Effect of Frequency and Similarity Neighborhoods on Pharmacists' Visual Perception of Handwritten Drug Names

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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
- This study focused on *visual perception of handwritten names*

Examples (from USP-MERP)

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

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

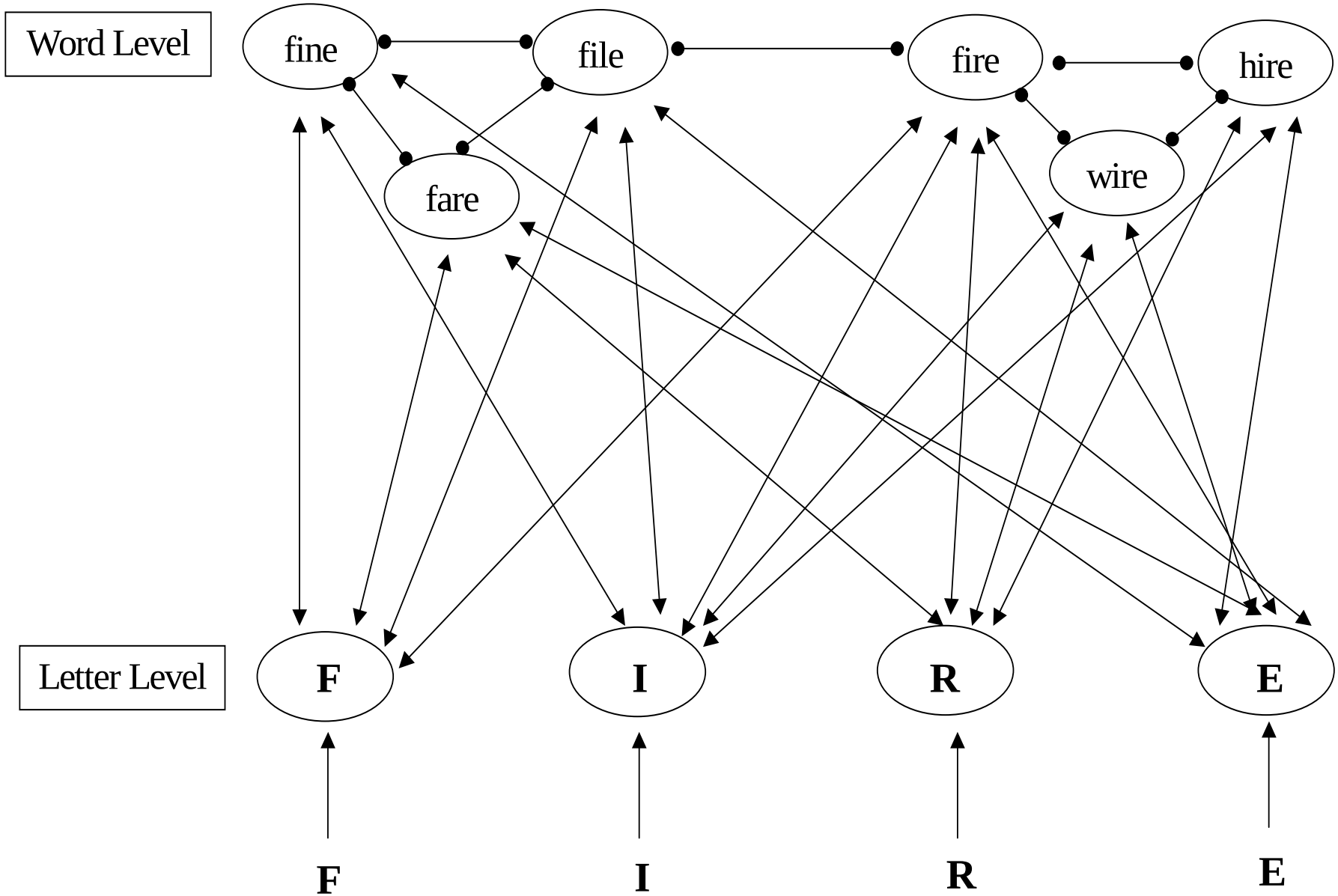
Objective Measures of Name Similarity

- N-gram measures of spelling similarity (e.g., bigram, trigram)
- Edit Distance
- Phonetic measures
- Phonological measures
- 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
- Competition between similar words
- Activation/competition models
- Influence of similarity and frequency

