Psycholinguistics of stuttering

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Why is this an interesting or valuable topic?

- The more we look, the more we see “linguistic” involvement in people who stutter (PWS)
  - We may need to re-conceptualize and re-evaluate available notions about the underlying deficit that produces stuttering
- However, even in the short-run, some findings, particularly in children, can inform diagnostic as well as therapeutic intervention considerations
Disclaimer

- There is now an enormous literature in this topic area –
  - I apologize in advance if I ignore a study you find important (or wrote 😊)
  - If I misinterpret you, I will insist we discuss it over lots of beer later 😊

Linguistic regularities that characterize normal disfluency and stuttering
What have we learned from typically developing children?

- Disfluency typically accompanies the earliest usages of emerging sentence structures (Colburn & Mysak, 1982; Wijnen, 1990; Rispoli & Hadley, 2001; Rispoli, 2003).
- Disfluent utterances tend to be those that are more complex within the child’s own system (Gaines, Runyan & Meyers, 1991).
  - There is a resurgence of interest in tracking early language formulation attempts (Rispoli, McKee, McDaniel, Garrett & colleagues).

- Fluency failure can be experimentally induced in typically developing children by manipulating syntactic demand (Pearl & Bernthal, 1980; Bernstein Ratner & Sih, 1987; Hall & Burgess, 2000).
  - These fluency failures tend to locate at constituent boundaries, suggesting that they are a symptom of grammatical encoding difficulty (Bernstein, 1981).
What have we learned from children who stutter?

- Stuttering in young children:
  - Tends to cluster at constituent boundaries, evidence of sentence encoding difficulty
    - *The cuddly little kitten is hiding under the chair.*
    - PARTICULARLY AT VERB PHRASE BOUNDARIES (Bernstein, 1981)
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- Stuttering ebbs and flows with measures of linguistic complexity (Bernstein Ratner & Sih, 1987; Gaines, Runyan & Meyers, 1991) and accuracy
  - Syntactic complexity more highly correlated w. utterances stuttered ($r = .954$) than length ($r = .701$) (Bernstein Ratner & Sih, 1987)
  - MLU (using traditional morpheme basis) is a better predictor of stuttering than syllable length of utterance or MLU in words (Brundage & Bernstein Ratner, 1989)

Therapeutic ramifications

- These patterns have important ramifications for programming of stuttering therapy with young children.
  - Traditional forms of therapy must take the linguistic complexity of therapy session targets into consideration, moving from easy to challenging language tasks.
  - These principles may also explain, in some part, why Lidcombe works for some children (Bonelli, et al., 2000).
Intake/outcome language measures for Lidcombe children

- This does not mean that children ‘lost language’ skills, but rather that they may have been encouraged to keep their conversational gambits more comfortably within fluency abilities.

What have we learned from children with delayed or impaired language?

- They are actually not normally fluent.
  - Moreover, they actually show more SLDs (stutter-like dysfluencies, such as part-word repetitions) than would be expected in language-normal children.
  - These patterns can be overt enough, for individual children, to prompt adults in the environment to dx them as language disordered and stuttering, which they are NOT (Boscolo, Bernstein Ratner & Rescorla, 2001, see also Hall, 1996, Hall et al., 1993).
Ex: Fluency in children with SLI

- As reported in Boscolo, Bernstein Ratner & Rescorla (AJSLP, 2002), by age nine, frequency of SLD’s was significantly different (p < .02) for children who had started as late talkers. These children had nearly twice the rate of SLDs per 100 words as their typically developing peers.

![Mean Disfluencies Observed (Grouped)]

Thus,

- There appears to be a continuum that involves language development, language proficiency and fluency (especially in terms of stutter-like disfluencies (SLDs)) in multiple populations.
General linguistic factors at stuttering onset

- Language screening scores predict chronicity (Yairi, et al., 1996; but see Yairi & Ambrose, 2005)
- Onset during rapid period of language growth (lexical spurt, morphological acquisitions)
  - Stuttering begins between 2-4 years of age, when language acquisition is dynamic, AFTER previously fluent speech production.
  - It is unattested to in the single- or two-word stage.

