

# Perceptual sensitivity to within-category acoustic variation by language impaired and typically developing adolescents.

Cheyenne M. Munson<sup>1</sup>, W. Dan McEchron<sup>1</sup>, Bob McMurray<sup>1</sup>, J. Bruce Tomblin<sup>2</sup>

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## Motivation

Typical work in speech perception focuses on mean performance, leaving the source of individual differences unexamined. Do individual differences in speech perception matter?

They do, if such differences in speech perception have functional consequences for higher levels of processing. There are two possibilities:

- Differences in speech perception cascade up the levels of the language processing system so that problems in perception lead to problems at higher levels.
- Higher levels of language processing are robust against differences in speech.

To understand the impact of speech perception on language, we should investigate processing in people varying along different dimensions of functional language use.

Specific and non-specific language impaired (LI) listeners can be characterized as having broad, overall deficits in language at multiple levels. If speech and language abilities are related we would expect to find differences in speech perception as a function of LI. Critical to testing this hypothesis is the ability to simultaneously measure variation in speech perception and relate it to processing at later stages (e.g. word recognition) and functional language ability.

## Categorical Perception in LI

Children with LI may have deficits in categorical perception (CP), at times performing less categorically than their peers (e.g. Tallal & Piercy, 1974; Sussman, 1993).

However, deficits may appear as a function of task demands and stimuli (Coady, Kluender, & Evans, 2005; Coady, Evans, Mainela-Arnold, & Kluender, 2007).

Research with typical listeners also suggests CP is largely an artifact of task (e.g. Schouten & Van Hoesen, 1992; McMurray, Aslin, Tanenhaus, Spivey & Subik, in press), so CP may not be the right way to measure speech perception in any population.

Finally, speech perception is difficult to measure directly. There are clear influences of decision processes and lexical structure on even simple phoneme judgments (Norris, McQueen, & Cutler, 2000; Newman, Sawusch, & Luce, 1997).

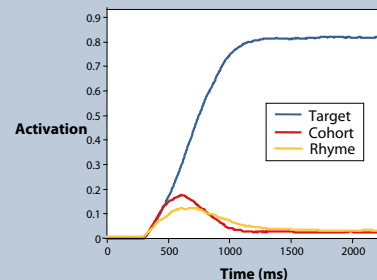
**Online spoken word recognition** offers an alternative.

- Measures the functional output of speech processing
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## Word Recognition

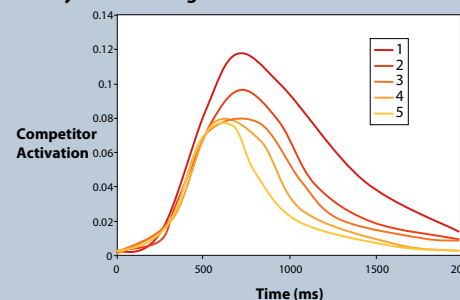
Online word recognition studies show that listeners hearing a target word (sandal) temporarily activate:

target (sandal) rhymes (candle) cohorts (sandwich)



In word recognition, issues of CP can be reframed as whether within-category acoustic detail is preserved (**gradient**) or discarded (**categorical**) (McMurray, Aslin, Tanenhaus, Spivey, and Subik, in press; McMurray, Tanenhaus, 2002; Andruski, Blumstein & Burton, 1994).

**Gradiency in word recognition:**



This task allows us to tap two aspects of language comprehension:

1. **Low level speech perception:** sensitivity to within-category detail.
2. **Overall lexical activation:** target activation/competitor inhibition.

## Logic

To evaluate the relationship between speech perception, higher level language, and functional language use, we aimed to measure differences in speech processing and word recognition for groups of listeners with typically developing (TD) and impaired language skills.

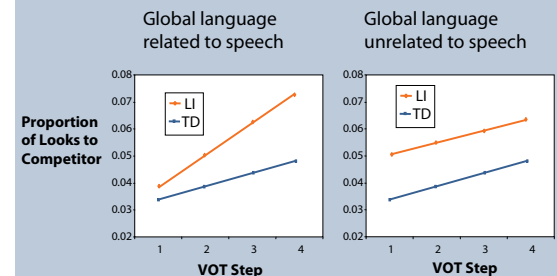
To do this we used an online word recognition task that assessed sensitivity to within-category variation in VOT for LI and TD listeners.

If variation in global language ability is due to cascading deficits speech, we ought to find differences in within-category sensitivity related to overall language.

