



Predicting and Preventing Drug Name Confusions: Strategies for Front Line Practitioners

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FOR Vargues Ramon AGE _____
ADDRESS ~~1111 W. 4th St.~~ DATE 6/23/95

NO REFILLS

REFILLS

LABEL

Penicil 20mg # 120 -
20mg P.O. Q6hr

Ferrous Sulfate 300mg # 100
300mg P.O. TID c meals

Humulin N
30 units SQ QAM.
Ram/Kath

PRODUCT SELECTION PERMITTED

DISPENSE AS WRITTEN

D.E.A. #

739 037 7-89

14 88-270



Plendil or Isordil?

- Isordil[®] prescribed
- Plendil[®] dispensed
- Cardiologist found negligent
- \$450,000 damage award
- First ever award for bad penmanship!



Objectives

- By the end of this presentation, participants will be able to:
 - Identify the major causes of drug name and drug product confusions.
 - Describe safe medication practices that can reduce the likelihood of confusion.
 - Develop a specific strategy for reducing name confusion errors in the context of neurology.



Drug Name Confusions

- Account for 15-25% of all reported medication errors in the US
- Specifically identified by IOM in their report on medical errors
- Mandated initiatives underway at FDA to address the problem
- Several ongoing 'disasters' involving high-profile products



Why Do These Errors Happen

- Similarity- and frequency-based errors in cognitive processing
- Memory (recall and recognition)
- Perception (visual and auditory)
- Motor control (picking wrong drug from drop-down menu)
- Poorly designed systems (e.g., handwritten orders, oral orders, no CPOE, etc.)



Examples (from USP-MERP)

- Lamisil[®] vs. Lamigel[®]
- Accupril[®] vs. Accutane[®]
- Celebrex[®] vs. Celexa[®]
- Cisplatin vs. carboplatin
- Hydroxyzine vs. Hydralazine
- Zosyn[®] vs. Zofran[®]
- Prilosec[®] vs. Prozac[®]
- Pediapred[®] vs. Pediaprofen[®]
- Prepridil[®] vs. Bepridil[®]



Examples (from Dr. Hier)

- Klonopin/clonidine
- Plavix[®]/Paxil[®]
- clozaril/klonopin
- Cytoxan[®]/cyclosporin
- Dantrium[®]/Danazol[®]
- Persantine/Periactin[®]
- Lovenox[®]/lovastatin
- famotidine/felodipine
- fluoxetine/fluphenazine
- Cerebyx[®]/Celebrex[®]
- Neurontin[®]/Dilantin[®]
- glyburide/glipizide, etc., etc.



Confusion not limited to drug names!

Plaque muddles Luther King killer with Hollywood actor

Officials are blaming a mix-up after a plaque honored the man who killed Martin Luther King instead of actor James Earl Jones.

The actor was the voice of Star Wars' Darth Vader and The Lion King's Mufasa.

The plaque, however, commemorated James Earl *Ray* for "keeping the dream alive"...

STAMPS ISSUED IN HONOR OF BLACK HERITAGE



Thank you
James Earl Ray
for Keeping the Dream Alive
City of Lauderdale
January 19, 2002





Jim Ryan battles voter 'confusion'

(Sun Times, 8/27/02)

"I'm not George Ryan," Attorney General Jim Ryan said Monday.

Repeatedly.

It's not easy sharing a surname with a governor who has more baggage than an airline.

Jim Ryan kept re-stating his identity at a news conference where he picked up the endorsement of the Illinois State Chamber of Commerce, the state's largest business organization. But the session was dominated by discussion of "the confusion factor" as the GOP nominee for governor fielded questions about a new poll showing his Democratic opponent, Rod Blagojevich, with a 14.6-point lead.



Ammonal or ammonol?

During the Battles of Ypres in WWI, 1915...they frequently dug huge mineshafts, filled them with explosives and blew each other up:

"But he seized on an idea that no one had thought of before: he would use ammonal, an explosive used in mining but new to warfare, with three-and-a-half times the strength of ordinary gunpowder. Cassels quickly sent in a requisition for 3,500 pounds of the ammonal but, in typical army fashion, a glitch developed immediately: no one back at headquarters had the faintest idea what ammonal was. Someone assumed that it was a drug, and dispatched an inquiry to the Royal Army Medical Corps. In due time, a reply was received: 'Ammonol is a compound drug extensively used in America as a sensual sedative in cases of abnormal sexual excitement.'

