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

Word Level

Letter Level
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

Low frequency neighbor

High frequency neighbor

Target name

Neighborhood radius
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
Befadme

Unsyn

Ventin

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

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<td>0.033</td>
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<td>NF</td>
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<td>SF x ND</td>
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<td>0.034</td>
<td>-3.423*</td>
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<td>NF x ND</td>
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<td>0.043</td>
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<td>SF x NF x ND</td>
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<td>0.024</td>
<td>-6.068*</td>
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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 to perceive correctly.

- For low frequency words, the presence of similar neighbors significantly increases the probability of a perceptual error.
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