The Meaning Mine
How the Brain Digs Out Sense from the Wor(l)d

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Part II

Morphology and the Brain
Lexical decision task

500 ms

DEAL/DEEL

2000 ms

press button

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The Meaning Mine
Nonwords

- JUVENATE (from REJUVENATE) takes longer to be rejected than PERTOIRE (from REPERTOIRE)
- VENT (which is also a bound stem in ADVENT, PREVENT, etc.) is slower than COIN
- DEJUVENATE takes longer to be rejected than DEPERTOIRE

(Taft and Forster, 1975)
Pre-lexical analysis and economy

- Morphological analysis doesn’t only stay in the lexicon. Taft and Forster (1975) say it’s pre-lexical (affix stripping)
- Lexical entry (not necessarily the word itself)
- Morphology as a way to obtain economy of resources
Morphology, form or meaning?

DEALER and DEAL share:

▶ form, similarly to DIALOG and DIAL
▶ meaning, similarly to COUCH and SOFA
Genuine morphology

(Rastle et al., 2000)
Frequency effect

(Keuleers et al., 2010)
“Morphological” frequency

Token based

- Base frequency (MOVE, MOVED, MOVING)
- Stem/root frequency (+MOVEMENT)
- Inflectional ratio

Type based

- Family size
Base and surface frequency

- REPROACH quicker than DISSUADE despite same surface frequency—APPROACH is more frequent than PERSUADE
- THINGS quicker than WORLDS despite same base frequency—THINGS is more frequent than WORLDS

(Taft, 1979)
Brain damage

- Agrammatic aphasia
- Problems at naming verbs
- Problems at comprehending passive sentences
- Good lexical decision
- Bad nonword repetition
- Bad reading of nonwords, function words and abstract nouns. Some semantic substitution (e.g., GLACIER for SKATING), possibly deep dyslexia?

(Luzzatti et al., 2001)
Bad perisylvian damage
Sensitive to morphology

- Singulars better than plurals, but only for regular forms
- Simple nouns better than derived nouns
- Truly derived words (e.g., DEALER) worse than opaque derivations (e.g., DEPARTMENT), pseudo-derivations (e.g., CORNER) and pseudo-affixed words (e.g., WHISPER)
Frequency and information

Why should there be frequency effects?

► You access a given representation more often, you strengthen it (sort of Hebbian learning)
► The more frequent, the less interesting
► The more frequent, the more predictable
Information processing and morphology

It’s not about frequency really, it’s about carrying information.

You see HUNTS

- it carries some amount of information per se
- it is a member of the morphological family (HUNT, HUNTING, HUNTED), which in turns carries some other amount of information
Inflectional entropy I

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Inflectional entropy II

$W$ is a morphological family with members $w$

$$H_{tot}(W) = - \sum_{w \in W} \frac{F_w}{F_W} \log_2 \frac{F_w}{F_W}$$

(Moscoso del Prado Martín et al., 2004)
### Inflectional entropy III

<table>
<thead>
<tr>
<th>w</th>
<th>$F_W$</th>
<th>$\frac{F_w}{F_W}$</th>
<th>$\log_2 \frac{F_w}{F_W}$</th>
<th>$H_W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>w1</td>
<td>11</td>
<td>.23</td>
<td>-2.09</td>
<td>-.49</td>
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<tr>
<td>w2</td>
<td>9</td>
<td>.19</td>
<td>-2.38</td>
<td>-.45</td>
</tr>
<tr>
<td>w3</td>
<td>9</td>
<td>.19</td>
<td>-2.38</td>
<td>-.45</td>
</tr>
<tr>
<td>w4</td>
<td>9</td>
<td>.19</td>
<td>-2.38</td>
<td>-.45</td>
</tr>
<tr>
<td>w5</td>
<td>9</td>
<td>.19</td>
<td>-2.38</td>
<td>-.45</td>
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<td></td>
<td></td>
<td></td>
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<td>-2.32</td>
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</table>

$\log_2 \frac{F_w}{F_W}$

<table>
<thead>
<tr>
<th>w</th>
<th>$F_W$</th>
<th>$\frac{F_w}{F_W}$</th>
<th>$\log_2 \frac{F_w}{F_W}$</th>
<th>$H_W$</th>
</tr>
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<tbody>
<tr>
<td>w1</td>
<td>43</td>
<td>.91</td>
<td>-.13</td>
<td>-.12</td>
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<td>w2</td>
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<td>.02</td>
<td>-5.55</td>
<td>-.12</td>
</tr>
<tr>
<td>w3</td>
<td>1</td>
<td>.02</td>
<td>-5.55</td>
<td>-.12</td>
</tr>
<tr>
<td>w4</td>
<td>1</td>
<td>.02</td>
<td>-5.55</td>
<td>-.12</td>
</tr>
<tr>
<td>w5</td>
<td>1</td>
<td>.02</td>
<td>-5.55</td>
<td>-.12</td>
</tr>
</tbody>
</table>

$\log_2 \frac{F_w}{F_W}$

-2.32

$-5.55$
Inflectional entropy IV

5 members; total frequency is 50; one dominant, the others equal freq
Information residual

\[ I_R(w) = I_s(w) - H_{tot}(F) \]