What reaction this information elicited from the Quartermaster General is not known, but one can speculate that he must have wondered why a company of coal miners needed so much of the stuff, way out in the front lines. The confusion was cleared up after another flurry of dispatches when someone finally was able to distinguish between ammonol, the sex drug, and ammonal, the high explosive."

(A Storm in Flanders: The Ypres Salient, 1914-1918: Tragedy and Triumph on the Western Front by Winston Groom. pg. 130.)



Carl Linnaeus even warned us!

- The quote is from Carl Linnaeus discussing the rules one should use to assign names to species and such. Rule Number 228 is:
- “Generic names with a similar sound give a handle to confusion”
- Linnaeus, C. *Critica Botanica*, 1737
(quoted in Stern, W. T. *Systematic Zoology*, 1959, vol. 8, p. 8)



Need for Improved Pre-Approval Screening

- FDA and manufacturers rely heavily on subjective measures and/or untested quasi-objective measures
- Handwritten and oral orders are examined by FDA-employed health professionals
- Insufficient practitioner review, no objective analysis of multiple attributes



Objective Measures of Name Similarity

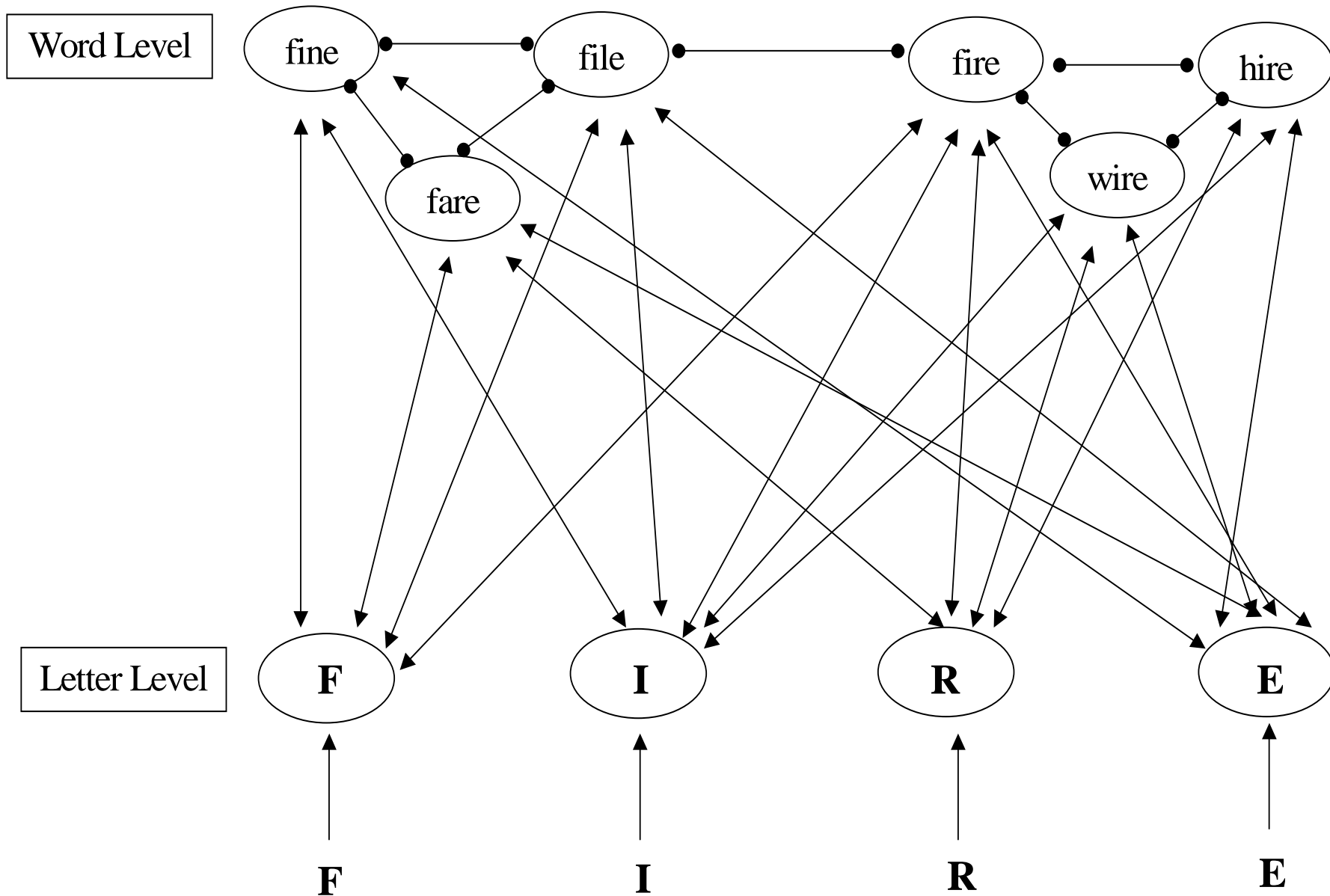
- N-gram measures of spelling similarity (e.g., bigram, trigram)
- Edit distance
- Phonetic measures
- Phonological measures
- Multiple attribute measures
- These measures have been validated in several peer-reviewed publications



