

The Role of Language in Medication Errors

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THANK YOU

I'm a cognitive psychologist

- I study
 - language

<http://web.mac.com/languageresearch>



LANGUAGE RESEARCH LABORATORY

I'm a cognitive psychologist

- I study
 - language
 - language perception
 - spoken word recognition
- What does that mean?
 - how we *represent* and *process* spoken words
 - when are we more or less likely to make mistakes
 - perceptual errors

Collaborators

- Bruce Lambert

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

- Paul Luce

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Collaborators

- Swu-Jane Lin
- Clement T. Yu

- David Lewis
- David Tcheng

- Laura Walsh Dickey
- William M. Fisher

- Robert D. Gibbons

- John W. Senders

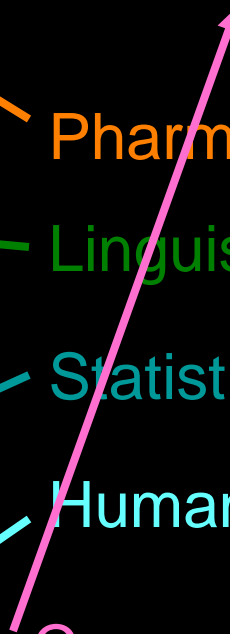
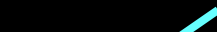
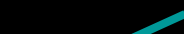
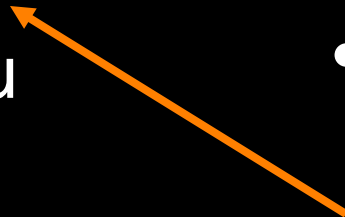
Pharmacy Administration

Linguists

Statistician

Human Factors

Computer Programming



Funding

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Quality

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Context

- Sound alike confusions play a threat to patient safety
- *Aren't most prescriptions written?*
 - See Labert, Chang, and Gupta (2003)
- *Memory* (false recognition) for drug names
 - See Labert, Chang, and Lin (2001)

Context

- Roughly 3.8 billion prescriptions dispensed in outpatient pharmacies annually in the United States (as of November 2008)
 - *Not to mention spoken orders in inpatient settings*
- Telephone orders account for 3-4% of total prescription volume
- 114 million telephone prescriptions per year
 - 312,000 phone orders per day
- 1.4% error rate would still result in
 - 1.6 million errors per year
 - 4,368 errors per day

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Context

- Cell phones may increase the risk of perceptual errors
- Many published examples of errors, some with fatal consequences
 - Liquibid vs. Lithobid
 - Klonopin vs. Clonidine

Objectives

- The FDA and the pharmaceutical industry have struggled to develop *methods for evaluating the confusability of new drug names*
- Predict the probability of auditory perceptual errors
- Develop a process for designing safer, less confusing drug names
- Using established experimental paradigms
- How - and to what extent - characteristics of *drug names, order takers, and background noise* impact listeners' ability to identify spoken drug names accurately

Theoretical Background

- The Neighborhood Activation Model
 - activation-competition model of spoken word recognition

Theoretical Background

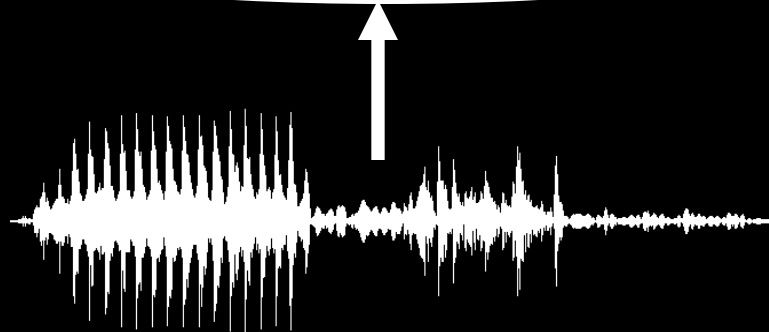
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activation levels

