1. Key diagnostic signs or markers

Guyette & Diedrich (1981) argued that there are no pathognomonic symptoms or necessary and sufficient conditions for the diagnosis DAS.

Thus, although it is clear that DAS causes severe, developmental speech problems, STILL there is:
1. Little agreement on which symptoms/behaviors are important
2. Paucity of data to support claims.

As a result, in clinical practice the disorder is mainly defined by exclusion. DAS is a 'label in search of a population'.
Defective level of processing

1. CAS at level of lexical representation → word form representation and retrieval
2. CAS at the level of phonological encoding
3. CAS at the level of motor planning
4. CAS at the level of motor programming
5. CAS at level of motor execution

Specific symptoms: diagnostic marker

DAS: A subtype marked by inappropriate stress
Shriberg, et al., JSLHR, 1997

Main result: 52% of 48 eligible samples from 53 children with suspected DAS had inappropriate stress, compared to 10% of 71 eligible samples from 73 age-matched children with speech delay of unknown origin.

Developmental evidence suggests that lexical stress errors are the result of incorrect word forms (rather than incorrect processing). Velleman, et al., JSLHR, 1999

The lexical stress errors of children in both SD and SD-DAS disorder groups were found to conform to patterns identified in metrical studies of younger normally developing children. Lexical metrical patterns did not differentiate the groups from each other. → low specificity

Speech characteristics in children with s-CAS referring to phonological encoding difficulties

- Poor sequencing of sounds
- Low phonemic & phonetic inventory
- Frequent vowel errors
- Substitutions of consonants
- Deviant phonological patterns
Forrest, AJSLP, 2003

- Syllable structure errors
- Anticipations / Perseverations
- Errors in Place-of-Articulation
Thoonen et al., JSHR, 1998
Clinical characteristics of CAS
- criteria for subject selection
- categorical approach
  - poorly or unintelligible speech (also reported by caregivers)
  - age-appropriate language comprehension (discrepancy criterion)
  - no evidence of dysarthria (exclusion of co-morbidity)
  - normal hearing
  - intellectual abilities within the normal range
Screening items
  - runs in families
  - deficits in expressive language skills

Specific speech characteristics of CAS
‘Difficulties with the transition from a phonological code to speech movements (articulation)’
- trial-and-error and struggle, searching or groping behavior
- sequencing difficulties with phonemes and syllables
- syllable structure errors → also complications
- inconsistency of articulation
- deviant coarticulation

History
- resistance to therapy

Development of coarticulation
Samples: “see”, “she”, “Sue”, “shoe” /si/, /ʃi/, /su/, /ʃu/
Speakers: adults and children age 3 - 7 years
Analysis:
  - second formant (F2) of vowel and fricative
  - spectral moment of fricative
Result:
  - children RE adults
  - less difference in acoustic spectral moments of fricative
  - larger effect of vowel upon fricative F2
Conclusion: children more coarticulation than adults gestures not yet aligned with speech segments.

Nittrouer, Studdert-Kennedy, & McGowan, JSHR, 1989

Speech Material

Syllable boundary: [ zusʃ#xVt ]
“zus giet” [ z uʃ #xi:t ] (sister pours) “ahuting”
“zus gaat” [ z uʃ #xat ] (sister goes)
“zus goot” [ z uʃ #xot ] (sister poured)

Syllable boundary: [ z#ʃ#sxVt ]
“ze schiet” [ z eʃ #sx:it ] (she shoots)
“ze schaatsen” [ z eʃ #sxat ] (they skate)
“ze schoot” [ z eʃ #sxot ] (she shot) "cluster"
Results

1. Syllabic structure strongly influences productions
   \(\Rightarrow\) effect of phonological encoding
2. Children with CAS show larger vowel (=context) effects.
   \(\Rightarrow\) strong coarticulation within and between syllables
   \(\Rightarrow\) evidence for motor programming deficit
3. Movement patterns of children with DAS are more variable.
   \(\Rightarrow\) a specific symptom; motor execution?