- Deficits in CP suggest that if groups show different within-category sensitivity, the LI listeners will be more sensitive.
- Enhanced sensitivity could arise from perceptual differences or from general causes, such as heightened activation for lexical competitors (McMurray, Samelson, Lee & Tomblin, 2006, submitted).

If global language is not related to speech, within-category sensitivity will be the same, though we may see differences in higher level abilities (like word recognition).

- We know that LI adolescents show less activation for targets and increased activation for cohorts and rhymes compared with peers (McMurray, Samelson, Lee & Tomblin, 2006, submitted).

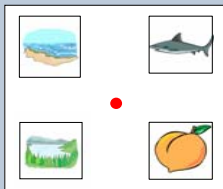


# Methods

## Procedure

Used visual world paradigm of McMurray et al. (2002).

On each trial participants were presented with four pictures on a computer screen (e.g. beach, peach, lake, and shark).



Participants heard an auditory stimulus and selected the corresponding picture.

- Auditory stimuli consisted of VOT continuum (e.g. beach/peach).

Eye-movements were monitored during the task.

Fixations were used as a measure of strength of lexical activation for different items.

## Stimuli

Auditory stimuli consisted of six 9-step VOT continua ranging from 0-40 ms. Both endpoints of each continuum were picturable words:

beach/peach	beak/peak
bail/pail	bear/pear
bees/peas	bin/pin

Stimuli were constructed from recordings of natural speech as in Coady et al., 2005.

Six L-initial words and six Sh- initial words were used as fillers along with the critical stimuli.

Each continuum step repeated 5 times.

## Participants

32 TD and 37 LI adolescents (14 – 20 y.o.)

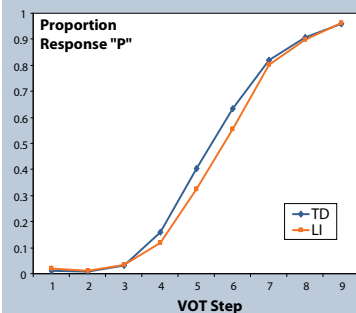
Language status assessed with epiSLI criteria of Tomblin, Records and Xhang (1996).

## Predictions

LI listeners may show more gradient patterns of lexical activation.

LI listeners may show different levels of activation for lexical competitors.

# Results



## Mouse-click analysis

Both LI and TD showed standard categorization functions.

- No group difference (LI group no more categorical).
- Replicates Coady et al. (2007), again with natural speech.

# Results

## Data processing

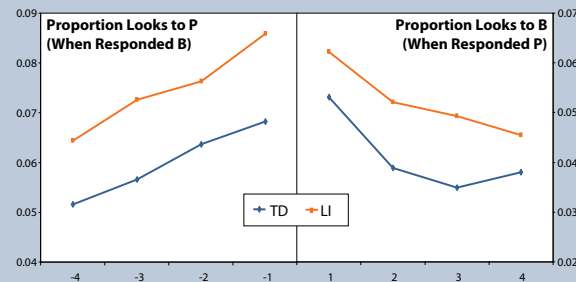
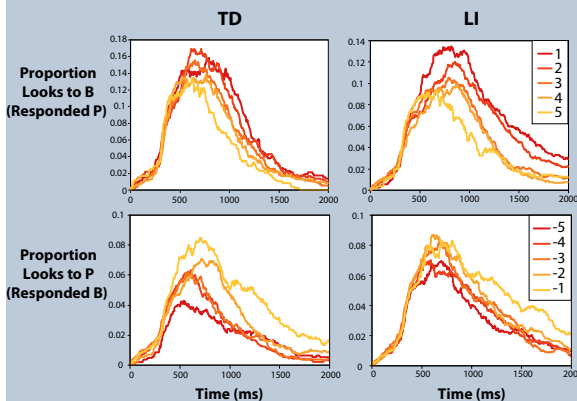
Logistic functions fit to each participant's data to obtain individual category boundaries.

Only trials for which participants clicked on correct targets (according to their boundaries) were used during analysis.

- Changes in looks to the competitor (the item on the other end of the continuum) must be due to **within-category** variation.

Category boundaries also used to re-compute VOT for each person

- Step was relative to individual category boundary rather than group mean.
- More **conservative** measure of within category sensitivity: boundary variation can't contribute to gradiency.



## Eye-movement analysis

LI group showed a higher activation for the competitor

- B side ( $F(1,65)=4.39, p < .05$ )
- P side ( $F(1,59)=4.92, p < .05$ )

Proportion of fixations to the lexical competitor showed sensitivity to within-category variations in VOT.

- B side ( $F(1,65)=16.00, p < .001$ )
- P side ( $F(1,59)=5.18, p < .05$ )
- As VOT approached the boundary, competitor fixations increased.