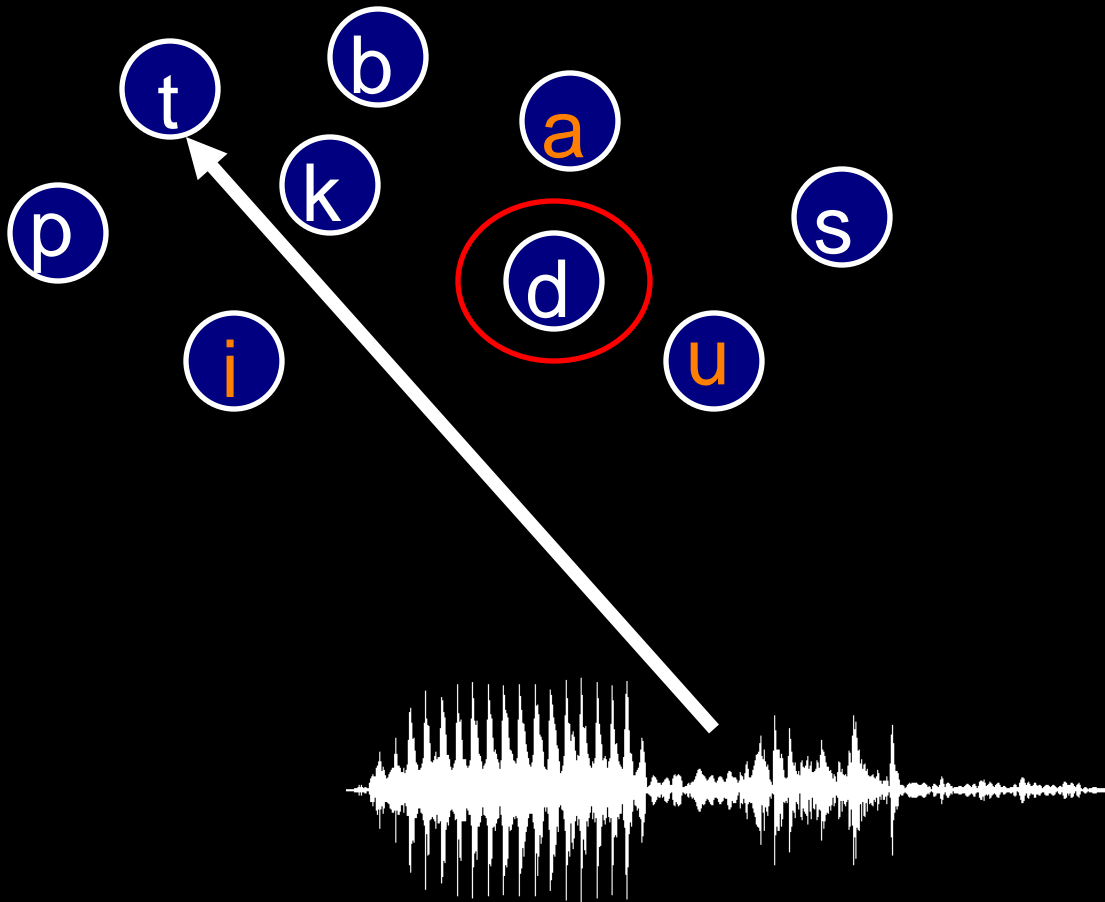
frequency



activated to the degree to
which they match the input



activated to the degree to which they match the input



activation levels

frequency

word decision units

pat

tab

dab

sip

p

t

b

k

a

s

i

d

u



activation levels

frequency

word decision units

cot

cat

o



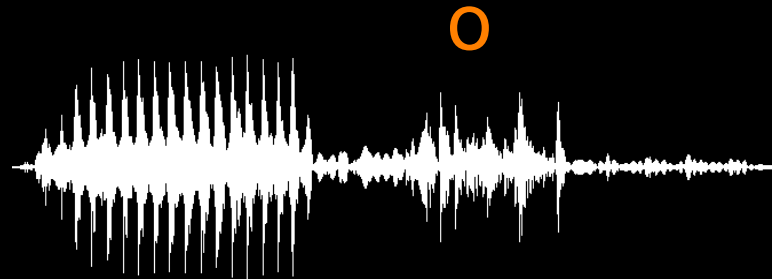
activation levels

frequency

word decision units

cot

cat



activation levels

frequency

word decision units

cot

cat

noise

?



