoustically and perceptually produced sounds that are mis-sequenced… are very difficult to assign to the motor level of speech production."* (McNeil et al., 2009: 256)
- *"The committee also specified characteristics that should not be used to diagnose AOS on the basis that such characteristics (e.g., anticipatory errors, transposition errors) were more likely attributable to other disorders, such as aphasia, rather than apraxia of speech."*
  (Wambaugh et al., 2006: xvii)

Symptoms

Segmental impairment

→ sequencing errors: a matter of debate

„PROS"

- *"Articulatory errors appear to be at times perseverative, with recurrence of phonemes recently articulated, and at times anticipatory, with the premature introduction of a phoneme that appears in a subsequent word."*
  (Darley et al., 1975: 263)
- perseveration as a frequent behaviour in patients with severe AOS
  e.g., Stevens, 1989: perseverative stereotypes may be due to inadequately disinhibited motor speech patterns when defective phonetic encoding fail to produce a desired verbal response ("locked-in" to a *verbal motor loop*)
- perseverative errors are often induced within "Minimal Pair therapy"
  e.g., Wambaugh et al., 1996: *shin – sin* → *shin – shin*

Symptoms

Segmental impairment

→ sequencing errors: a matter of debate

„PROS"

Inventory of articulation characteristics of apraxia from the apraxia Battery for Adults – 2 (Dabul, 2000)

Speech Behavior

1. Exhibits phonemic anticipatory errors (gleen glass for green grass)
2. Exhibits phonemic perseverative errors (pep for pet)
3. Exhibits phonemic transposition errors (Arifca for Africa)
4. Exhibits phonemic voicing errors (ben for pen)
5. Exhibits phonemic vowel errors (moan for man)
6. Exhibits visible/audible searching
7. Exhibits numerous off-target attempts at the word
8. Errors are highly inconsistent
9. Errors increase as phonemic sequence increases
10. Exhibits fewer errors with automatic speech than volitional speech
11. Exhibits marked difficulty initiating speech
12. Intrudes schwa sound /IPL/ between syllables or in consonant clusters
13. Exhibits abnormal prosodic features
14. Exhibits awareness of errors and inability to correct them
15. Exhibits expressive-receptive gap

Symptoms

Segmental impairment

- phonological errors
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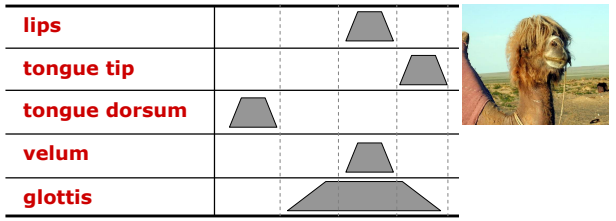
  - substitutions (e.g., *nail* → *dail*)
    → often the reaction is phonemically close to the intended word
  - elisions (e.g., *frog* → *fog*)
  - additions (e.g., *room* → *broom*)
  - sequencing errors: anticipations, perseverations, transpositions
    (e.g., *playback* → *bayback / playpack / bayplack)*
- phonetic distortions
  = "ill-formed", gradual aberrations from target phoneme
  - e.g., phonetic denasalizations of nasal consonants: /m/, /n/ or /ŋ/ sound as if the nasal passage is obstructed

Symptoms

Segmental impairment

→ gradual (phonetic) and categorical (phonemic) errors: two error types resulting from a common motor mechanism (Ziegler, 2008)



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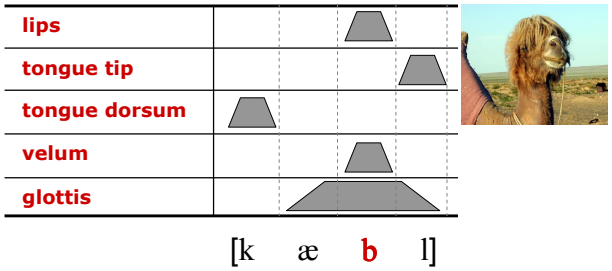

→ missing lowering movement of the velum

Symptoms

Segmental impairment

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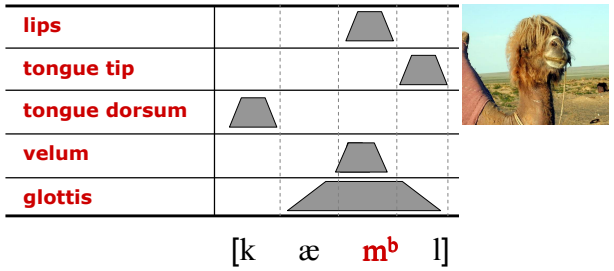


→ ill-timed, premature elevation movement of the velum (denasalizations)

Symptoms

Prosodic impairment

= disturbances concerning the flow and melody of speech (e.g., Kent & Rosenbek, 1982)

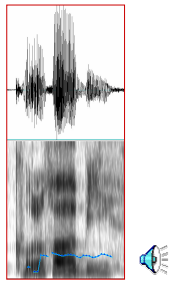
- scanning speech
  - syllable segregation
  - equal stress / syllable isochrony
- articulatory prolongation
  - lengthening of sounds
  - lengthening of the transitions between sounds (schwa-insertion, intrasyllabic pauses)
- disruptions of the speech flow
  - articulatory groping
  - self corrections
  - unfilled pauses

} **slow speaking rate**

Symptoms

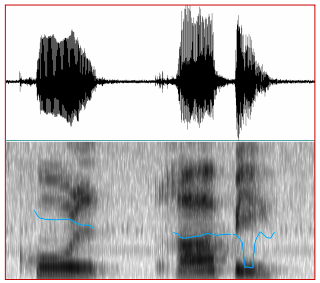
Prosodic impairment

Normal speaker



Kohlrabi: 691 ms

Patient with AOS



Kohlrabi: 2160 ms (pause: 450ms)

Symptoms

Prosodic impairment

→ a matter of debate: Is the prosodic impairment a direct outcome of impaired motor programming ("primary symptom") or a compensatory behavior ("secondary symptom")? (e.g., Boutsen & Christman, 2002)

Examples for prosodic impairments as "secondary symptoms":

- disruptions of the speech flow as a ***consequence*** of articulatory groping and self-corrections
  e.g, initiation difficulty in *clown* → [f.. t.. k. k.. klɑʊn]
- reducing speech rate as a conscious or automatic ***strategy*** to prevent segmental errors
  e.g., [kl] in *clown* → [kəlɑʊn]
  [sp] in *spoon* → [/s/puːn]

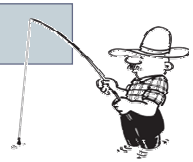
Symptoms

Prosodic impairment

→ reducing speech rate as strategy to master complex speech strings in normal speakers…

She sells sea-shells on the sea-shore.
The shells she sells are sea-shells, I'm sure.
For if she sells sea-shells on the sea-shore
Then I'm sure she sells sea-shore shells.

