4pSC4

Acoustic phonetic variability and auditory word recognition by dyslexic and non-dyslexic children

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Introduction

- Dyslexics show a phonological awareness deficit, and some are impaired in phoneme categorization
- Not clear whether impaired in normal auditory word processing
- Bonte & Blomert (2004) ERP study suggested normal late-stage lexical access, but deviant early acoustic → phonological processing

Acoustic variability and normal word processing

- Trial-to-trial acoustic phonetic variation due to talker voices, speaking rate, style, and tokens impairs spoken word recognition (Sommers & Barcroft 2006 review; Ryalls & Pisoni 1997 for children)
- Effects of talker and rate variation seen when processing is “slow and effortful” (McLennan & Luce 2005)

Talker and allophone variability

- Words spoken by multiple talkers are recognized more slowly and less accurately compared to single talkers (e.g. Mullenix et al. 1989)
- Different allophones of a phoneme (e.g. released/unreleased final stop consonants) likewise provide personal/stylistic variation without lexical ambiguity

Research questions: Variability

- Do children demonstrate less accurate/slower recognition of words with greater acoustic variability due to different talkers?
- Do children demonstrate less accurate/slower recognition of words with greater acoustic variability due to different allophones?

Research questions: Dyslexia

- Do dyslexic children demonstrate less accurate/slower word recognition than non-dyslexic children with greater acoustic variability due to talkers?
- Do dyslexic children demonstrate less accurate/slower word recognition than non-dyslexic children with greater acoustic variability due to allophones?

Method: Word recognition task

Subjects hear:

- A prompt suggesting the target word
- The target word
- A series of 7 test probes, which are either the same word as the target, or a different (phonemically overlapping) word

Subjects respond:

- For each probe, press a key or button for "same word" or "different word"

Computer records choice and latency.

Method: Talkers

- All targets: 1 Californian woman
- Test probes in trials with single talker: same Californian woman
- Test probes in trials with multiple talkers: 2 Californian men, women, boys, girls (the women different from the one above)
- Mixed talker trials vary not only in voice (including age and sex), but in personal speaking rate and to some extent style, especially with children

Method: Wordlist

- All high-frequency words familiar to children
- Target words for Talker trials:

  cake, big, teach, pool
- Target words for Allophone trials:

  trade, hit, quit, treat
- Foil words vary in initial consonant, vowel, or final consonant

Single vs. Mixed talker trials

- Target stimuli are same in both sets
- In 4 Single talker trials, target voice also produces the probes
- In 4 Mixed talker trials, target voice does not produce any probes
- Number of match probes in a trial is 3 or 4 (randomized)
- Order of probes in trials randomized
- Order of Single and Mixed trial blocks balanced across subjects

Sample trials:
Single vs. Mixed talkers

Prompt	Prompt
Target: **TEACH**	Target: **TEACH**
Probes:	Probes:
1. **teach**	1. teeth
2. **teach**	2. **teach**
3. tale	3. **teach**
4. peach	4. **teach**
5. teeth	5. **teach**
6. **teach**	6. tale
7. **teach**	7. peach

Allophone trials

- 4 Allophone trials all use multiple talkers
- Target voice is always among the probe voices
- 2 targets have unreleased final stop, 2 targets have released final stop
- 4 match probes in each trial:
  - SAME voice as target, vs. different
  - SAME allophone as target, vs. different

Sample allophone trial

Prompt

Target: **QUIT** (released /t/)

Probes:

1. pit
2. **quit** (unreleased /t/)
3. **quit** (released /t/)
4. quite
5. **quit** (released /t/)
6. quiz
7. **quit** (unreleased /t/)

Bells and whistles in methods for child listeners

- Practice items before new blocks
- Trials blocked into game-like "levels" with encouraging screen displays
- Spoken prompts to suggest what the target word is (in a voice different from any of the stimulus voices)
- RT countdown bar to encourage responses under 2 sec