activation levels

frequency

word decision units

cot

cat



bat

substitution

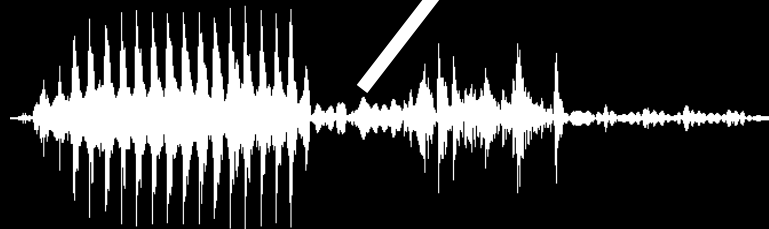
cast

addition

__at

deletion

cat



35 neighbors

cut

bat

cab

cash

calf

cart

cast

that

cap

sat

kit

at

rat

cat

pat

mat

hat

fat

cot

curt

kite

chat

can

coat

nat

tat

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35 neighbors

cut

bat

cab

cash

calf

cart

cast

that

cap

sat

kit

at

rat

pat

cat

hat

fat

cot

mat

chat

can

coat

curt

kite

caught

can't

nat

tat



boom

room

7 neighbors

zoom

doom

tomb

zoo

womb

loom



NAM states that errors are a function of

- intelligibility of the word
- frequency
- *similarity* and *frequency* of neighboring words

What this means for our work

- Errors to a given drug are **more** likely when that drug
 - is hard to hear
 - background noise
 - has more neighbors
 - is more similar to its neighbors
 - has higher frequency neighbors
 - prescribing frequency

Method

- Participants
- Design
- Stimuli
- Procedure


Participants

- **Pharmacy students**
 - 2005 at the University at Buffalo
- American Association of Family **Physicians**
 - 2005 in San Francisco
- American **Pharmacists** Association
 - 2005 in Orlando
- Academy of Medical Surgical **Nurses**
 - 2005 in Las Vegas
- **Lay people**
 - Members of the Cleveland State University community
 - 2007 - 2008 academic year

Design

- 198 drug names
- Every participant heard ALL 198 drug names
- Background babble
- Three different signal-to-noise (S/N) ratios

Stimuli

- Amplitudes of the drug names manipulated to create three S/N conditions
- Amplitude of the babble was constant
- Babble: 65 db
- Drug names: 63, 68, 73 db


Experimental design: Counterbalanced lists

- List 1

coldrine (-2)

aquatarn (+3)

nestrex (+8)

- List 2

coldrine (+8)

aquatarn (-2)

nestrex (+3)

- List 3

coldrine (+3)

aquatarn (+8)

nestrex (-2)