Fischers Fritze fischt frische Fische.
Frische Fische fischt Fischers Fritze.



Implications for therapy

Prosodic impairment as secondary symptom

- **If…**
  a) prosodic impairment is predominant in a patient
  (i.e., scanning speech, phoneme lengthenings, lengthenings of the transitions between sounds)
  b) segmental impairment is very mild
  (i.e., the patient is intelligible, only producing an insignificant amount of segmental errors)

Primary goal of treatment:
→ enhancing segmental skills
e.g., complex / polysyllabic words, tongue twister
→ …in a fluent manner!
e.g., through metrical pacing, metronome

Symptoms

Speech behaviour

→ high awareness of impairment, controlled manner of speaking

- articulatory groping "Dose" (engl. *tin*)
- self-corrections (e.g., *frog → fog, no… frog*)
- laborious, effortful speaking
  e.g., exertion of the facial muscles, increased loudness
  → may lead to an increase of segmental errors

„du" → [dⁱu]  ⟷ „du" → ✓ 

- dissatisfaction with speech performance

Implications for therapy

Speech behaviour

Significant goal of treatment: Modifying speech behaviour

1. Tension reduction
- EMG – feedback (McNeil et al., 1976)
- behavioural stress relaxation methods (Vogel et al., 1988)

→ patients performed better while receiving feedback / after the relaxation units

2. Reduction of "overarticulated" speech (Aichert & Ziegler, 2010)
- direct feedback regarding the extension of the articulatory movements
- implicit instructions: "speak softly", "whisper"

RK   HD

→ patient D. produced less phonetic errors, he was perceived with less speech effort by conversational partners and he reported being more relaxed while speaking

Symptoms

Error variability

e.g., Darley et al., 1975, Wertz et al., 1984, Ziegler, 2008; Staiger et al., under revision

- Errors are inconsistent
  - the same utterance may be produced correctly in one instance and inaccurately in another
  - errors may have different qualities

"*planet*"
→ [plænɪt]
→ [pænɪt]
→ [pəlænɪt]
→ [plænᵈɪt]

- Islands of unimpaired speech

→ even severely impaired speakers may have preserved abilities to produce "automatic speech", such as greetings *("hello", "How are you")*

Symptoms

Error variability / inconsistency as primary clinical characteristic of AOS

However:
A number of factors make a word more or less difficult for patients with AOS

Factors influencing apraxic speech

- syllable structure (single consonants < consonant clusters)
  (e.g., Odell et al., 1990; Aichert & Ziegler, 2004; Romani & Galluzzi, 2005; Staiger & Ziegler, 2008)
- word length (e.g., tea < tomato)
  (e.g., Odell et al., 1990; Strauss & Klich, 2001; Edmonds & Marquard, 2004; Ziegler, 2005, 2009)
- word position (coda consonants < onset consonants)
  (e.g., Klich et al., 1983; Canter et al., 1985; Haley et al., 2001; Aichert & Ziegler, 2004)
- manner of articulation (e.g., vowels < nasals < plosives < frikatives < affricates)
  (e.g., Trost & Canter, 1975; MacKenzie, 1982; Odell et al., 1990; Haley et al., 2001)
- syllable frequency (high frequency syllables < low frequency syllables)
  (Aichert & Ziegler, 2004; Laganaro, 2008; Staiger & Ziegler, 2008)
- etc.

→ Outcome: tendencies, but also inconsistent results

Factors influencing apraxic speech

Example: Influence of word position

…the apraxic speakers had their greatest difficulty in initiating word production… (Canter et al., 1985: 212)

N = 12 studys

initial > medial/final	medial/final > initial	no effect
N = 6	N = 1	N = 5

→ Reasons for the heterogenous results:
- Variability of the disorder itself?
- Variability of the investigations (e.g., choice of different materials and modalities, different analysis)?

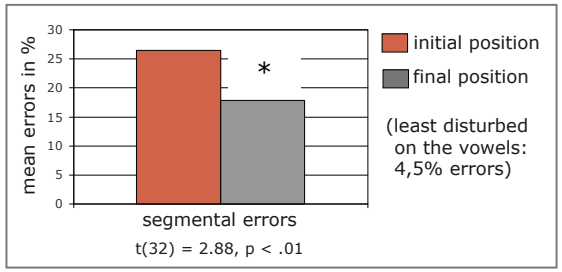
Factors influencing apraxic speech

Aichert & Ziegler 2007-2010

→ Assessment in 18 different clinical institutions in Germany
→ data from 33 patients with AOS (7 patients with pure AOS)

I. Influence of word position (monosyllabic words)

Group effect



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I. Influence of word position (monosyllabic words)

Individual patterns

	more errors on *initial* position*	more errors on *final* position*
segmental errors	n = 10	n = 3
+ articulatory groping	n = 18	-
+ prosodic errors	n = 21	-

* Chi-Quadrat, p < .05. / .01 / .001

→ „descriptive": in consideration of all error types 32 out of 33 patients produced more errors word initial

Factors influencing apraxic speech

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I. Influence of word position (monosyllabic words)

Conclusion

- in patients with AOS we have to consider not only segmental errors in order to explain the disorder:
  - articulatory groping reflect initiating difficulties; this compensatory strategy may lead to correct word onsets; e.g., *Frosch* → ʃ.. f.. fʁɔʃ
  - prosodic errors also reflect compensatory strategies to avoid segmental errors on word onsets; e.g., *Stift* → /ʃ/tʁft

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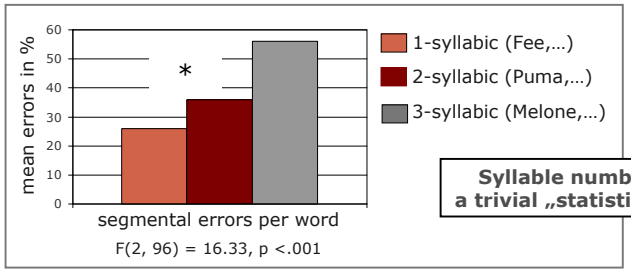
II. Influence of syllable number (1-, 2- and 3-syllabic words)

Group effect



Syllable number effect: a trivial „statistical" effect?