Method: Subjects

- 10 dyslexics, 10 controls
  - Dyslexics at or below 25th percentile on one or two subtests of Woodcock test of reading ability (words, nonwords)
  - Controls at or above 40th percentile on both subtests
- All have normal performance IQ
- Age ranges in both groups 8–14
- Groups not yet carefully matched on all variables

Data analysis

- Scoring: eliminate errors, too-short RTs; replace RTs longer than 3 SDs with 3 SDs
- RTs corrected for word duration
- Foils not analyzed, only matches
- Separate analyses of Talker variability trials vs. Allophone variability trials
- Due to missing values, some averaging, but some cells empty

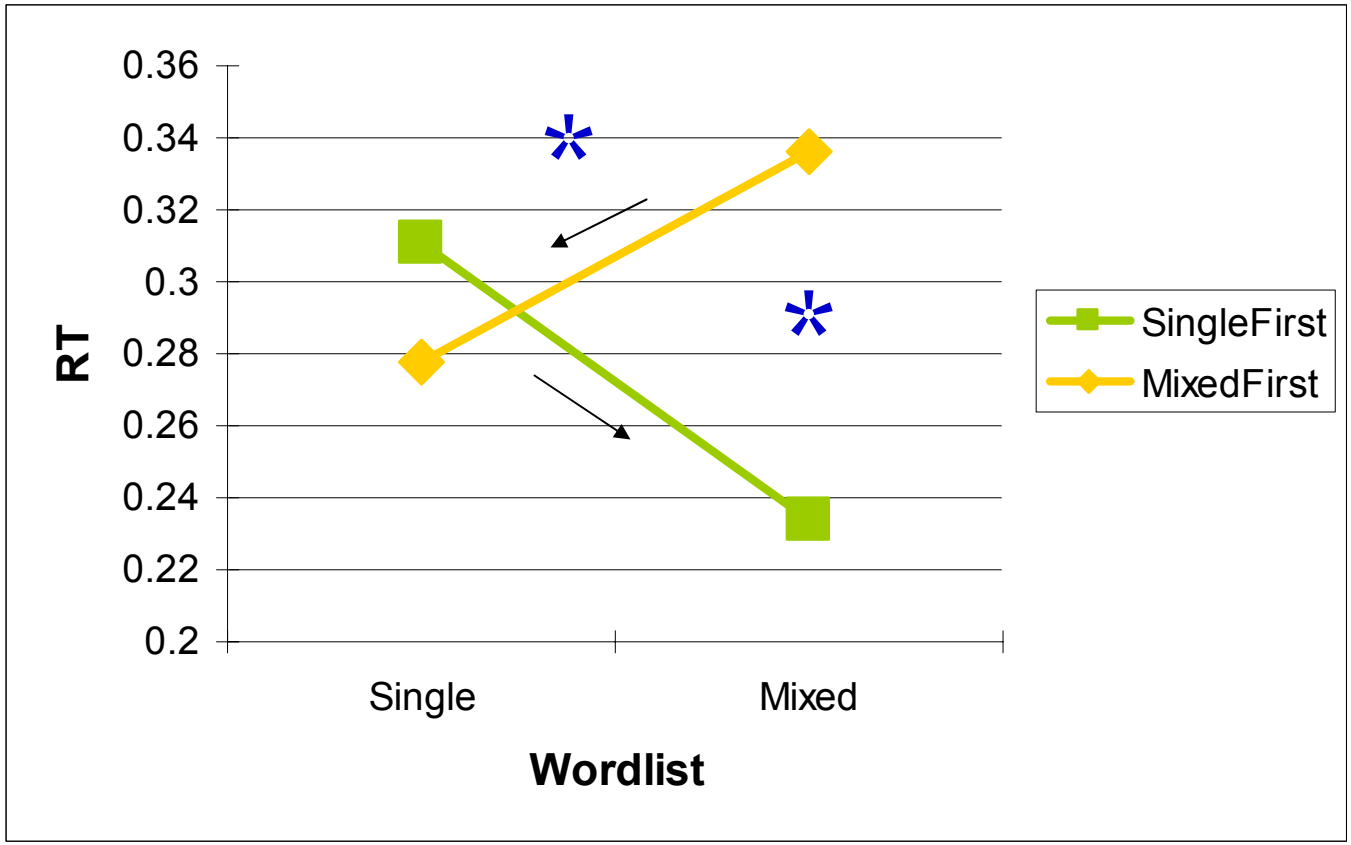
Analysis of Talker trials

- 1 datapoint per trial: average RT of correct matches
- RM ANOVA
  - Between-subject factors:
    - Group (dyslexic, control)
    - Wordlist (order1, order2)
  - Within-subject factors:
    - Talkers (target voice, mixed voices)
    - Word (big, cake, pool, teach)

Results: Talker variability

- In the Talker variability trials, is a mixed set of voices harder (slower)? (Talkers factor)
  - No effect of Talkers (no main effects at all)
- Does the order of conditions matter? (Wordlist interactions)
  - Talkers x Wordlist interaction
  - Mixed talker trials are slower when they are heard first, and those subjects are faster when they then hear the Single talker trials