Syntactic factors at stuttering onset

- Stutter events gravitate toward first elements in surface constituents,
- and show a sturdy correlation with both early ungrammaticality and imposed sentence formulation demands (e.g. elicited imitation or developmental sentence scoring), both indices of encoding stress (see Bernstein Ratner, 1997; Bloodstein & Bernstein Ratner, 2007 for summaries).
Formulation difficulty and stuttering at onset

- There are strong interactions between fluency and grammaticality (stuttering children) in spontaneous speech (Bernstein Ratner, 2000)

Syntactic effects on children’s stuttering

- At onset, children will stutter more on sentences that are grammatically more advanced, or show signs of formulation difficulty (e.g., errors)
- As they grow, you can experimentally demonstrate the following:
  - Their stuttering rate is higher for their more complex spontaneous utterances (e.g., Gaines, Runyan & Meyers, 1991; Logan & Conture, 1995, 1997; Melnick & Conture, 2000; Zackheim & Conture, 2003…), but see Yaruss, 1999 as well.
  - On structured elicitation tasks, complexity is a much better determinant of stuttering than is mere length (Bernstein Ratner & Sih, 1987)
Lexical access and fluency

Lexical factors, from our labs and others...

- Silverman (Wagovich) & BR (2002) – lexical diversity reduced in CWS
  - Interesting given the loci of fluency breakdown at verb phrase boundaries
- Newman & BR (2007 and in progress) – speeded lexical retrieval in AWS/CWS
  - Not slower than peers, but sometimes downright inaccurate
  - Similar patterns of lexical organization
- Conture and colleagues: “negative lexical priming” in CWS – possible immature lexicon
- Bottom line – problems are unlikely to be purely lexical, but work on verbs can be taken to reinforce theories of syntactic formulation difficulty in PWS
The take-home message on lexical findings to date?

- Hard to provide guidance on “lexical” strategies for kids who stutter, there don’t seem to be real lexical features to their stuttering.

Phonetic/phonological factors in stuttering?

- There aren’t any, in my opinion (JFD, 2005),
  - But others, notably Howell & colleagues, disagree.
- Patterns that have been reported appear to be artifacts of other factors, such as word- or sentence-level features...
  - Examples from our kids at onset: lots of /w/, /y/, other early developing sounds are stuttered more than other sounds – why?
  - The reason is the words they are in.
Example: stuttered phoneme frequency vs. attempted phoneme frequency at stuttering onset

Why so many stuttered /w/s and /y/s?
It’s about the words, not the sounds
What about later phonological features of stuttering?

- Adults DO develop sound-based fears, that is clear.
- And children may develop a “motor memory” that requires attention to observed patterns of difficulty.
- Although there are no strong relationships between sounds in error and fluency failure in CWS, concurrent treatment of phonological and fluency targets MAY be complex, depending upon approaches used (e.g., fluency shaping vs. overt correction of articulation errors may be oppositional in emphasis) (Byrd, Wolk & Davis, 2007).

Linguistic processing in People Who Stutter (PWS)
What are the typical language skills of CWS?