Visual Perception of Drug Names

- Perceptual features at multiple layers of abstraction (e.g., segment, letter, word)
- Spreading activation between layers
- Activation/competition models
- Influence of similarity and frequency

Interactive Activation Model





Similarity and Frequency

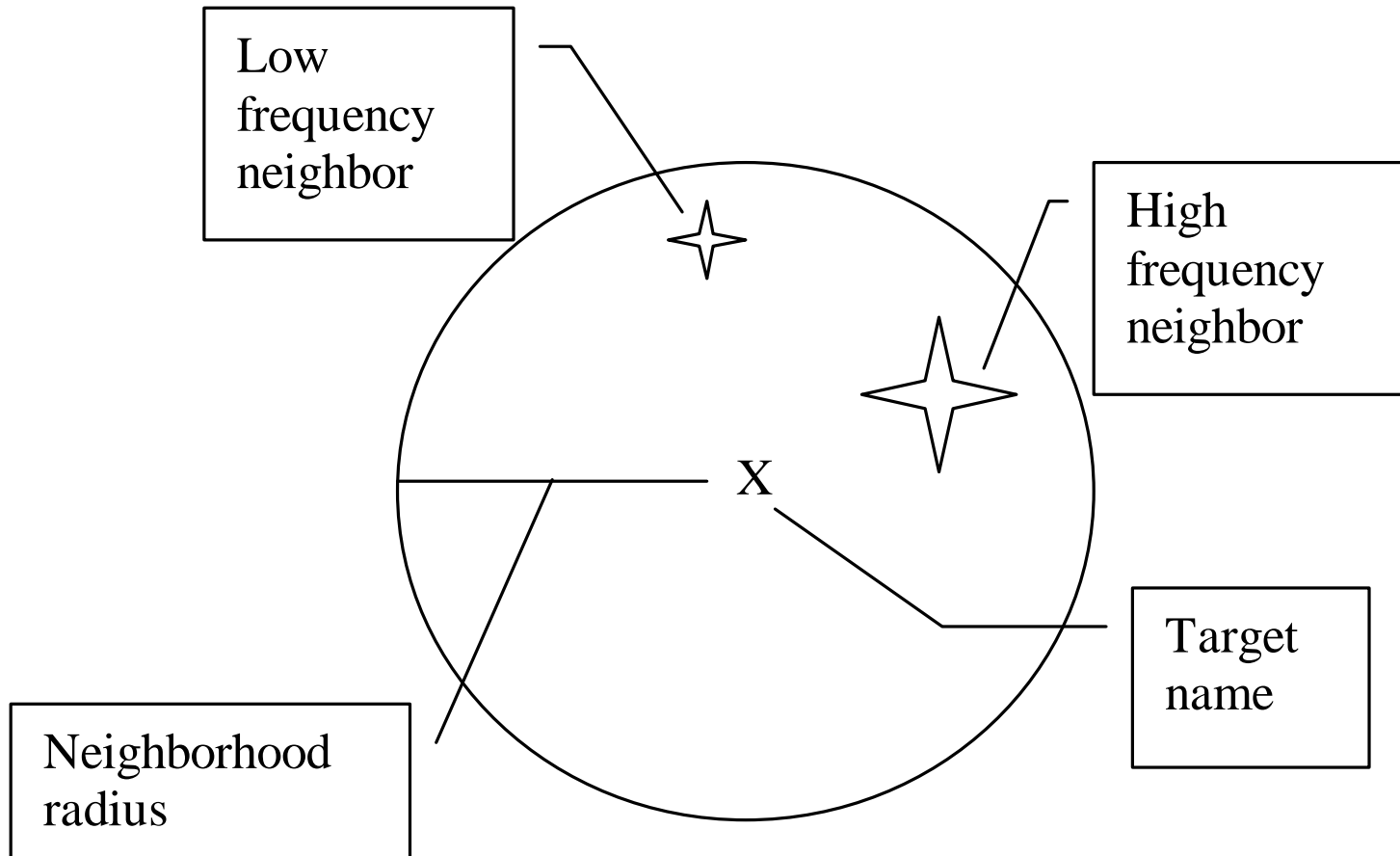
- In general, frequency (of prescribing) increases perceptual accuracy
- In general, similarity (to other names) decreases perceptual accuracy