Talker x Wordlist interaction



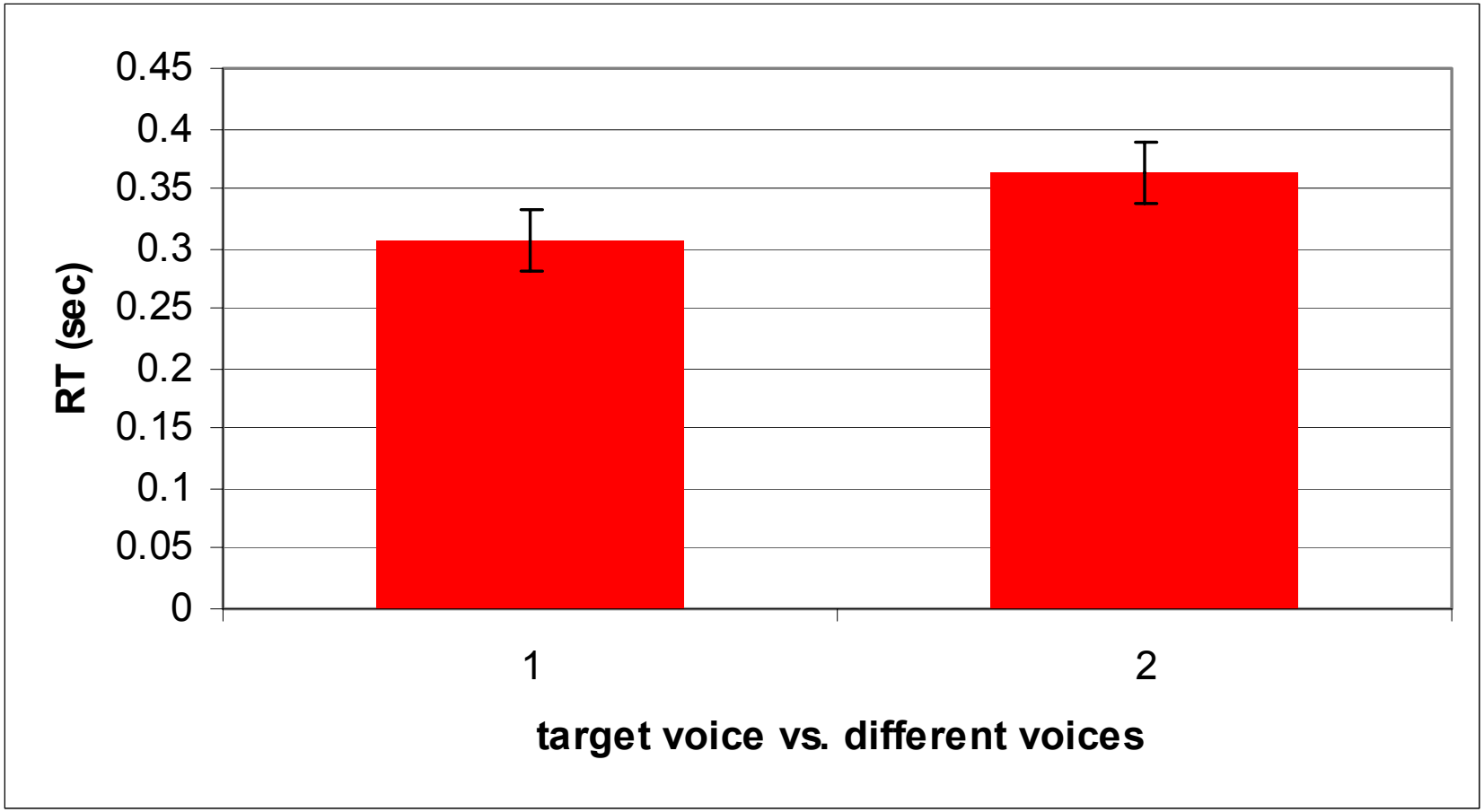
Analysis of allophone trials

- 1 datapoint per match probe
- Averaged 2 trials with released stop targets and 2 with unreleased targets
- 2 RM ANOVAs
  - Between-subject factors:
    - Group (dyslexic, control)
    - Wordlist (order1, order2)
  - Within-subject factors:
    - Talker (target voice, other voice)
    - Allophone (released, unreleased)

Results: Talker variability

- In the Allophone variability trials, is a probe harder (slower) when the voice is different from the target voice? (Talker factor)
  - Main effect of Talker in trials with released stops in targets
  - Probes with voices different from target voice are slower than probes with the target voice