- See summary in Hall, Wagovich & BR, 2007 (Conture & Curlee text)
- Some disagreement, but a number of studies show:
  - CWS score more poorly on assessments, albeit “sub-clinically”, but often significantly.
  - Some evidence of mis-matched skill domains (see Anderson & Conture studies)
  - High level of co-morbidity with other disorders (usually excluded in most studies of skill level)

Adults who stutter process language atypically

- They demonstrate atypical fMRI activation even when listening to language stimuli (see de Nil, 2005 for summary of many studies)
  - But activation studies are tough to interpret...
- They show atypical dichotic listening profiles, with reversed or no ear advantage (see Bloodstein & Bernstein Ratner, 2007 for summary)
- They show slowed, reduced and atypically lateralized ERP responses (Weber-Fox & colleagues); even in childhood (Weber-Fox et al., 2008)
- They may, in fact, have aberrant left hemisphere anatomy (Jancke, Hanggi & Steinmetz, 2004; Foundas et al., 2001, 2003, 2004; Sommer et al., 2002), EVEN IN CHILDHOOD (Chang et al., 2008)
A preview of Luc’s talk? From Sommer et al. 2002

- “...decreased white matter tract coherence in the Rolandic operculum and the inferior arcuate fascicle linking temporal and frontal language areas...” (and oro-facial motor regions)

This is normally where I would present lots of Luc’s slides, but you will get to see them soon 😊
Use an array of basic psycholinguistic techniques, and it gets interesting

- Priming (virtually exclusive to Conture and colleagues, and using children):
  - Phonological priming – no real group differences
  - Lexical priming – CWS showed “negative” lexical priming (immature mental lexicon?)
  - Syntactic priming – CWS are slower in general, and get a bigger boost from primes (suggests weak grammatical system?)
- Nang et al. (in review) no real phonological or semantic priming differences between AWS and AWNS

Other techniques

- Neighborhood studies: no real evidence of lexical organization differences in adults and older kids who stutter (Newman & BR, 2007 and others)
- Non-word repetition: some subtle deficits; more general links to capacity limitations, rather than phonological encoding per se (Hakim & BR, 2005; see also Bosshardt)
  - But not seen in adults (Weber-Fox, et al., 2008)
- Dual task paradigms – conflicting results? But perhaps not incompatible.
  - PWS seem limited (see summary, Bosshardt, 2006; newer reports soon from Nang et al., in review)
  - Fluency may be improved through dual task demands (Vasic & Wijnen, 2005)
- Memory models? Declarative vs. procedural (Ullman)
So how does a language processing problem show up as a SPEECH disorder?

- Ongoing work by Anne Smith and colleagues at Purdue has shown interesting differences in how the motor systems of PWS and PWNS “handle” language demand...
  - A fast demo... bear with me...

How to measure linguistic effects on the motor system: the spatial-temporal index

Work being done by Anne Smith (Purdue) and colleagues

Practiced motor movements:

- Thing about

Handwriting...

And its regularity across exemplars
Task: Say, “Buy Bobby a puppy”
Measure: stability of repetitive movements to obtain a spatial temporal index (STI)

Results:
Children are variable, adults are not

Over childhood, the STI is negatively affected by linguistic complexity, as in:

“Buy Bobby a puppy”

Vs

“You buy Sally a kitty and I will buy Bobby a puppy”


See also J. Kleinow & A. Smith (2000) same issue.
Adults do not typically destabilize motor ability under linguistic demand.

But, adults who stutter show motor stability effects when linguistic complexity is increased (Kleinow & Smith, 2000 -- example of AWS.)
So...

- It may be the case that the motor and language systems of PWS are imperfectly coordinated, or more easily overwhelmed by increased demands across domains.

- Note: this is NOT a simple Demands and Capacities Model – it IS testable.

Other intriguing hypotheses

- Deficits in the motor system that can be compensated for by the mirror neuron system (Kalinowski, Saltuklaroglu and colleagues)
  - PWS benefit from external excitation of mirror neurons consistent with the motor act in question – need the extra “jolt”.
  - Still doesn’t explain some of the features of early stuttering, as well as general belief that a 2 year old won’t profit from AAF.
My current preferred model of stuttering onset

Linguistic and motoric fragility

Hyperfunctional self-monitoring

Disfluency

Awareness & struggle

Learning/development of secondaries

How this information can build/improve on models of stuttering

Our current models do not adequately address:
Stuttering onset

- Why is stuttering not there at the first word? Or the first multi-word utterances?
- Why do stuttering children seem to know they have problems, when children with SLI or articulation problems are basically oblivious?