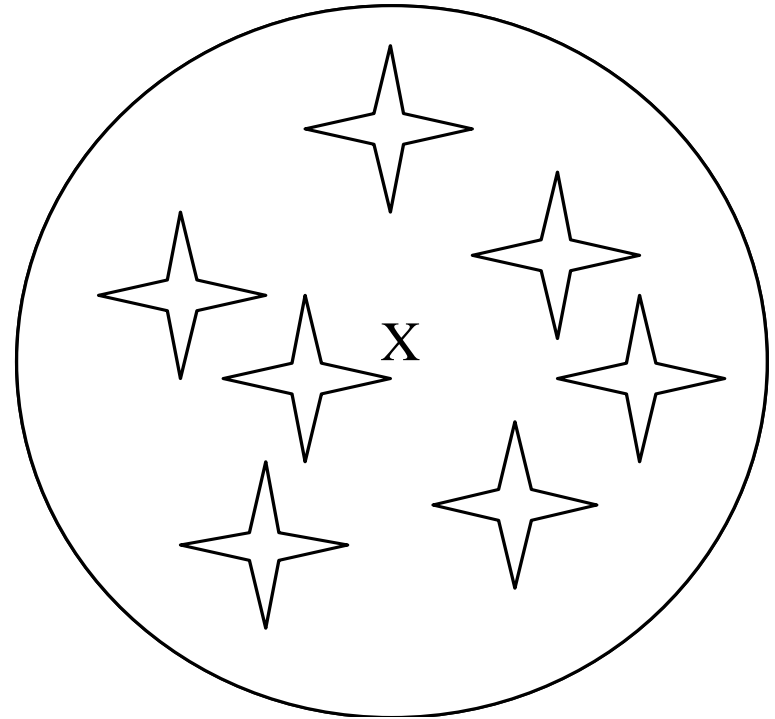
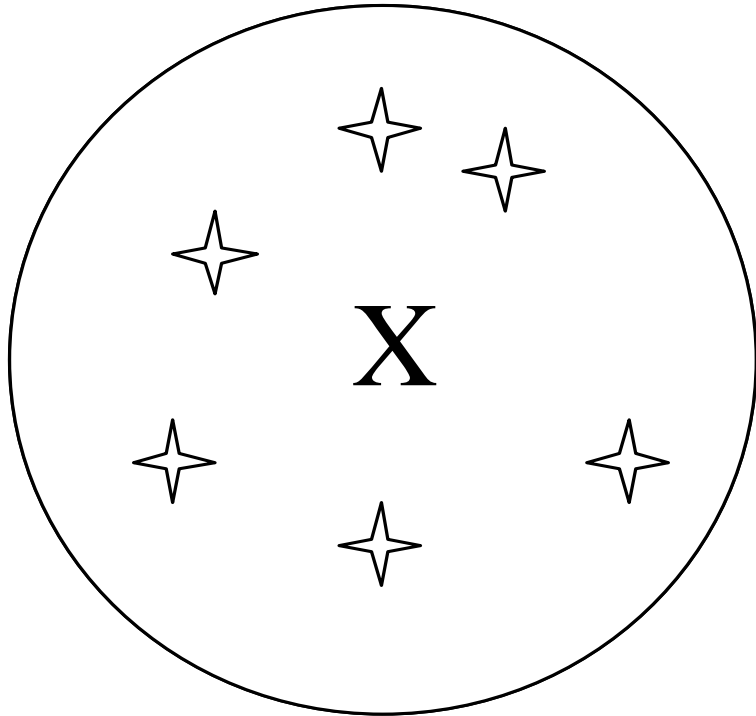
Definitions