Effect of Talker on RT

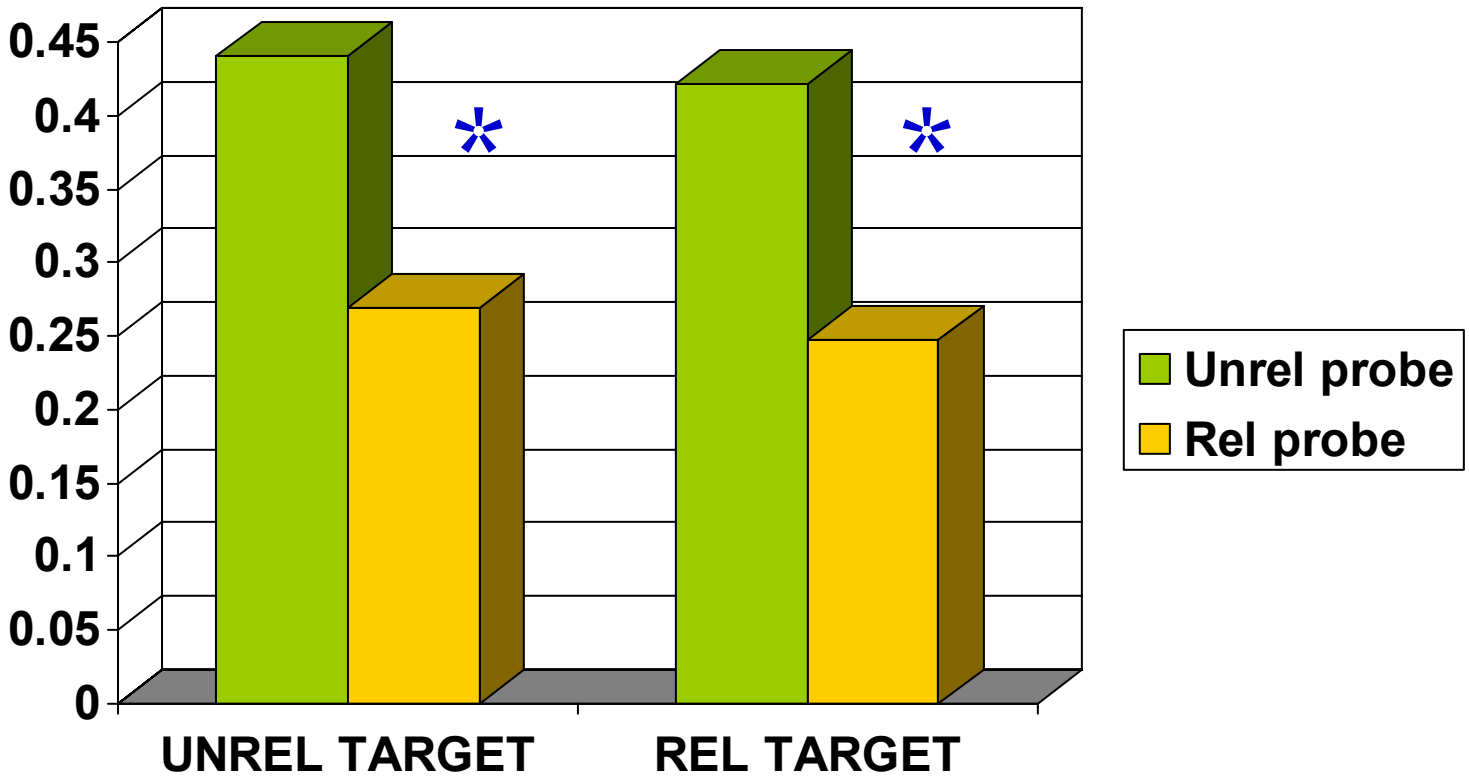


Results: Allophonic variability

In the Allophone variability trials, is a probe with a different allophone harder (slower)? (Allophone factor)

- Main effect of Allophone in both analyses:
- Probes with unreleased allophone are slower than probes with released allophone, whether it matches the target allophone or not