- A personal opinion: we need to concentrate on kids close to onset to figure out what stuttering is – it changes too quickly after that to draw good conclusions
  - Would we study SLI this way?

From adults to children: Problems in modeling stuttering onset

- Although stuttering is widely viewed as a disorder of speech motor control, abnormalities in speech motor function are not seen in early stages of the disorder, and become apparent only later (Kelly, Smith & Goffman, 1995).
- Stuttering is not present at the onset of language acquisition, but has its onset after children develop rudimentary syntax (Bernstein Ratner, 1997).
How a problem either resolves or becomes chronic

- If 80% get better within ~ 2 years, what does this tell us?
  - One predictor is language strength – what are the others?
- Can a problem that starts with a transient limitation become permanent?
  - I think it is possible

We have a need to place stuttering within general models of speech/language production.
Levelt’s Model of Speech Production

Important addition of the self-monitoring and editing function

And the syllabary – frequent combinations of phonemes that allow rapid phonological realization

Estimates that 500 most frequent syllable TYPES account for 80% of spoken TOKENS

We have made initial attempts...

- E.g., the Covert Repair Hypothesis,
  - But not much empirical support, especially in children, in whom the problem first arises...
  - But, the problem could be in areas not targeted to date, such as levels “further back” from pre-articulatory stages and self-monitoring
    - I prefer the lemma level to those further down the chain.
    - Or, the problem could/is likely to involve multiple areas that then intersect with the motor system.
**Lemmas:** entries that include both meaning and grammatical properties of the word (gender, potential structures in which it may participate, such as verb argument possibilities, etc.

**Phonological word**
(Previous slide): units of production that include content words and functors to which they are attached, e.g. "He decided to defend" actually creates syllable boundaries that do not match lexical entries for the verb and pronoun.

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What “bridges” currently work best?

- What area of linguistic formulation is likely to be most fragile in PWS?
  - My vote: syntax or verbal morphology
  - Why?
    - Phonology just doesn’t seem to make it:
      - We should see problems from first words
      - Recent proposals (e.g., that the syllabary is vulnerable in PWS) don’t explain the very clear syntactic regularities at stuttering onset.
    - The lexicon findings seem muddy –
      - Which makes sense if some of the grammar is “projected” from the lexicon (e.g., picking a word forces its grammatical “consequences” for sentence planning), a tenet of most current linguistic theories.
Will that be enough?

- No, I personally think we will need to build in either/both
  - Self-monitoring differences
  - Motor differences
  - Temperamental differences
    - That convert fluency failures into stutters – they are not the same thing.

Future opportunities and challenges
Challenge: thinking multi-dimensionally

- We can’t stick to modular models and dichotomous reasoning – it hasn’t worked for other branches of cognitive psychology, and probably won’t work for us.
  - Motor vs. linguistic, learned vs. innate, emotional vs. physiological, etc.
- Motor theories can’t explain stuttering onset well, or the regular features of early stuttering;
- Linguistic theories can’t explain why fluency breakdown looks like STUTTERING and not normal disfluency.
Bridging between etiology and treatment:

- What causes stuttering may, in the end, not be most helpful in treating it.
  - The cognitive, affective as well as behavioral features of stuttering arise quickly, and require serious therapeutic attention
    - Some arise within a week of onset, in my experience
- So, I’d like to end on a less theoretical note...

Language production in the real world: pragmatics and fluency

- Lots of things will predict fluency in typical as well as atypical speakers
  - Some of them are the things we’ve just talked about
  - Others are broader issues of “generalization”, challenge and learning
    - Task demands by level of
      - Spontaneity
      - Conversational pressure (addressees, topic, pacing)
      - Listener responses
  - PWS are just like the rest of us, and this needs to be built into therapy...