- **Stimulus Frequency**: the log prescribing frequency of a given drug
- **Neighborhood**: the set of names within a given distance (3 edits) of a stimulus name
- **Neighborhood density**: the number of other names in a stimulus word's neighborhood
- **Neighborhood frequency**: the mean log prescribing frequency of the names in the neighborhood

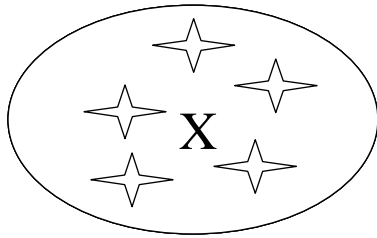
Neighborhood Illustration



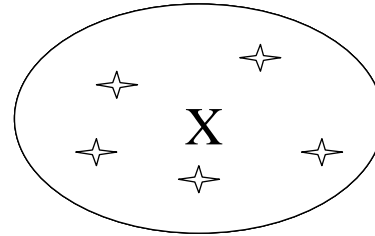
Dense Neighborhoods: High and Low Frequency



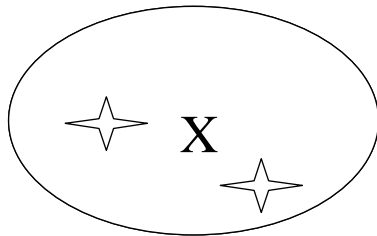
1) High SF, High NF, High ND



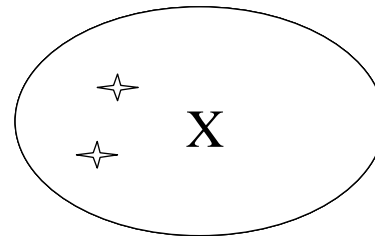
2) High SF, Low NF, High ND



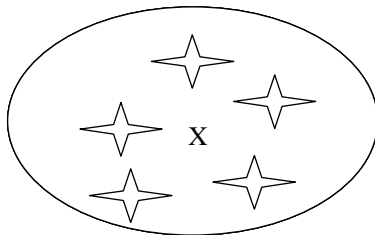
3) High SF, High NF, Low ND



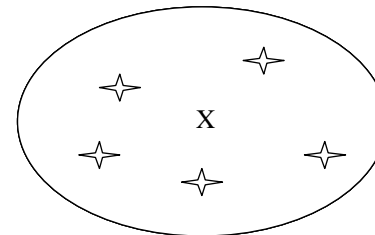
4) High SF, Low NF, Low ND



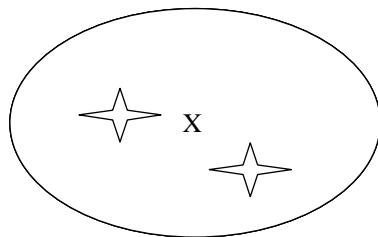
5) Low SF, High NF, High ND



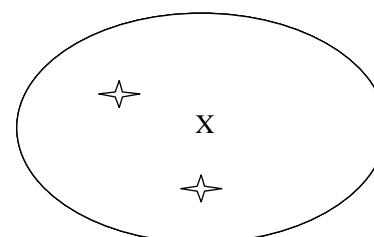
6) Low SF, Low NF, High ND



7) Low SF, High NF, Low ND



8) Low SF, Low NF, Low ND





Examples

- High log SF names ($\log SF > 7$): Ventolin[®], Dyazide[®], Provera[®]
- Low log SF names ($\log SF < 3$): Vistazine[®], Antispas[®], Protaphane[®]
- Name from a sparse neighborhood: Flexeril[®] (no neighbors in NAMCS/NHAMCS)
- Name from a dense neighborhood: Dynabac[®], Synalar[®], Rynatan[®], Dynapen[®], Dynacirc[®], Dynacin[®], Cynobac[®]



Hypotheses

- Error rates in visual perception will increase as stimulus frequency decreases
- Error rates in visual perception will increase as neighborhood density increases
- Error rates in visual perception will increase as neighborhood frequency increases



Methods and Design

- 2 x 2 x 2 design (stimulus frequency by neighborhood density by neighborhood frequency)
- Stimuli and prescribing frequency data taken from 1992-1996 NAMCS and NHAMCS government databases



Stimuli: Drug Names

- Twenty names each were selected at high and low levels of prescribing frequency (i.e., the log of the number of NAMCS/HAMCS prescriptions), neighborhood frequency (i.e., the average log prescribing frequencies of names within an edit distance of 3 from a given name), and neighborhood density (i.e., the number of names within an edit distance of 3 of a given name).



Methods and Design

- Participants were licensed, practicing pharmacists drawn from attendees at the 2000 National Community Pharmacists Association annual meeting (N=37)
- Task is a noise-masked visual perception task
- Participant must identify a degraded drug name after 3-second exposure

TRUATION

Befidme

Unasyn

Ventolin

Solator



Procedure

- Pharmacist seated in front of Macintosh computer
- Drug names appear for 3 seconds
- Names degraded as if sent by a bad fax machine
- Row of XXXXs replaces name after 3 seconds
- Pharmacist types in correct response
- 5 practice trials, 160 test trials