Allophones in targets & probes

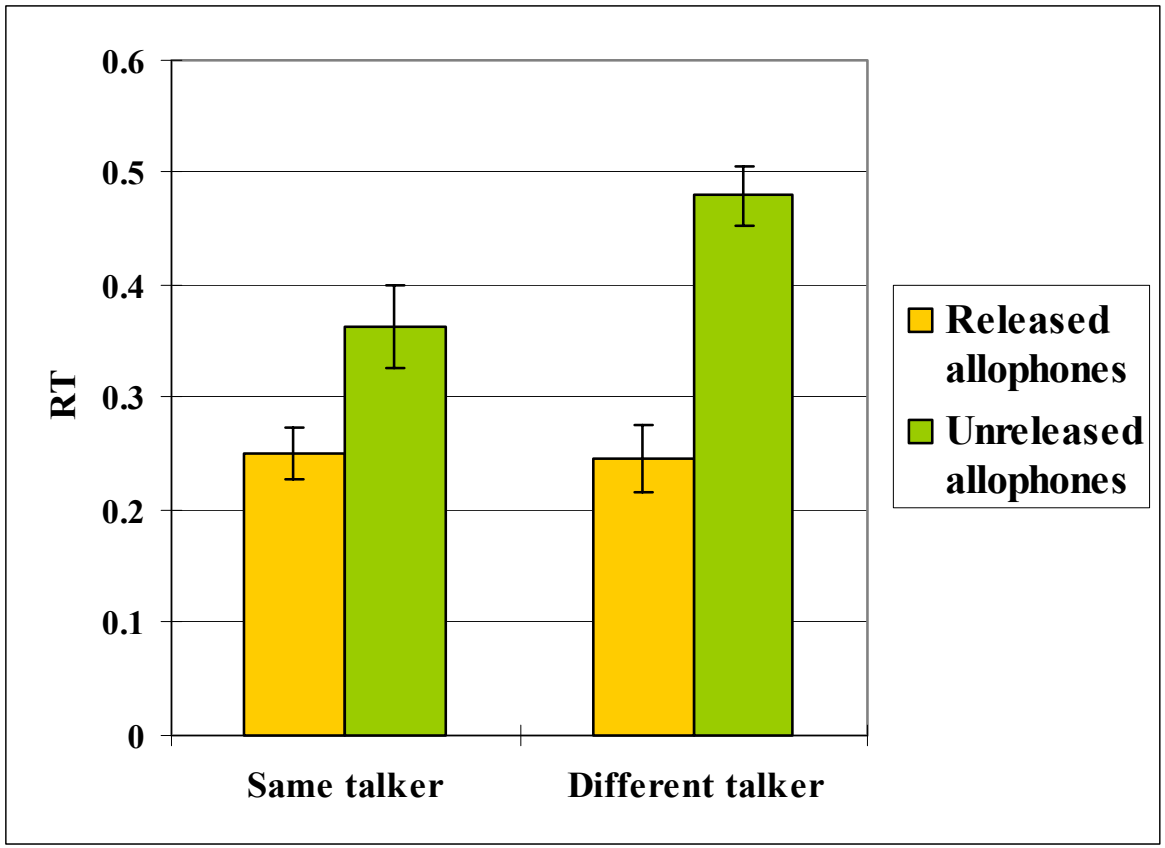


Results: Allophonic variability

Is it even harder (slower) when the talker also varies? (Talker interactions)

- Allophone x Talker interaction in trials where target has a released allophone:
  - Unreleased allophone probes are especially slow in a different voice
  - Talker effect only with unreleased allophone probes

Talker x Allophone interaction with released allophone targets



Summary: Talkers

- In the Talker variability trials, there was no overall effect of Single talker vs. Mixed talkers; listeners were slowest on Mixed talker trials when heard first (same result as Ryalls & Pisoni 1997)
- In the Allophone variability trials with released stop targets, listeners were slowest on unreleased allophones in a different voice from the target