(Moscoso del Prado Martín et al., 2004)
# Information residual

<table>
<thead>
<tr>
<th></th>
<th>Schreuder and Baayen (1997)—Exp. 3</th>
<th>Neijt et al. (2003)</th>
<th>De Jong et al., 2003—Exp. 1b</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traditional analyses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-) Freq.:</td>
<td>$F(1,956) = 562.57^{***}$</td>
<td>(-) Freq.:</td>
<td>(-) Freq.:</td>
</tr>
<tr>
<td>(-) Fam. Size:</td>
<td>$F(1,956) = 129.13^{***}$</td>
<td>(-) Fam. Size.:</td>
<td>(-) Pos. Fam. Size.:</td>
</tr>
<tr>
<td>(+) Cum. Freq.:</td>
<td>$F(1,956) = 68.29^{***}$</td>
<td>Cum. Freq.: $F &lt; 1$</td>
<td>(-) Pos. Cum. Freq.: $F(1,1287) = 5.90^*$</td>
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<tr>
<td></td>
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<tr>
<td><strong>Explained variance ($r^2$) (%)</strong></td>
<td>44</td>
<td>47</td>
<td>39</td>
</tr>
<tr>
<td><strong>$I_R$ analyses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(+) $I_R$:</td>
<td>$F(1,958) = 923.37^{***}$</td>
<td>(+) $I_R$:</td>
<td>(+) $I_R$:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$F(1,1037) = 212.25^{***}$</td>
<td>$F(1,1289) = 60.96^{***}$</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>(+) $I'_R$:</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>$F(1,1289) = 168.49^{***}$</td>
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<tr>
<td><strong>Explained variance ($r^2$) (%)</strong></td>
<td>48</td>
<td>47</td>
<td>35</td>
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<tr>
<td><strong>Comparison of models (%)</strong></td>
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<td>0</td>
<td>−4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+1</td>
</tr>
</tbody>
</table>
Lexical decision and ERP

500 ms

DEAL/DEEL

2000 ms

press button
Lexical decision and ERP

(Lavric et al., 2012)
New morphemes

Table 1
Examples of trained affixes and stems, their associated meanings, and untrained affixes in one counterbalancing list.

<table>
<thead>
<tr>
<th>Affix</th>
<th>Examples of trained novel words (S+A+) and associated meanings</th>
</tr>
</thead>
<tbody>
<tr>
<td>-nule</td>
<td>Climb(nule) is someone who climbs mountains with dangerous peaks</td>
</tr>
<tr>
<td></td>
<td>Build(nule) is someone who is able to build furniture at a remarkable speed</td>
</tr>
<tr>
<td>-ane</td>
<td>Lock(ane) is the bank section containing the mechanism used to lock the vault</td>
</tr>
<tr>
<td></td>
<td>Bring(ane) is the waiting room used for people who bring the queen presents</td>
</tr>
<tr>
<td>-lomb</td>
<td>Knit(lomb) is a tool used to knit crossover patterns into woollen cloth</td>
</tr>
<tr>
<td></td>
<td>Pour(lomb) is a bottle cap used to pour exact measures of a liquor</td>
</tr>
<tr>
<td>-esh</td>
<td>Creep(esh) is the price of buying stealth equipment used to creep noiselessly</td>
</tr>
<tr>
<td></td>
<td>Wrap(esh) is the extra cost of getting a shop assistant to wrap presents</td>
</tr>
<tr>
<td>-tege</td>
<td>Whipe(tege) is a leatherworker who has designed a new type of horse whip</td>
</tr>
<tr>
<td></td>
<td>Grain(tege) is the person who buys the grain needed to produce chicken feed</td>
</tr>
<tr>
<td>-ose</td>
<td>Cre(ose) is a device used to measure the rum ration for sailing crew</td>
</tr>
<tr>
<td></td>
<td>Bom(bose) is a delicate tool used to help defuse different types of bomb</td>
</tr>
<tr>
<td>-halk</td>
<td>Bird(halk) is a populated area where a rare bird has built a nest</td>
</tr>
<tr>
<td></td>
<td>Meat(halk) is the place on an exploration ship where dried meat was stored</td>
</tr>
<tr>
<td>-uck</td>
<td>Van(uck) is the tax paid for importing a van from the United States</td>
</tr>
<tr>
<td></td>
<td>Gun(uck) is the fine for illegal possession of a gun in Canada</td>
</tr>
</tbody>
</table>

*Note: The second list of affixes (untrained in this example) consists of -nept, -tund, -ort, -aph, -labe, -hoke, -ude, -ete. The affix meanings always denote a person, a place, a tool, or a cost.*

(Tamminen et al., 2012)
New morphemes

A

3-way interaction (learning x time of-testing x context)*

ns

* 

Learning effect (ms)

50

40

30

20

10

0

Training stem (e.g. climbnule)

New stem (e.g. sailnule)

Context

B

Stem recognition

Affix recognition

Whole-word (stem + affix combination) recognition

ns

ns

p = .08

Immediate test

Delayed test

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The Meaning Mine
What we’ve done today

Affix stripping and lexical entry
  Nonwords
  Morphological priming
  Frequency effects
  Brain–damaged patients

Information theory
  Entropy

Where and when
  ERP

Learning


References

Readings II