Interactive Activation Model



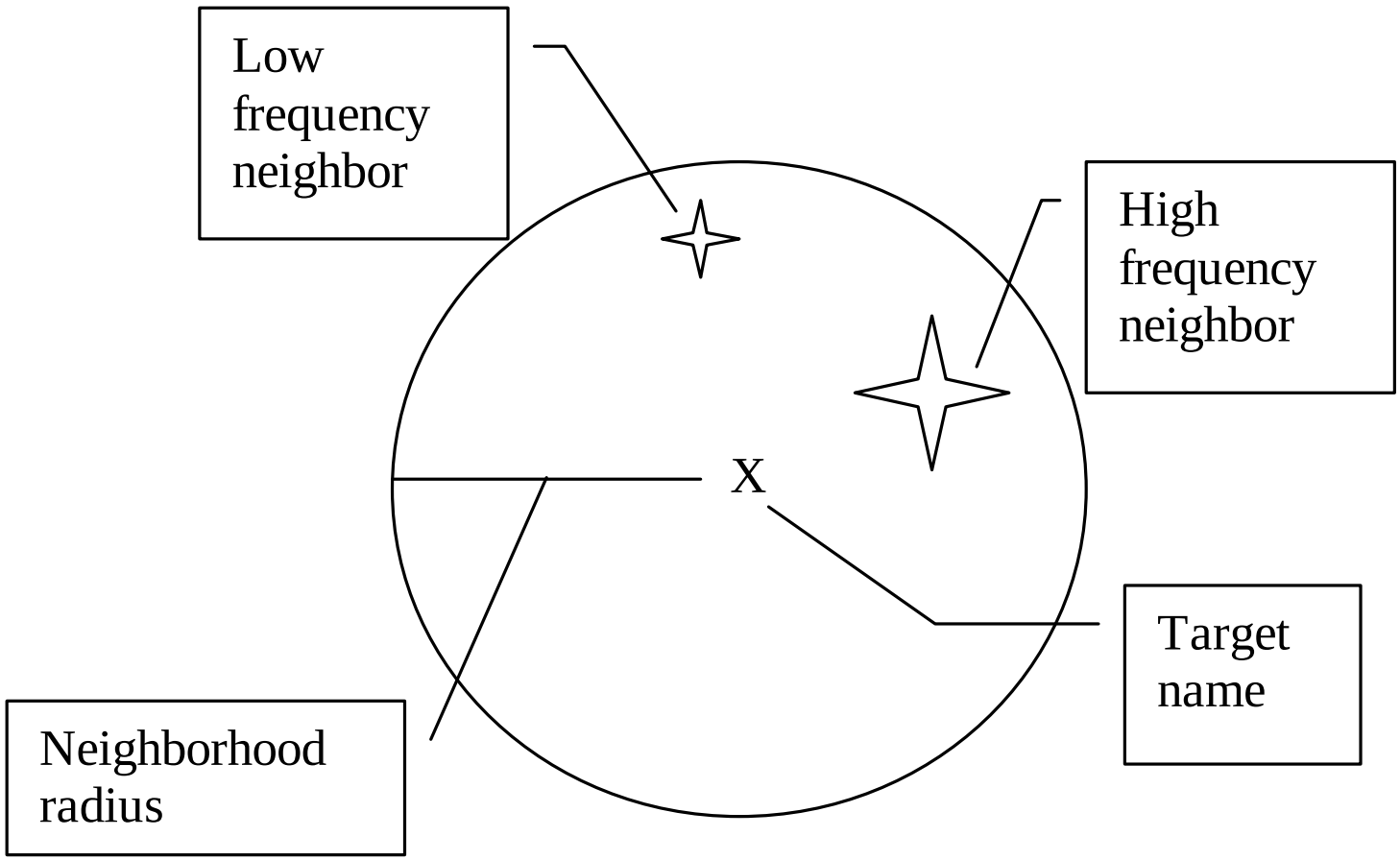
Similarity and Frequency

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

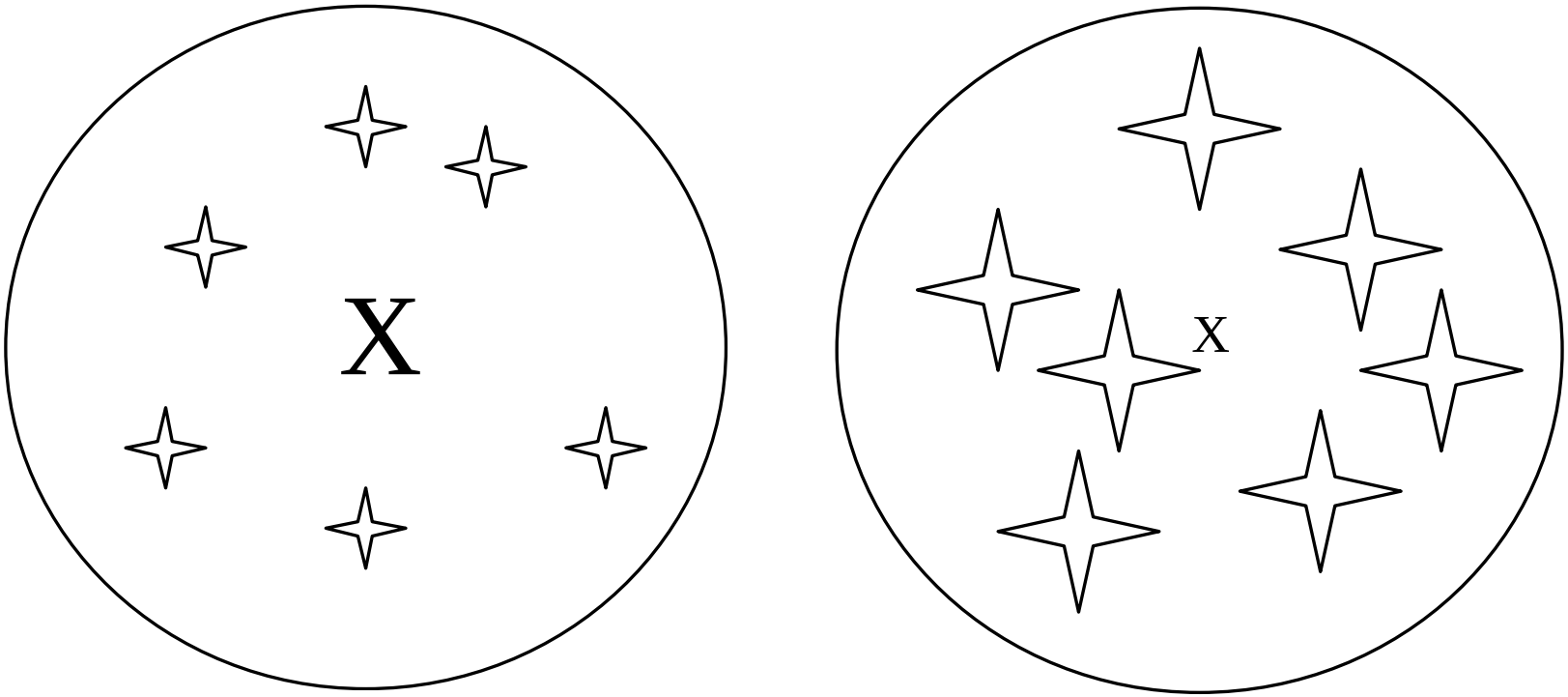
Definitions

- 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



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

Methods and Design

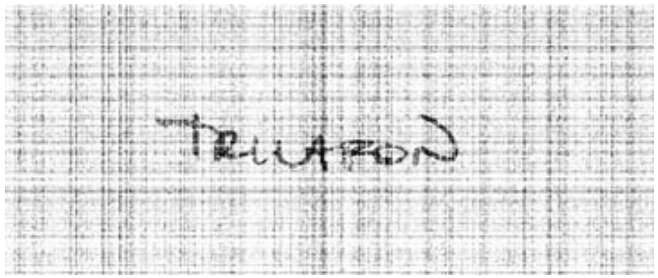
- 2 x 2 x 2 design (stimulus frequency by neighborhood density by neighborhood frequency)
- Stimuli and prescribing frequency data taken from 1992-1996 NAMCS and NHAMCS government databases