Procedure

- Hearing screening
- Main experiment
- Accent and familiarity phase

Procedure

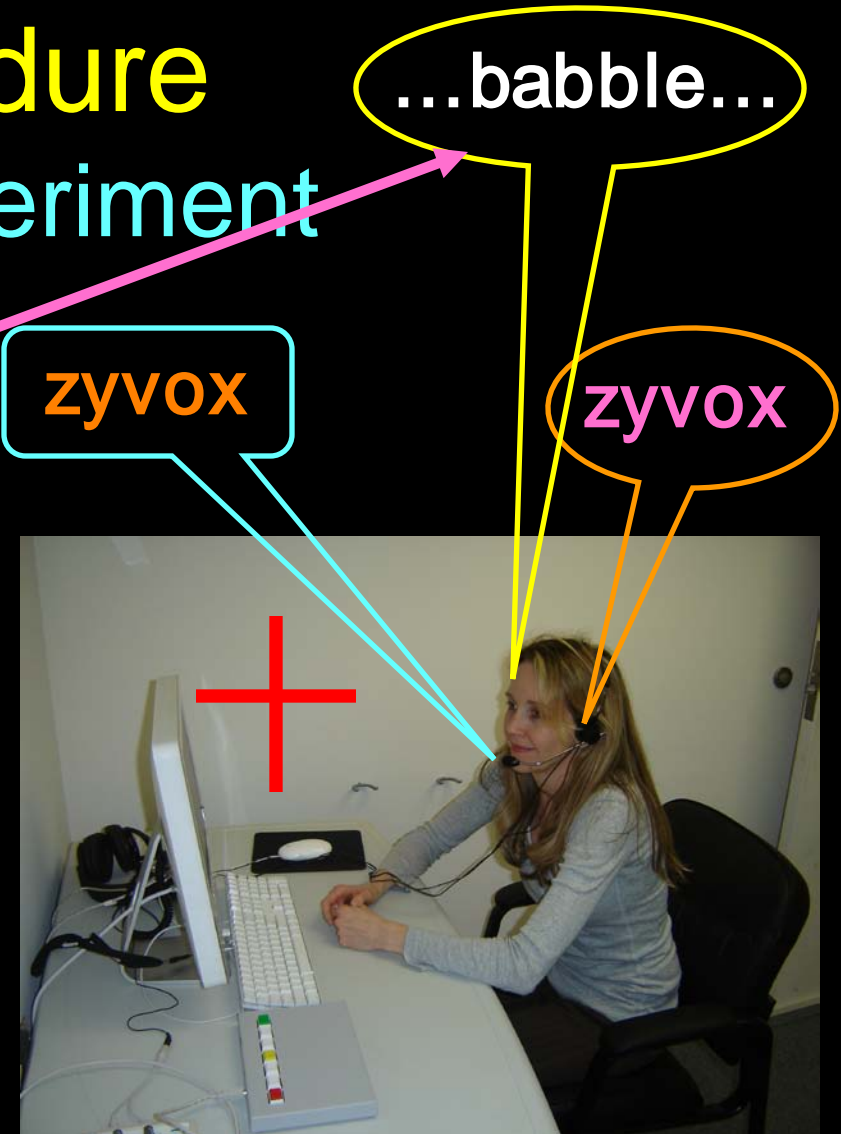
Hearing Screening

- *Rough* hearing screening using a recently calibrated audiometer
- 40 db or less at 500, 1,000, 2,000, & 3,000 Hz
- Only a few participants “failed” hearing screening

Procedure

Main Experiment

- Participants heard continuous babble
- Participants saw a large red cross
- Participants heard a spoken drug name
- Instructed to repeat the drug name as *quickly* and *accurately* as possible
 - responses were recorded



Procedure

Accent and Familiarity Phase

- Participants **saw** a drug name on the screen
- Instructed to pronounce the drug name as *quickly* and *accurately* as possible
 - **responses were recorded**
- Participants rated their familiarity on a 1-7 scale
 - 1 = not familiar
 - 4 = somewhat familiar
 - 7 = very familiar

zyvox

zyvox



Scoring Spoken Responses

- 249 participants
 - 62 pharmacists
 - 74 physicians
 - 70 nurses
 - 43 lay people
- Spoken responses were transcribed for each participant to
 - ALL 198 drug names during the main experiment AND
 - ALL 198 drug names during the accent and familiarity phase
- $198 \times 2 = 396$ recorded responses per participant
- $396 \times 249 = \underline{98,604}$ responses to transcribe

Scoring Spoken Responses

98,604 responses to transcribe

Scoring Spoken Responses

- Accent
 - a function of geographical location
 - regional dialect
 - a function of where professional received training
- Acceptable variants

Responses considered correct if

- the response matched the reference pronunciation exactly
- the response matched after applying generally accepted rules for pronunciation variation to reference pronunciations
- the response was judged acceptable by two linguists who could provide linguistic justification for other legitimate variants

Dependent Variable

(outcome measure)