Factors influencing apraxic speech

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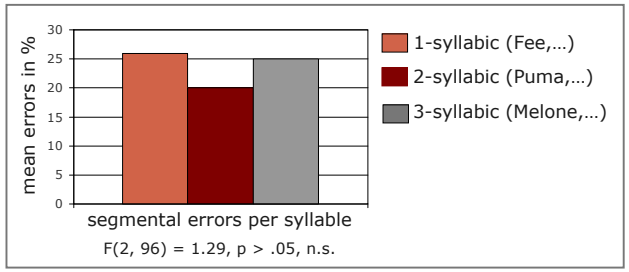

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Factors influencing apraxic speech

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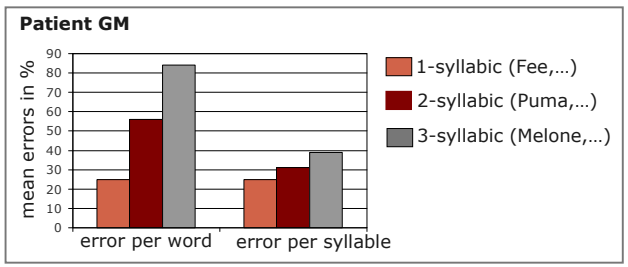
Individual patterns: rather diverse



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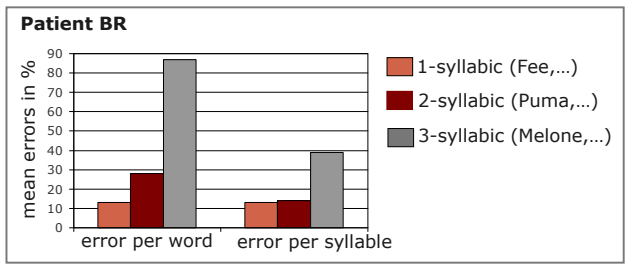

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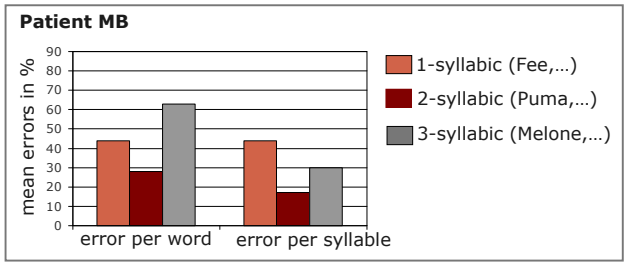

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Conclusion

- influence of different error types: it makes a large difference in the results if we count absolute error numbers (i.e., "errors per word") or relative error numbers (i.e., "errors per syllable")
- there ***is*** individual variation in AOS!

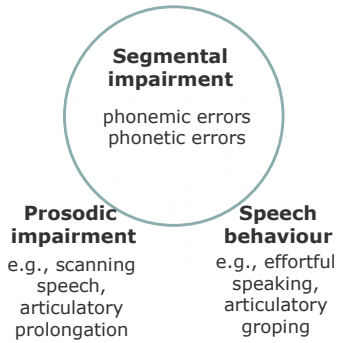
Implications for assessment and therapy

Factors influencing apraxic speech

→ **Assessment**
conduct a comprehensive error analysis and bear "possible" factors in mind, which are known to influence the occurrence of speech apraxic errors;
not every patient with AOS is sensitive to all factors described in the literature!

→ **Treatment**
control for those factors which *individually* influences the patient's speech production!

Symptoms



- overlap of symptoms
  → which symptoms are primary, which are secondary?
- variability within and between patients with AOS
- however: there are also factors influencing the speech of a patient with AOS

Assessment

Goals of Assessment

- diagnose AOS and distinguish AOS from other speech and language disorders (dysarthria, aphasic-phonological impairment)
- estimate the severity of AOS
- assess the speech apraxic symptoms regarding to *segmental impairments*, *prosodic impairments* and *speech behaviour*
- assess the (individual) factors influencing the patient's speech production (e.g., word length, syllable complexity)
- assess the communicative abilities

→ foundation for setting the goals for treatment

→ „quality management": measuring the outcome after therapy

Assessment

Differential Diagnosis of AOS: Why is it difficult to distinguish AOS from dysarthria and aphasic-phonological impairments?

→ no consistent set of diagnostic criteria for AOS: patients with AOS may present with a broad variety of clinical signs

! the same fact applies to dysarthrias and aphasic-phonological disorders

→ rare condition of pure AOS: the disorder is almost always associated with aphasic and/or dysarthric condition

→ many symptoms belonging to AOS are also characteristic for aphasia (e.g., phonemic errors) and dysarthria (e.g., phonetic distortions)

Assessment

Methods of Assessment

Spontaneous speech

- evaluate speech apraxic symptoms in a rather natural context (conversation)
- investigate general communicative abilities; e.g., use of non-verbal communication

Systematic assessment

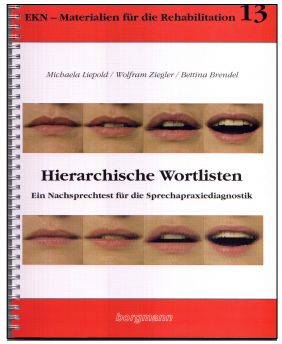
- assess factors influencing apraxic speech systematically (→ controlled speech materials)
- e.g., repetition of words with varying length and syllable complexity

→ combinate both methods

Assessment

Methods of Assessment

- Systematic Assessment in German: *Hierarchische Wortlisten* (Liepold et al., 2003)



Repetition test
(16 word lists á 6 items ⇨ 96 items)

Systematic control for following factors:
- syllable number
- syllable complexity
- lexicality