Summary: Allophones

- In the Allophone variability trials, unreleased allophones are slower regardless of the target allophone
- Only when the target stop is released, do other effects of interest arise: Talker, Group

Why are released stops special?

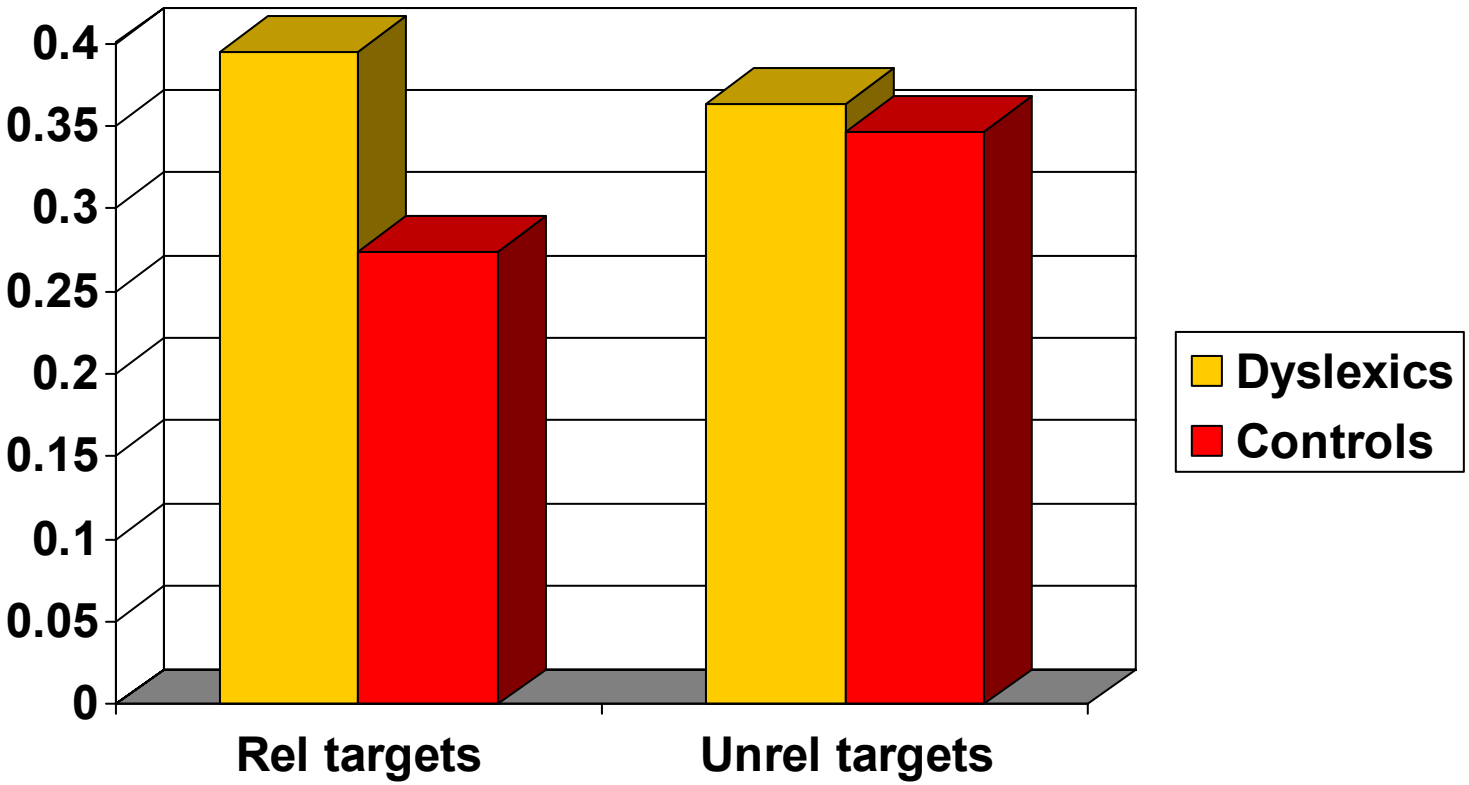
- Released final stops are a form of clear speech; they are presumably better exemplars of the stops
- Better exemplars produce more lexical activation and faster word recognition (Streeter & Nigro 1979, Andruski, Blumstein & Burton 1994, McMurray, Tanenhaus & Aslin 2002, Blumstein 2004) – which we see here with generally faster recognition of released probes
- Perhaps activation of released target also facilitates comparison with probes