- Accuracy in identifying spoken drug name

Predictions

- Noise (babble)
 - +8 will be more accurate than +3 and -2
 - +3 will be more accurate than -2
- Similarity and frequency of neighboring words
 - drugs with less similar and lower frequency neighbors will be more accurate than drugs with more similar and higher frequency neighbors
- Familiarity
 - drugs rated as more familiar will be more accurate than drugs rated as less familiar
- Prescribing frequency
 - drugs with higher prescribing frequency will be more accurate than drugs with lower prescribing frequency

Results

- Mean accuracy
– 32%

We wanted people to make errors

We learn from the **types of mistakes** that are made

I could NOT hear drug names initially

Results

- Noise (babble)
- Similarity and frequency of neighboring words
- Familiarity
- Prescribing frequency

Most main effects were consistent across groups

Results

- Noise (babble)
 - +8 more accurate than +3 and -2
 - +3 more accurate than -2
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Results

	<u>Pharmacists</u>	<u>Physicians</u>	<u>Nurses</u>	<u>Lay People</u>
-2db	20%			
+3db	42%			
+8db	56%			

Results

	<u>Pharmacists</u>	<u>Physicians</u>	<u>Nurses</u>	<u>Lay People</u>
-2db	20%	16%		
+3db	42%	37%		
+8db	56%	50%		

Results

	<u>Pharmacists</u>	<u>Physicians</u>	<u>Nurses</u>	<u>Lay People</u>
-2db	20%	16%	12%	
+3db	42%	37%	30%	
+8db	56%	50%	45%	

Results

	<u>Pharmacists</u>	<u>Physicians</u>	<u>Nurses</u>	<u>Lay People</u>
-2db	20%	16%	12%	7%
+3db	42%	37%	30%	21%
+8db	56%	50%	45%	36%

Results

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	<hr/>	<hr/>	<hr/>	<hr/>
	39%	34%	29%	21%

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except in laypeople



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Results

- Types of errors
 - Mispronunciation of the drug name
 - 90% of errors
 - Substitution errors
 - 10% of errors
 - response corresponded to another real drug name
 - could produce potentially harmful wrong drug errors

Results

Substitution Errors

- Prediction from language research is that rare names will be misheard as common names *but not vice versa*
- Substitution errors go in the direction of the more frequently prescribed name 90% of the time
 - substituted name was, on average, prescribed *229 times more frequently than the target*

Conclusions

- As predicted
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Conclusions

- As predicted, accuracy increased as signal-to-noise ratio increased
- As predicted
- As predicted

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 - *but just a few decibels make a significant difference!*
- As predicted
- As predicted

Conclusions

- As predicted, accuracy increased as signal-to-**noise** ratio increased
 - but just a few decibels make a significant difference!
- As predicted, accuracy was influenced by the *similarity neighborhood* of each drug name
- As predicted

Conclusions

- As predicted, accuracy increased as signal-to-**noise** ratio increased
 - but just a few decibels make a significant difference!
- As predicted, accuracy was influenced by the *similarity neighborhood* of each drug name
- As predicted, more **familiar** names were perceived more accurately than less familiar names

Conclusions

- Our model should be useful to policy makers and drug companies
 - evaluate the confusion potential for **new** and **existing** drug names
- Previous studies consider (at least implicitly) confusability to be symmetrical
 - if two names are similar then confusion in either direction is equally likely
 - our findings strongly contradict this notion
 - confusion is almost entirely asymmetrical
 - confusions overwhelmingly going in the direction of the more frequent name in a pair of confusing names

Conclusions

- When policy makers consider potential for harm related to a drug name confusion, they must consider the direction of the error
 - which drug will be mistaken for which
- More familiar and more frequently prescribed drugs will tend to have lower error rates

Conclusions

- When policy makers consider potential for harm related to a drug name confusion, they must consider the direction of the error
 - which drug will be mistaken for which
- More familiar and more frequently prescribed drugs will tend to have lower error rates, *but in thinking about harm*
 - must be weighted against their much higher number of opportunities for error

Conclusions

- Results not only inform research and policy on drug name confusions
- Previous work on similarity neighborhoods done almost exclusively on one syllable (CVC) words
- Results extend to longer words
- Results extend to a specialized vocabulary

Thank you

Questions?

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