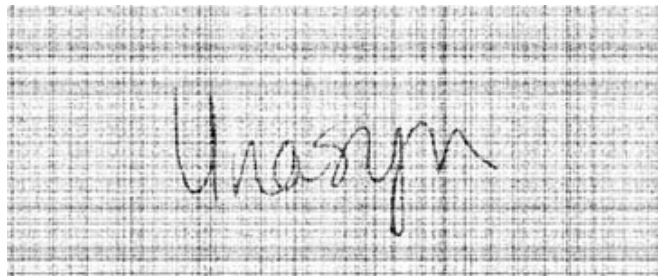
Stimuli: Drug Names

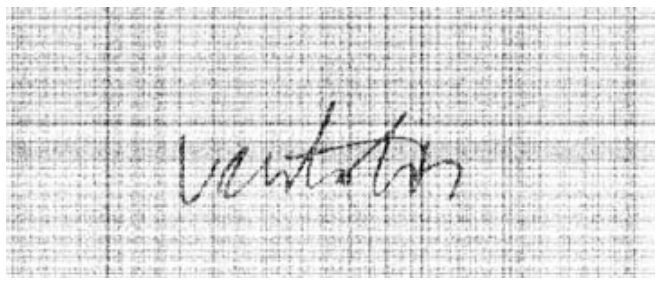
- Twenty names each were selected at high and low levels of prescribing frequency, neighborhood frequency, and neighborhood density.