Assessment

Methods of Assessment

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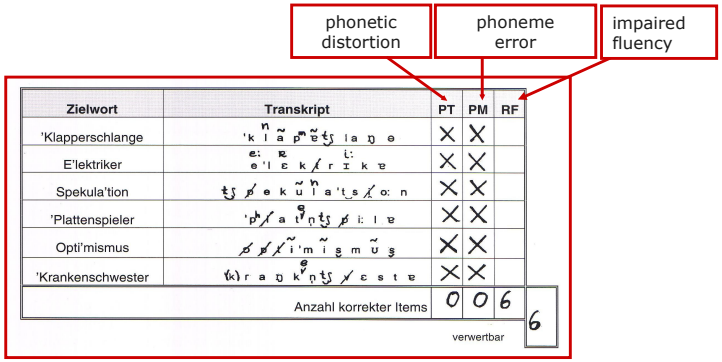

Assessment

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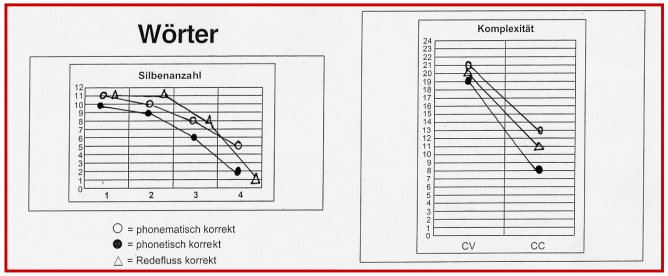
- Systematic Assessment in German: *Hierarchische Wortlisten* (Liepold et al., 2003)

Patient's profile: e.g., influency of syllable number and syllable complexity



Assessment

Assessment of Oral-facial apraxia

- AOS is often associated with oral-facial apraxia
- Assessment of oral-facial apraxia
  - → volitional, non-speech oral movements (e.g., Bizzozero et al., 2000)
    e.g., tongue, lip and jaw movements, smiling, humming, blowing,…

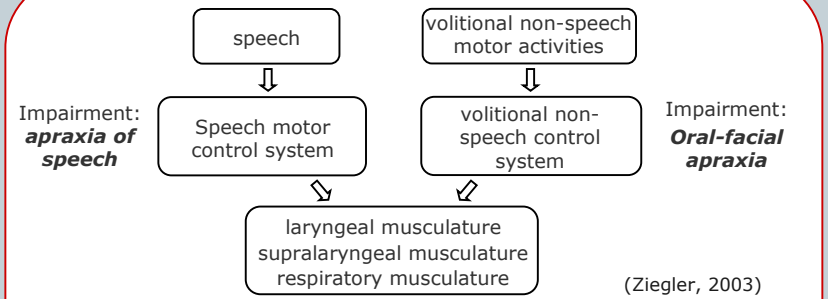
Examples:
„Pass the tip of your tongue over your upper lip."
„Pretend to give a kiss."
„Clear your throat."

  - → patients are usually unimpaired in natural contexts (e.g., blowing on command vs. blowing out a candle)

Patient HK

Implications for therapy

Role of non-verbal assessment for treatment?



(Ziegler, 2003)

- → dissociations between AOS and apraxia for non-speech oral-facial movements!
- → no transfer from non-speech oral movements to speech movements in patients with AOS (e.g., Yorkston et al., 1999).

Implications for therapy

Role of non-verbal assessment for therapy?

„What is the evidence of oral motor therapy" in Childhood apraxia of Speech?

"…The evidence indicates that non-speech behaviours are not a precursor to later speech learning, so they are not a "foundation" for speech.
There are many well-tried, efficacious, efficient, effective therapies available for us to choose from when devising intervention for individual clients. Oral motor therapy is not one of them. With no theoretical underpinning, and in the absence of an evidence base, it is clear that oral motor therapies are not for us… [Australia]."
Bowen (2005: 146)

Implications for therapy

Role of non-verbal assessment for therapy?

→ non-speech oral motor movements are useful when they are directly combined with speech

= **Phonetic derivation** (e.g., Wertz et al., 1984)
e.g., /f/ derived from blowing out a candle

→ requirement: no severe oral-facial apraxia

Our goal, to elicitate speech movements, should be focused within every exercise!

Theoretical aspects and clinical implications

Theoretical aspects

⇨ What are the units of speech motor programming?

⇨ Which of these motor programs are available to patients with AOS?

⇔

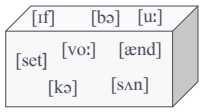
Clinical implications

⇨ Which units should be chosen for treatment to obtain optimised learning and transfer effects in patients with AOS?

What are the units of speech motor programming?

*„...establish the **syllable** as the unit of articulatory programming"*
(Crompton, 1982: 136)

Mental syllabary



= ready-made motor programs for high-frequency syllables

phonetic encoding
(Levelt et al., 1999)

→ reduce the computational load of the phonetic processing during speech production

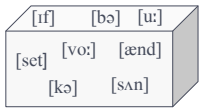
→ experimental evidence: syllable frequency effect on word production delays in normal subjects (e.g., Levelt & Wheeldon, 1994)

→ language acquisition: the syllable is thought to be the first unit produced by children during the babbling stage (e.g., Schiller et al., 1996; MacNeilage, 2001)

What are the units of speech motor programming?

*„...establish the **syllable** as the unit of articulatory programming"*
(Crompton, 1982: 136)

Mental syllabary



= ready-made motor programs for high-frequency syllables

phonetic encoding
(Levelt et al., 1999)

segment-by-segment assembly

k l ɑʊ n

= compose low-frequent or entirely new syllables (e.g., in reading aloud a new word or nonword)

Which of these motor programs are available to patients with AOS?

Varley & Whiteside (2001)

- patients with AOS have *no* access to the mental syllabary
- they compensate insufficiently for this problem by using the segmental assembly route

Aichert & Ziegler (2004), Edmonds & Marquadt (2004), Staiger & Ziegler (2008)

- effects of syllable frequency and syllable structure
- patients with AOS do have access to the mental syllabary; the syllable-sized programs are at least partially destroyed

„While the exact nature of breakdown during the motor programming stage is not clear, it is apparent that the syllable is maintained and appears to be the core unit in AOS." (Edmonds & Marquardt, 2004: 1120)

Segments and syllables in the treatment of AOS

Segments as target units

- the correct production of single segments is required before sequences of phonemes within syllables and words can be trained (Dabul & Bollier, 1976)
- the strategy to compensate via the segmental route should first be supported by treating the articulatory pattern of segmental plans (Varley et al., 2005)

Syllables as target units

- even patients with severe AOS have access the to the syllabic motor programs (Aichert & Ziegler, 2004)
- the syllable as basic speech unit should be considered as target in therapy (e.g., Odell, 2002)
- normal speech motor learning in language acquisition is based on syllabic learning (MacNeilage, 2001)

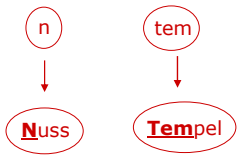
⇨ Until now there are no studies which compared the effectiveness of learning single segments to the learning of whole syllables.

Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

▶ Research questions

1. Are there learning effects after training single segments and single syllables?
2. Are there transfer effects into larger units, i.e., into one- and two-syllabic words?



Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

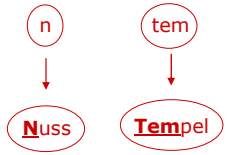
- Method

assessment: selection of 3 target phonemes / 3 target syllables and 3 control phonemes / 3 control syllables individually for each patient

learning phases à 45-50 minutes (during 2 sessions)

Investigation of learning effects: repetition of the learning & control items in isolation

Investigation of transfer effects: analysis of the phonemes embedded in 1-syllabic words / analysis of the syllables embedded in 2-syllabic words



Effects were investigated immediately & 1 week after the second learning phase

Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

- Patients
  - 4 patients with severe AOS and concomitant aphasia
  - the expressive abilities (modality: repetition) of all patients were dominated by the apraxic errors

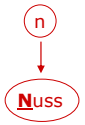
	age	time post onset (months)	severity of aphasia
MG	75	38	minimal
BD	75	3	moderate
AS	35	12	severe
CK	56	5	severe

Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

- Results

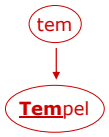
a) Segmental Learning



	MG	AS	CK	BD
learning effects	-	+	-	-
transfer effects	-	-	-	-

- significant learning effects only in AS; however, no transfer of the learned segments into syllables

b) Syllable Learning



	MG	AS	CK	BD
learning effects	+	+	+	-
transfer effects	+	+	-	-

- significant learning effects in three patients & significant transfer effects in MG und AS
- no changes on the control syllables
- stable effects for at least one week

Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

- Discussion

Segmental learning

- reasons for missing learning effects in three patients:
  - single consonants are articulatory „artificial" units
  - maybe even nonverbal motor processes were activated

Only patient AS, who didn´t exhibit oral-facial apraxia showed a learning effect!

Segments and syllables in the treatment of AOS

Influence of intensive phonomotor rehabilitation on apraxia of speech

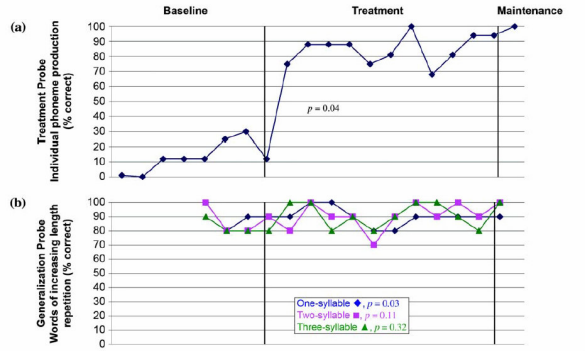
Kendall et al., 2006

- single-patient study: patient with AOS, mild Broca`s aphasia
- *"For oral-motor movements, he showed difficulty initiating and repeating movements such as coughing, puffing out cheeks, protruding tongue, etc."* (p. 411) → oral-facial apraxia
- "phonomotor rehabilitation" = treatment of single phonemes (therapeutical techniques: mouth pictures, mirror, verbal description)
  - → *"While able to learn to produce individual sounds, the subject did not exhibit generalization to other aspects of motor production."* (p. 409)
  - → *"One possible explanation for the lack of generalization may be a ceiling effect. Our subject had >85 percent accuracy in repetition of multisyllabic words (e.g., snowman) before the start of treatment…"* (p. 416)

Segments and syllables in the treatment of AOS

Influence of intensive phonomotor rehabilitation on apraxia of speech

Kendall et al., 2006, p. 415



Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

► Discussion

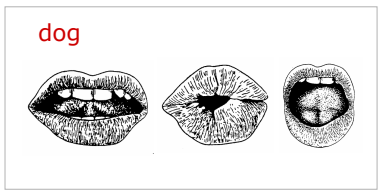
n → Nuss

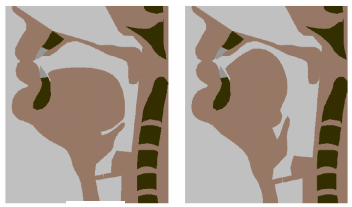
Segmental learning

- reasons for missing learning effects in three patients:
  - single consonants are articulatory „artificial" units
  - maybe even nonverbal motor processes were activated
- reasons for missing transfer effects in AS…
  …even if a single phoneme is controlled as a verbal behaviour:
  - coarticulatory processes within syllables (e.g. /n/ in [ni:] - [nu:]) are part of phonetic encoding (e.g., Levelt et al., 1999)
  - these adjustments to the phonetic context cannot be done by speech apraxic patients without exercise

Segments and syllables in the treatment of AOS

Speech production is not a string of single phonemes





Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

- Discussion

Syllabic learning

tem → **Tem**pel

- learning effects in three patients:
  - the syllable as "natural" speech motor unit is easier to acquire than single consonants
- transfer effects in two patients:
  - transfer into two-syllabic items require less speech motor adjustments than coarticulatory processes within syllables

→ syllable as optimal unit for speech motor „reacquisition"
→ intrasyllabic coarticulatory processes are trained from the beginning

Segments and syllables in the treatment of AOS

Learning experiment I (Aichert & Ziegler, 2008a)

- Discussion

Syllabic learning

tem → **Tem**pel

- learning effects in three patients:
  - the syllable as "natural" speech motor unit is easier to acquire than single consonants
- transfer effects in two patients:
  - transfer into two-syllabic items require less speech motor adjustments than coarticulatory processes within syllables

Why did patient BD not benefit from syllabic learning?