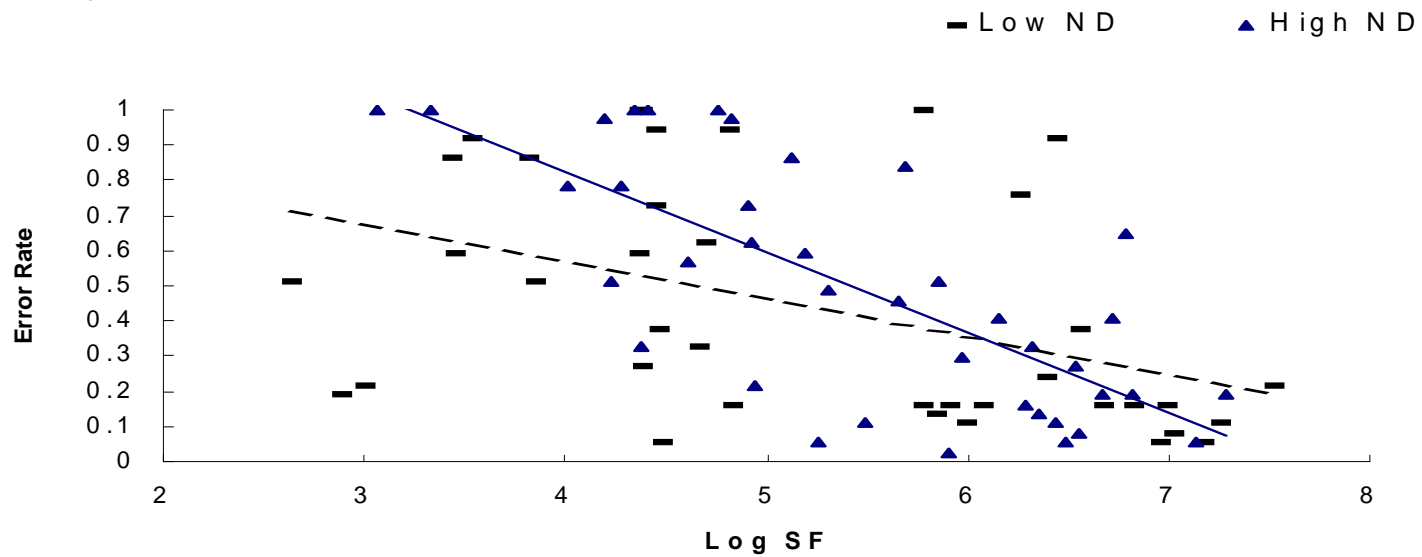
Analysis Plan

- Independent Variables
 - Stimulus Frequency
 - Neighborhood Density
 - Neighborhood Frequency
 - 2- and 3-way Interactions
- Dependent Variable
 - Error (1 = error; 0 = correct)
 - All misspellings coded as error
- Mixed-effects logistic regression
- Backward Elimination

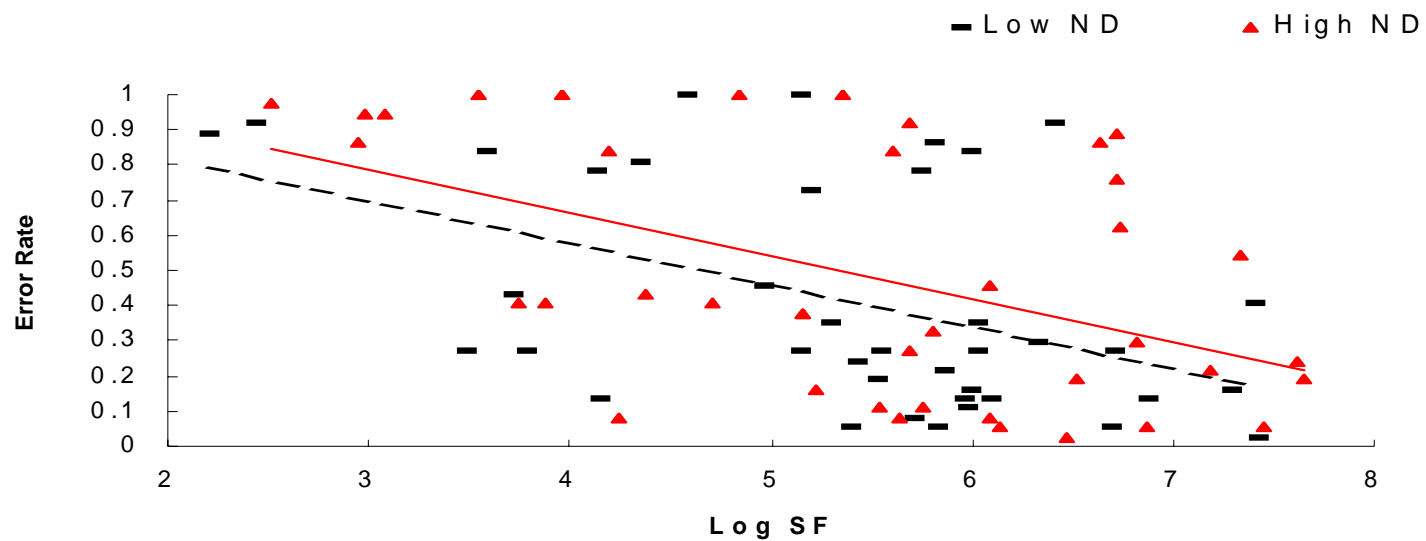
Parameter Estimates

Variable	Estimate	SE	Z
Intercept	0.129	0.147	0.878
SF	-0.612	0.033	-18.474*
NF	0.096	0.054	1.783
ND	0.186	0.053	3.495*
SF x NF	-0.206	0.042	-4.886*
SF x ND	-0.116	0.034	-3.423*
NF x ND	0.031	0.043	0.726
SF x NF x ND	-0.144	0.024	-6.068*

(a) High NF



(b) Low NF





Limitations

- Somewhat contrived, laboratory task
- Relatively small, non-representative sample of pharmacists (NCPA attendees)
- Noise and exposure durations may be unrealistic



Patient Safety Lessons

- Similarity and frequency are still basic mechanisms of error. Look for them everywhere.
- Probability of error not most important endpoint
- Minimize harm
- Harm is a function of number of opportunities for error, probability of error and severity of error



Barriers and Obstacles

- Bias still favors “front-line” solutions despite rhetoric about latent errors and systems
- Interdisciplinary research can fall through the cracks as entrenched institutions each say “that’s outside our area”
- Measuring downstream impact of upstream fixes is very difficult/impossible
- Patient safety orgs still lack human factors expertise



What's Next?