This gradient effect of VOT did not interact with language status on either side of the boundary ( $p > .1$ ).

The analysis was repeated without the two steps closest to the boundary (-1 and 1) to be conservative.

- Gradient effect was still found on both sides of the continuum (both  $p < .01$ ).
- Effect not solely due to enhanced sensitivity near the boundary.

# Conclusions

## Summary

For both TD and LI listeners, activation for competitors was systematically related to VOT, even within the category:

- Gradient sensitivity to VOT (speech perception) was not affected by language status.

LI participants showed more activation for competitors overall.

## Implications

If LI listeners are insensitive to fine-grained detail (the Tallal hypothesis), they should not have shown such gradient sensitivity.

If LI listeners perceive speech non-categorically they should have shown heightened gradient sensitivity.

Inhibition of competitors on a lexical level, rather than differences in perceptual sensitivity, may underlie perceptual problems for LI listeners.

Global language ability appears to be:

- Not directly tied to perceptual processes
- Related to lexical processes (inhibition of competitor)

Word recognition may be a robust process (against individual differences in speech perception ability). Language and speech perception abilities are not systematically related.

# References

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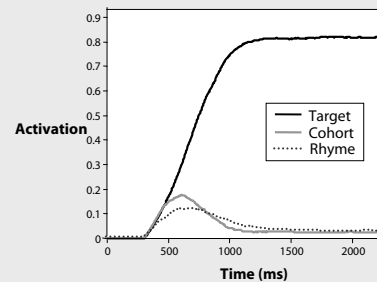
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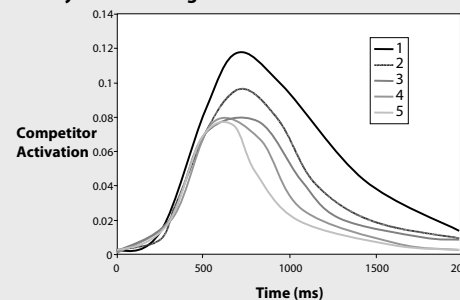
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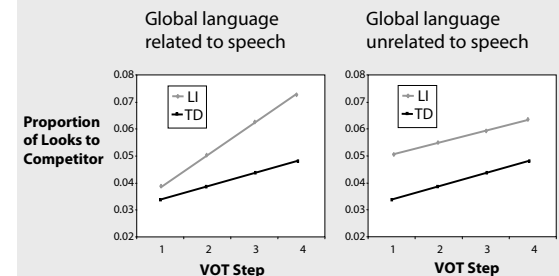
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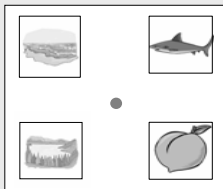


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## Stimuli

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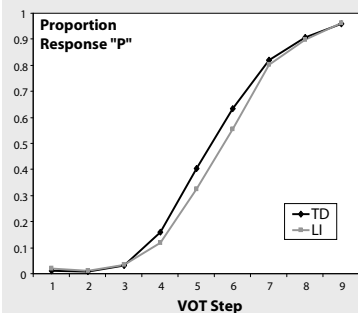
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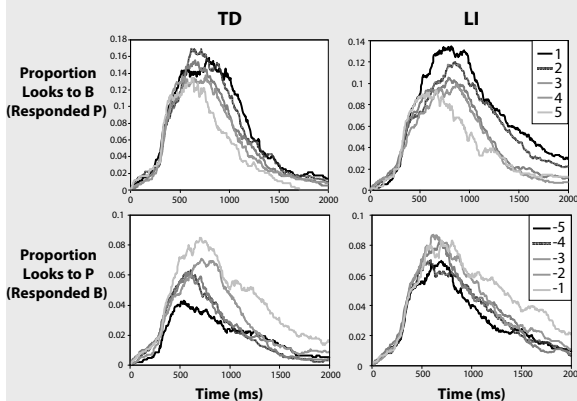
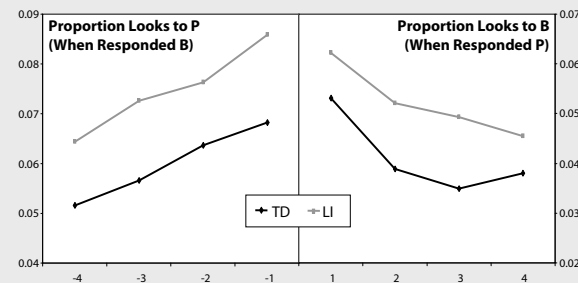
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