- the small amount of target syllables (three syllables) might have led to perseverations
- for BD a more variable learning with a larger amount of dissimilar items could have been more effective

Ingrid Aichert, EKN München Audiologopædisk Forenings in Nyborg - 28.3.2012

Implications for therapy

Treatment of simple syllables in patients with severe AOS

- single vowels: *a:, e:, i:, o:, u:*
- simple CV-syllables with "easy" consonants
  e.g., target phoneme "n" in *na, ne, ni, no, nu*
  → treatment of different coarticulatory context
  → variability as a main principle of articulatory movements
- vowel-initial syllables (VC)
  a → an → na → ne, ni, etc.
- derivation of single phonemes *directly* followed by an embedding of the target phoneme into syllables

→ if possible: choose familiar, high-frequency, illustrable words

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Implications for therapy

Treatment of simple syllables in patients with severe AOS

consonant /m/				consonant /n/		
am	ma	mam	*Mama*	*an*	*Anna*	*na*
im	mi	mim	*Mai*	*in*	*nie*	
om	mo	mom	*Oma*	on	no	*Nonne*
um	*muh*		*Mumm*	*ein*	*eine*	*nein*

consonants /m/ und /n/
Mann *Name* *Mähne* *Miene* *mein* *meine* *Mohn*
phrases: *mein Mann, ein Name, an Oma, im Mai, eine Nonne*

„ma", „mo"
(= nonsense syllables)

„die Oma"
(*the grandma*)

Ingrid Aichert, EKN München Audiologopædisk Forenings in Nyborg - 28.3.2012

Implications for therapy

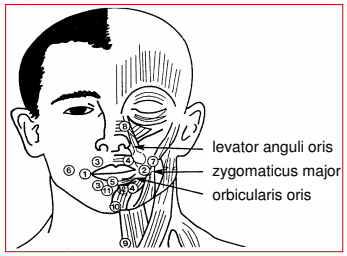
Techniques for the derivation of sound patterns

- watch the clinician's model
- phonetic derivation (e.g., Wertz et al., 1984)
  → teaching sounds by non-speech behaviours
  e.g., /f/ in "*feel*" derived from blowing out a candle
  → teaching sounds by modifying sounds they can
  e.g., /pa/ derived from /ma/
- derive sounds from high-frequent, familiar words
  → e.g., /j/ in "*Januar*" (engl. *january*) or "*jubeln*" derived from /j/ in the high-frequent syllable "ja" (engl. *yes*)
- derive sounds from different (easier) word positions
  → e.g., /k/ in the initial position (e.g., "Kaffee", engl. *coffee*) derived from the final position (e.g. "sag", engl. *say*)

Implications for therapy

Techniques for the derivation of sound patterns

- tactile / kinesthetic cues (e.g., PROMPT, Square et al., 2001)

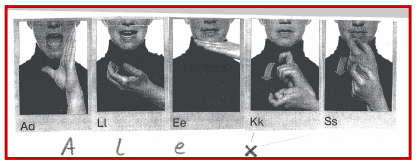


patient AS producing „warm" (engl. *warm*)

Implications for therapy

Techniques for the derivation of sound patterns

- non-meaningful gestures for single sounds
  Intersystemic reorganization (Rosenbek et al., 1976):
  utilization of a relatively intact system (gesture) to facilitate functioning of an impaired system (speech)



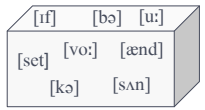
„Alex"

„gut"

→ pre-condition: no severe limb apraxia and no severe cognitive limitations

Is there an need to train every single syllable separately?

Mental syllabary



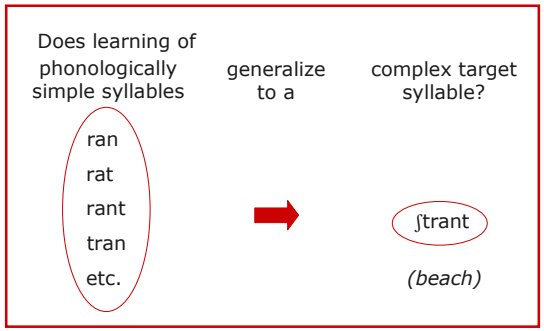
„a store of complete gestural programs for at least the high-frequency syllables of the language"
(Levelt et al., 1999: 32)

→ **Hypothesis:**
Only practice of a syllable in its complete form would lead to a learning effect of this syllable in patients with AOS.

Is there an need to train every single syllable separately?

Learning experiment II (Aichert & Ziegler, 2008b)

- Research question



Is there an need to train every single syllable separately?

Learning experiment II (Aichert & Ziegler, 2008b)

- Method

→ 24 learning phases within 2 sessions

Is there an need to train every single syllable separately?

Learning experiment II (Aichert & Ziegler, 2008b)

- Patients

4 patients with AOS (two patients with pure AOS)

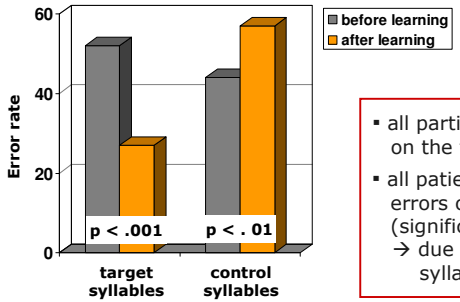
	RK	*KH*	*LF*	*MK*
Age	49	65	59	49
Gender	m	f	m	m
Months post-onset	4	2	7	41
AOS: Severity score[a]	mild-to-moderate	mild-to-moderate	moderate	moderate
Aphasia classification	no aphasia[b]	no aphasia[b, c]	Broca's aphasia[d] (mild-to-moderate)	Broca's aphasia[d] (mild-to-moderate)

Is there an need to train every single syllable separately?

Learning experiment II (Aichert & Ziegler, 2008b)

- Results

Group data



Individual analyses

- all participants produced fewer errors on the target syllables after learning
- all patient showed a tendency for more errors on the control syllables (significant in RK)
  → due to perseverations of the trained syllables

Is there an need to train every single syllable separately?

Learning experiment II (Aichert & Ziegler, 2008b)

- Discussion

→ Complex target syllables, which had never been exercised, improved significantly after the training of phonologically simple units.