- Publication and dissemination
- Auditory perception studies
- Software development and dissemination
- Application to formularies within individual health systems
- Integration with other error prevention methods



Discussion and Implications

- Word frequency effect is extremely powerful. Rare names much more difficult to perceive than common names.
- Dense neighborhoods inhibit perception, especially of low frequency names in high frequency neighborhoods.
- Keep neighborhoods sparse to minimize error.
- Use neighborhood measures as part of pre-approval screening.



Conclusion

- The less frequently a drug name is prescribed, the more difficult it is to be perceived correctly in a noise-masked visual perception experiment.
- For low frequency words, the presence of similar neighbors significantly increases the probability of a perceptual error.



Acknowledgments

- National Patient Safety Foundation
- Robert Gibbons, Paul Luce



What about Prevention?

- Pre-approval screening
- Post-event labeling changes (e.g., Lamictal, cisplatin)
- CPOE-based solutions
- Safe prescribing practices
- Doctor-patient interaction
- Dispensing and administration fixes



Pre-Approval Screening

- FDA and manufacturer's joint responsibility
- Should use validated measures
- Should search on multiple attributes
- Criteria for acceptance/rejection of new names should be rational and explicit
- Companies soon mandated to submit pre-approval info about name confusion

Labeling Changes





CPOE-based Solutions

- Warnings on known confusing names
- Dose checking
- Indication checking
- Non-alphabetical presentation on menus
- Querying for distinguishing attributes
- “Tall man” lettering



Safe Medication Practices (from ISMP)

- Prescriptions should clearly specify the dosage form, drug strength, and complete directions.
- Include the product's indication on all outpatient prescriptions and on inpatient *prn* orders.
- With name pairs known to be problematic, reduce the potential for confusion by writing prescriptions using both the brand and generic name.



Safe Medication Practices (from ISMP)

- Accept verbal or telephone orders only when truly necessary. Encourage staff to repeat back all orders, spell the product name, and state its indication.
- When feasible, use magnifying lenses and copyholders under good lighting to keep prescriptions and orders at eye level during transcription.



Safe Medication Practices (from ISMP)

- ●Change the appearance of look-alike product names on computer screens, pharmacy and nursing unit shelf labels and bins (including automated dispensing cabinets), pharmacy product labels, and medication administration records by highlighting, through bold face, color, and/or tall man letters, the parts of the names that are different (e.g., hydr**OXY**zine, hydr**AL**Azine).



Safe Medication Practices (from ISMP)

- Affix “name alert” stickers to areas where look or sound-alike products are stored (available from pharmacy label manufacturers).
- Store products with look or sound-alike names in different locations. Avoid storing both products in the fast-mover area. Use a shelf sticker to help locate the product that is moved.



Additional Solutions (from Dr. Gordon Schiff)

- Focus prevention efforts on small set of “high alert” medications
- Make errors visible, local, personal
- Print names (not cursive)
- Short feedback loops (via nurses)
- Check meds each visit
- Restrict personal formulary
- Use brand and generic names
- Write Rx “out loud” when patient present
- Minimize switching/use of new drugs



Developing Strategies for Neurology

- Identify small set of “high alert” drugs
- Put safe medication practices in place
- Exploit Gemini system
- Include MDs, RNs, Pharm.D.'s, patients in solution
- Track progress
- Continuously improve



Summary

- By the end of this presentation, participants will be able to:
 - Identify the major causes of drug name and drug product confusions.
 - Describe safe medication practices that can reduce the likelihood of confusion.
 - Develop a specific strategy for reducing name confusion errors in the context of neurology.
- Did we achieve our objectives?