Nijland, 2003

Modular Approach \ldots leaves us with \ldots

1. CAS at level of lexical representation
   \(\Rightarrow\) word form representation and retrieval
2. CAS at the level of phonological encoding
3. CAS at the level of motor planning
4. CAS at the level of motor programming
5. CAS at level of motor execution

Percentages Syllable Productions

<table>
<thead>
<tr>
<th>Target</th>
<th>“shuting”</th>
<th>“cluster”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct</td>
<td>Omission</td>
</tr>
<tr>
<td>1 RL (5;0)</td>
<td>25.0</td>
<td>41.7</td>
</tr>
<tr>
<td>2 JB (5;1)</td>
<td>94.4</td>
<td>2.8</td>
</tr>
<tr>
<td>14 JP (5;7)</td>
<td>97.2</td>
<td>0</td>
</tr>
<tr>
<td>17 PW (5;10)</td>
<td>97.2</td>
<td>0</td>
</tr>
<tr>
<td>20 AA (5;11)</td>
<td>66.7</td>
<td>16.7</td>
</tr>
<tr>
<td>21 KB (5;11)</td>
<td>52.8</td>
<td>33.3</td>
</tr>
</tbody>
</table>

Children with DAS (age 5;10)

“zus goot” | zus#xot | (sister poured)

Results

Nijland, 2003
Kent (2004) challenged the modularity of motor control processes in general: ‘.speech, or any motor behavior, is best viewed as a cognitive–motor accomplishment.’

Bishop (1997): cognitive neuropsychology reasoning applied to acquired disorders is based on dissociation.

In developmental disorders associations are the rule rather than the exception.

Karmiloff-Smith et al. (2003): Although selective deficits in adult patients might justify claims about cognitive modularity, seemingly similar deficits found in children cannot be used to argue that such cognitive modules are prespecified in the infant brain.

gradual emergence of the adult modular system.

Smith et al. (2003): Although selective deficits in adult acquired disorders is based on cognitive neuropsychology reasoning applied to developmental disorders is based on dissociation. Karmiloff-Smith et al. (2003): Although selective deficits in adult patients might justify claims about cognitive modularity, seemingly similar deficits found in children cannot be used to argue that such cognitive modules are prespecified in the infant brain.

The synaptic weights are tuned during a babbling phase in which random movements of the speech articulators provide tactile, proprioceptive, and auditory feedback signals that are used to learn the mappings between different neural representations.
Simulation study: Methods

Manipulation of feedforward/feedback ratio during imitation learning of new utterances. Systemic mappings are fully acquired.

Symptoms assessed:
- deviant coarticulation
- speech sound distortion
- searching articulation
- increased variability

Utterances: \( V_1 \rightarrow C \rightarrow V_2 \), \( V_1, V_2 = \{ a, i, u \} \)

Fig. 2. Schematic representation of the speech sound target for /ab/. The light gray columns indicate the measurement points. At each of these points, the mean forward value was calculated over a 30 ms time window (three measurements with 10 ms time intervals).
Figure 3. Example of coarticulation: the F2 values of V1 and C differ depending on V2.

Figure 4. Anticipatory (ANT) and carry-over (COT) coarticulation for V1, C, and V3 in relation to feedforward/feedback ratio.

Figure 5. Anticipatory (left) and carry-over (right) coarticulation for different feedforward/feedback ratios.

Figure 6. Vowel distortion in relation to feedforward/feedback ratio.

Figure 7. Grooving: variability over the course of the production of speech sounds in relation to feedforward/feedback ratio.

Figure 8. Token-to-token variability: mean variability of mean formant frequencies (left) and mean standard deviation of the coarticulation, speech sound distortion, and grooving indices (right) between productions of speech sounds.
Further research
1. Test the specificity of the results by comparisons with other parameter manipulations (e.g. neural noise)
2. Further tracking phonological development and possible deficient word-form representations as the result of deviant perceptual-motor development.
3. Focus not only on specific symptoms of CAS, but also on non-specific speech and other symptoms. Secondary features are as vital as the core features in constraining a theory. Morton & Frith, 2000, (p. 358) Analyze overlap between CAS and phonological disorder at particular developmental stages.

Further research
“The phonetic parameters characterizing early words are also characteristic of prior and contemporaneous babble” Oller, Wixman, Doyle, & Ross, 1976; Stoel-Gammon & Cooper, 1984; Vihman, Macken, Miller, Simmons, & Miller, 1985
Children with a phonological disorder need more redundant acoustic information to perform a perception task, and produce less precise and less controlled (more ballistic) speech movements in a production task, as compared to age-matched controls and adults. McCune & Vihman, 2001

Speech Learning experiment
Task: Learn new syllables like: /nVC/, /nVC/, /mVC/, /mVC/
Conditions:
- Articulatory instruction without auditory target
- Auditory training, then articulatory training
Prediction:
- Due to poor systemic mapping, children with CAS profit less from auditory training than children with SSD of a different origin.

Thank you for your attention