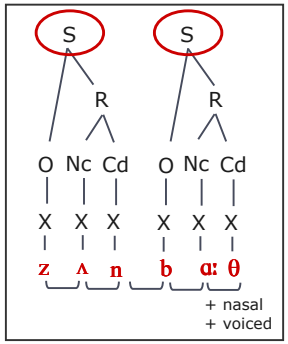
- the transfer effects cannot easily be explained by the assumption of holistically stored syllable programs
- in contrast, the results suggest that the gestural scores of overlearned syllable routines have an internal architecture
- structurally related syllables may be interconnected and share overlapping elements of their internal make-up

Is there an need to train every single syllable separately?

Learning experiment II (Aichert & Ziegler, 2008b)

- Discussion

The internal architecture of phonetic plans (Ziegler, 2005, 2009)



Articulatory phonology

" [...] a hierarchy of unit types, including segments, onsets and rimes, syllables, feet, and words. The more tightly bonded units are those that we would expect to cohere in speech production and planning ..."
(Goldstein & Fowler, 2003: 164)

Is there an need to train every single syllable separately?

Learning experiment III (Schoor, Aichert & Ziegler, in press)

- Research question

Training syllable [na:t], engl. *seam* (n = 4 training syllables)

	Transfer conditions	
1	[nʊs]	onset → onset
2	[ga:s]	nucleus → nucleus
3	[gu:t]	coda → coda
4	[ʁa:t]	rhyme → rhyme
5	[na:x]	onset-nucleus → onset-nucleus
6	[naɪt]	onset-coda → onset-coda
7	[zaɪn]	onset → coda
8	[tu:x]	coda → onset

Is there an need to train every single syllable separately?

Learning experiment III (Schoor, Aichert & Ziegler, in press)

- Results & Discussion
  - improvement only on those constituents which were part of a training syllable (e.g., [na:t] → [na:x])
  - transfer effects were confined to conditions in which overlapping segments of the learning and the transfer syllables pertained to the same syllable constituent (e.g., [na:t] → [gu:t] vs. [tu:x])
  - at least consonants in the onset position should be trained in their specific vowel context:
    e.g., [na:t] → larger transfer effect on the onset consonant [n] in the untrained syllable [na:x] compared to the [n] in [nʊs] entailing a different vowel context.

Implications for therapy

„Learning a syllable from its parts"

„craft"	C1	C2	CC
coda	ca**f**	ca**t**	ca**ft**
	ra**f**	ra**t**	ra**ft**
onset	**c**af	**r**af	**cr**af
	cat	**r**at	**cr**at
			craft

Implications for therapy

Importance of coarticulation

- the process of adjusting an onset consonant to its vocalic context has to be trained explicitly in speech apraxic patients.

/d/	
Diebe	dösen
Dose	Durst
Dame	Delfin
Dübel	Dienstag

Stuhl - Stiel - Stahl
Mast - Most - Mist
Rose - Riese - Rasen
Hölle - Halle - Hülle
Tusche - Tasche - Tische

Implications for therapy

Sound Production Treatment (e.g., Wambaugh et al., 1998)

- training selected sounds in the context of single words

Acquisition and Response Generalization Items /ʃ/ phrases (elicited by repetition)

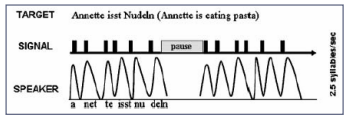
Trained	**Untrained**
the mash	the ash
the bash	oh gosh
a push	my leash
the mush	I gush
her cash	the hash
a rush	the bush
her wish	her lash
her sash	the whoosh
my quiche	the fish
a hush	a rash

Suprasyllabic aspects

- **Background**

Apraxia of Speech

- prosodic impairments in AOS (Kent & Rosenbek, 1982; Itoh & Sasanuma, 1984)
- rhythm-based treatment methods have proved successful (e.g., Rubow et al., 1982; Wambaugh & Martinez, 2000; Brendel & Ziegler, 2008)
  → reduction of prosodic *and* segmental errors

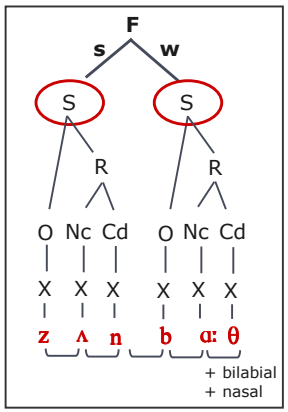


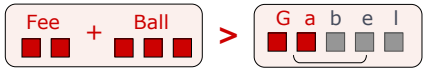
Metrical Pacing Therapy (MPT)
(Brendel & Ziegler, 2008: 82)

- influence of prosodic factors to apraxic speech:
  higher error rate for accented vs. unaccented syllables (Odell et al., 1991)

Suprasyllabic aspects

Ziegler, 2005: A nonlinear Model of Word length effects in Apraxia of Speech





[…] the process of combining two syllables to a trochaic foot turned out to be less vulnerable than a purely combinatorial relationship would predict. In other words, two separate monosyllabic utterances are considerably more vulnerable to apraxic failure than a single disyllabic trochee. p. 620

→ **however:**
- interaction of stress and syllable frequency?
- influence of the initiation difficulties?
- no comparison of different stress patterns

Suprasyllabic aspects

Influence of word stress in patients with AOS (Aichert & Ziegler, 2009)

- Patients: 12 patients with AOS, 5 patients exhibiting pure AOS
- Material: 48 nouns of low word frequency

	CV	CVC	CCVC / CVCC
2-syllabic / trochaic	*Haken*	*Wespe*	*Flanke*
2-syllabic / iambic	*Menü*	*Mandat*	*Kontakt*

↳ control of the stressed syllable for sublexical frequencies (Aichert et al., 2005)

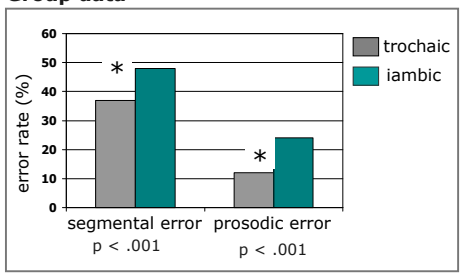
- Method: Repetition of the wordlist (twice) / n = 96 items per patient

Suprasyllabic aspects

Influence of word stress in patients with AOS (Aichert & Ziegler, 2009)

- Results

Group data



→ whereas the complex iambic words turned out to be most error-prone, trochaic words with a simple CV structure proved to be the easiest