Results: Dyslexia

Main effect of Group in trials where target has a released allophone:

- Controls are faster than dyslexics
- No significant interactions of any factors with Group (e.g. the groups share the Talker x Allophone effect of slower unreleased stops in a different voice)

Group difference by target



Summary: Dyslexia

- Dyslexics are slower than controls in a subset of trials: Allophone trials with released allophone targets
- Specifially, dyslexics are not any faster with released allophone targets than with unreleased allophone targets

Overall summary

- Children re Talker variability: Effects in some conditions, but not all
- Children re Allophone variability: Unreleased allophones are slower; whether it matches target doesn't matter
- Dyslexic children re Talker variability: Perform like controls
- Dyslexic children re Allophone variability: Slower than controls on some targets; perform like controls re probes

References

Andruski, Blumstein & Burton (1994) The effect of subphonetic differences on lexical access. *Cognition* 52: 173–187

Blumstein (2004) Phonetic Category Structure and Its Influence on Lexical Processing, *Proceedings of the 2003 Texas Linguistics Society Conference: Coarticulation in Speech Production and Perception*, ed. Agwuele et al., Cascadilla Proceedings Project

Bonte & Blomert (2004) Developmental dyslexia: ERP correlates of anonalous phonological processing during spoken word recognition, *Cogn Brain Res* 21: 360–76

McLennan & Luce (2005) Examining the Time Course of Indexical Specificity Effects in Spoken Word Recognition, *J. Exp. Psych: LMC* 31: 306–321

McMurray, Tanenhaus & Aslin (2002) Gradient effects of within-category phonetic variation on lexical access. *Cognition* 86: B33–B42

Mullenix, Pisoni & Martin (1989) Some effects of talker variability on spoken word recognition, *JASA* 85: 365–378

Ryalls & Pisoni (1997) The effect of talker variability on word recognition in preschool children, *Dev. Psychol*. 33: 441–52

Sommers & Barcroft (2006) Stimulus variability and the phonetic relevance hypothesis: Effects of variability in speaking style, fundamental frequency, and speaking rate on spoken word identification, *JASA* 119: 2406–2416

Streeter & Nigro (1979) The role of medial consonant transitions in word perception, *JASA* 65: 1533–1541