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







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

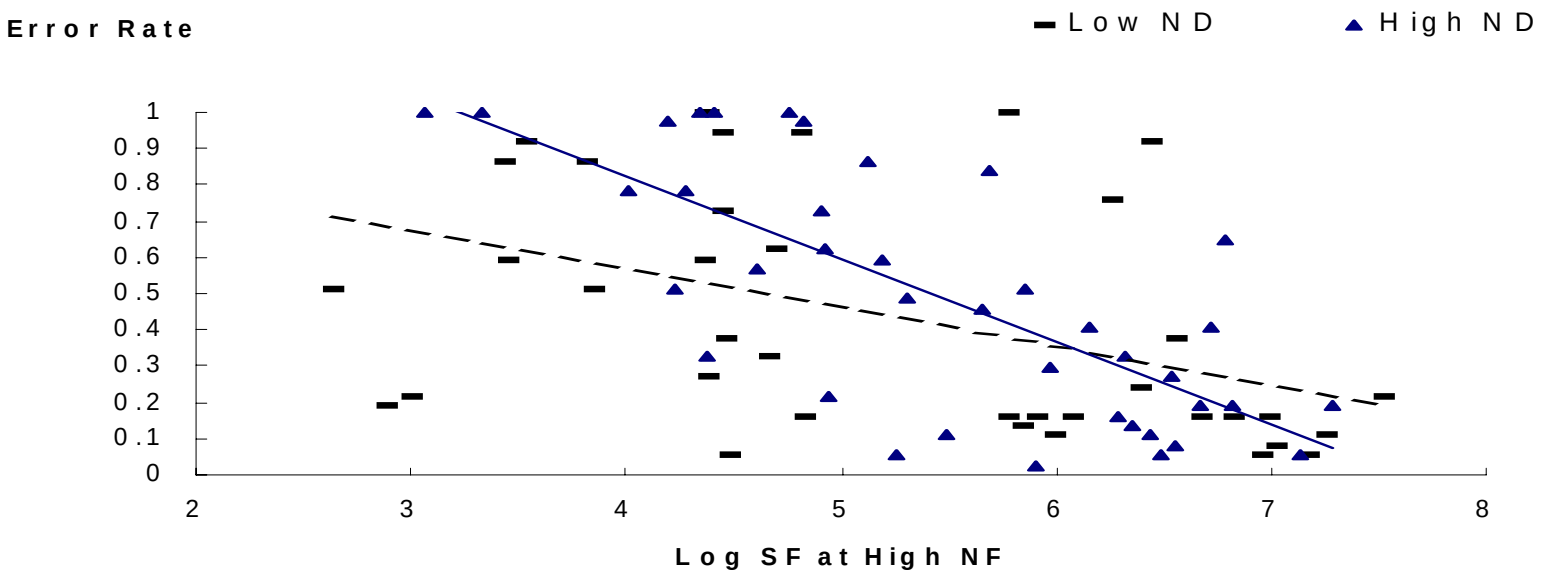
Analysis Plan

- 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

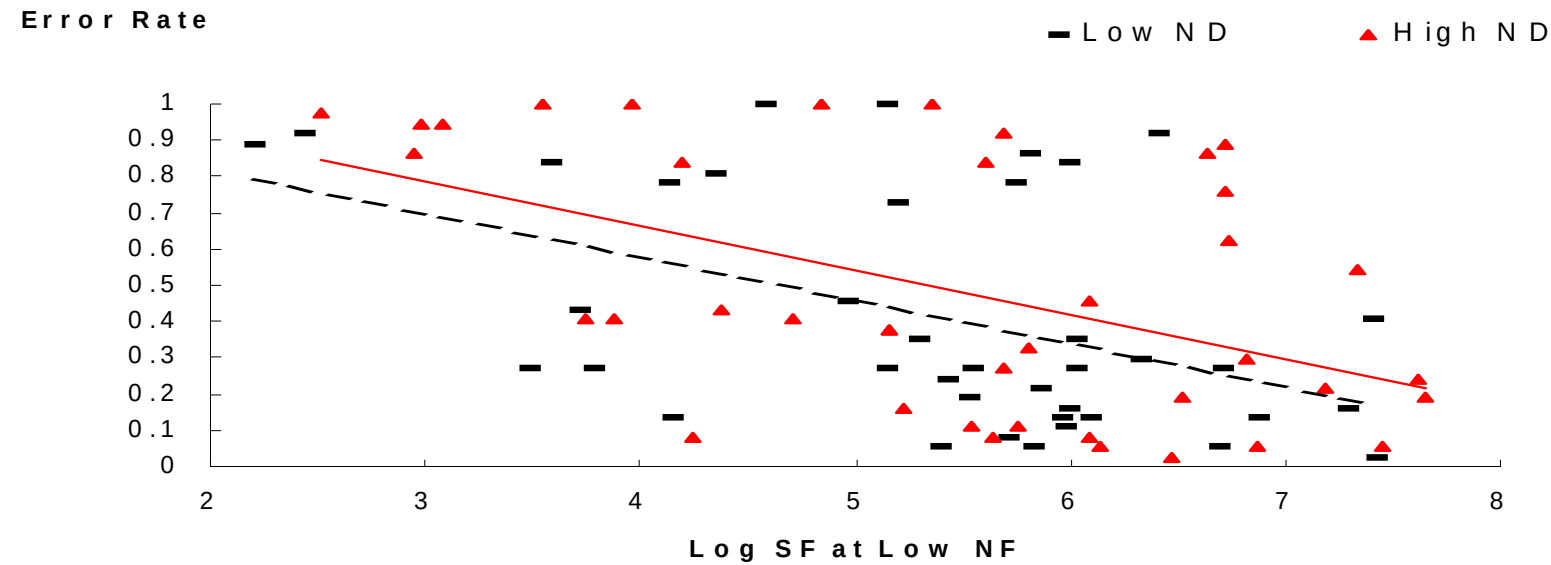
Parameter Estimates

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)


Error Rate
Low ND
High ND
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2
3
4
5
6
7
8
Log SF at High NF

(b)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Log SF at 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

- Rare names much more difficult to perceive than common names.
- Dense neighborhoods inhibit perception
- NF amplifies effect of ND
- SF lessens effect of ND
- Keep neighborhoods sparse
- Use neighborhood measures in pre-approval screening.

Conclusion

- The less frequently a drug name is prescribed, the more difficult it is perceive correctly.
- For low frequency words, the presence of similar neighbors significantly increases the probability of a perceptual error.

Acknowledgments

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