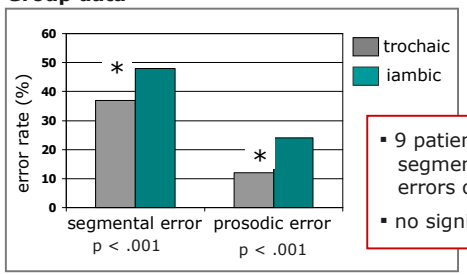
	trochaic CV	iambic CVCC
segmental errors	29%	57%
prosodic errors	8%	29%

Suprasyllabic aspects

Influence of word stress in patients with AOS (Aichert & Ziegler, 2009)

- Results

Group data



Individual analyses

- 9 patients produced significantly more segmental errors and/or more prosodic errors on iambic words
- no significant differences in 3 patients

Suprasyllabic aspects

Influence of word stress in patients with AOS (Aichert & Ziegler, 2009)

- Results


	Judo (engl. *judo*)	**Ju**wel (engl. *juwel*)
segmental errors	45%	64%
prosodic errors	20%	30%
error on initial syllable	34%	53%
articulatory groping	22%	30%

Suprasyllabic aspects

Influence of word stress in patients with AOS (Aichert & Ziegler, 2009)

- Discussion
  - the regular metrical pattern in German, the trochaic form, *facilitates* articulatory accuracy in patients with AOS
  - stressed syllables are not per se more error-prone compared to unstressed syllables (vs. Odell et al., 1991)
    - → highest error rate on the first, unstressed syllable of the iambic words (e.g., /ju/ in [ju've:l])

⇨ close link between segmental and prosodic aspects in speech motor planning (e.g., Ziegler, 2005, 2009)

Implications for therapy

Item selection in treatment planning (Aichert & Ziegler, 2010):
Trochaic words, phrases and poems

***Kas**se* (cash desk)	***ei**ne **lau**te **Pau**ke* (a loud timbal)
***Ton**ne* (barrel)	***ei**ne **fet**te **Hen**ne* (a fat hen)
***Tel**ler* (plate)	***ei**ne **dic**ke **Bac**ke* (a thick cheek)
***Mut**ter* (mother)	***ei**ne **lee**re **Tu**be* (an empty tube)

***Hat** der **al**te **He**xen**mei**ster*	*Good! The sorcerer, my old master*
***Sich** doch **ein**mal **weg**be**ge**ben!*	*left me here alone today!*
***Und** nun **sol**len **sei**ne **Gei**ster*	*Now his spirits, for a change,*
***Auch** nach **mei**nem **Wil**len **le**ben.*	*my own wishes shall obey!*
***Sei**ne **Wort**' und **Wer**ke*	*Having memorized*
***Merkt** ich **und** den **Brauch**,*	*what to say and do,*
***Und** mit **Geis**tes**stär**ke*	*with my powers of will I can*
***Tu**' ich **Wun**der **auch**.*	*do some witching, too!*
(Goethe: Der Zauberlehrling)	*(Goethe: The sorcerer's apprentice)*

Suprasyllabic aspects

Influence of sentence stress in a patient with AOS
(Aichert, Croot & Ziegler, 2009)

Croot, Au & Harper (2010)

Dash would just gaze at her, Gab could not doubt.
Rock chicks in lace and heels lag on the road.

(underline = tongue twister word)

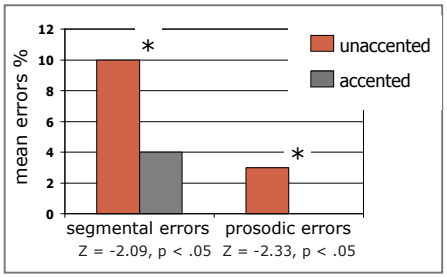
→ sentence-level prominence protects against error in normal speakers

⇨ replication of the study in a German patient with pure AOS

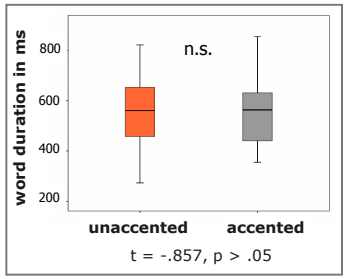
Suprasyllabic aspects

Influence of sentence stress in a patient with AOS
(Aichert, Croot & Ziegler, 2009)

- Results



Analysis of word durations



→ sentence-level prominence protects against errors in a patient with pure AOS

Implications for therapy

Item selection in treatment planning: Stressed words within phrases

e.g., Contrastive Stress Drill (Wertz et al., 1984)

clinician's question	patient's answer
WHO bought a book?	The CHILD bought a book.
WHAT did the child buy?	The child bought a BOOK.
Did the child BORROW the book?	No, the child BOUGHT the book.

Theoretical aspects and clinical implications

Summary

Theoretical aspects

- syllable as basic speech unit of articulatory programming
- the gestural scores of overlearned syllable routines have an internal architecture
- there is a close link between segmental and prosodic aspects in speech motor planning

⇔

Clinical implications

- syllable as optimal unit for speech motor „reacquisition" in patients with severe AOS
- untrained syllables / words improve after the training of phonologically related items (transfer)
- regular metrical patterns of words and stressed words in phrases facilitate the production abilities
  → control of suprasyllabic aspects may enhance speech motor learning in patients with AOS

Abteilung für Neuropsychologie, Klinikum Bogenhausen
Fachklinik Bad Heilbrunn
Fachklinik Lenggries
Kliniken Schmieder Stuttgart - Tagesklinik für ambulante und teilstationäre Rehabilitation
Kliniken Schmieder Stuttgart - Gerlingen
Logopädische Praxis Averdieck, München
Logopädische Praxis Rubi-Fessen, Köln
Logopädische Praxis Karl, München
Logopädische Praxis Seith, München
Logopädische Praxis Haulitschek, München
MUTABOR – Therapeutische Tagesstätte auf dem Stemmerhof
Neurologische Klinik Bad Aibling
Neurologisches Krankenhaus München
Praxis Dialog, München
Praxis für Logopädie Dr. Gabriela Barthel, Aalen
Praxis für neurologische u. neuropsychologische Rehabilitation Prof. Dr. Fries, München
Schwabinger Krankenhaus, München
ZAPP – Zentrum für angewandte Patholinguistik, Potsdam

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