The relative efficiency of Taiwan Sign Language and (Signed) Chinese

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- 57 participants
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- Jean Ann for useful comments
- Some of this work was previously presented in Hsinchu (fall 2004) & Changsha (fall 2005)

Goals

• Review classic evidence that sign language is well designed for its modality
• Provide new quantitative evidence in a somewhat larger study than usual

Mouth, hand, and brain

• The mouth has small moving parts, so speech can be fast
• The hands and arms are large, so signing tends to be slower
• Yet the brains of speakers and signers run at the same speed (intended propositions)
• Hence natural sign languages have evolved to be inherently more efficient

Efficiency effects in processing

• ASL signs are recognized faster than English words (Grosjean, 1981)
  - Overlapping features ensure that signs have fewer lexical neighbors
• Nativeness benefits the rapid perception of ASL signs (Mayberry & Fischer, 1989)
  - Innately guided phonological processing is key to efficient language processing

Efficiency and language design

• Attempts to sign a spoken language tend to cause morphemes to drop out (Marmor & Petitto, 1979; Wodlinger-Cohen, 1991)
• Simultaneous communication with accurately produced Signed English slows down speech (Wilbur & Petersen, 1998)
• Deaf children taught Signed English tend to modify it into something more efficient, more like ASL (Supalla, 1991)
The efficiency of ASL vs. (Signed) English

- Bellugi & Fischer (1972):
  - Determined basic articulatory rates
  - Established identity of transmission efficiency
  - Addressed simultaneous communication
  - The central inspiration for our own work

Bellugi & Fischer (1972)

- Three native bilinguals of English and American Sign Language (acquired ASL from deaf parents as young children)
- Each told the same spontaneous story in English, ASL, and both simultaneously
- Bellugi, Fischer, and Newkirk (1979) added three monolingual native ASL signers

ASL sign speed vs. English word speed

Counting propositions

- Bellugi & Fischer defined propositions as “simple underlying sentences”
- Signaled by main verbs or predicates with subjects (overt or covert)
- Calculated proposition “duration” (seconds per proposition)
- Transmission efficiency is the inverse: Proposition rate (propositions per second)
Transmission efficiency in ASL vs. English

Transmission efficiency for monolingual ASL signers

Transmission efficiency in simultaneous communication

Representational efficiency

Measuring representational efficiency

Examples of “syllables” in TSL
Our study

- Fixed discourse:
- Many different signers
  - 26 deaf signers
    - 4 native TSL signers
  - 31 hearing signers
    - 3 native TSL signers
- Thorough quantitative analysis

Modes

- 26 deaf
  - 24 told the story only in sign
  - 2 (with hearing aid) told the story both in sign and in spoken Chinese
- 31 hearing
  - 3 (native bilinguals) told it only in separate modes
  - 26 told the story three times: sign only, speech only, both simultaneously
  - 2 only with both modes simultaneously

Procedure

- Stories were transcribed
  - (For simultaneous speaking and signing, words from each mode were transcribed in parallel)
  - Pauses were removed
  - (Meaningless given need for page turns)
  - We then counted:
    - Duration in seconds
    - Words (signs) in each mode
    - Propositions: main verbs and predicates
    - “Syllables”: characters for Chinese, movement excursions for signing

Words in simultaneous communication

- The 28 parallel transcripts make it clear that many more words are spoken than signed
- This partly reflects the efficiency of signing, but apparently also the loss of information
- Thus what’s actually signed may not TSL or Signed Chinese, but an inconsistent pidgin

Sample transcript

<table>
<thead>
<tr>
<th>Spoken:</th>
<th>Signed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>有個小男 孩 他和</td>
<td>有男 孩 和</td>
</tr>
<tr>
<td>exist class small boy he and</td>
<td></td>
</tr>
<tr>
<td>狗 養</td>
<td>狗養</td>
</tr>
<tr>
<td>dog raise</td>
<td></td>
</tr>
</tbody>
</table>

Spoken: 他 的 小狗 養 了 | Signed: 狗養 |
The efficiency of TSL vs. Chinese

- Following Bellugi et al. (1979), we analyzed three (near) native Chinese/TSL bilinguals
  - All were hearing (with deaf relatives)
- They told the story in each mode separately
- Two measures:
  - Propositions/second: Transfer efficiency
  - Propositions/syllable: Representational efficiency

Open questions at this point

- Are these three bilinguals typical?
- What effect does nativeness have?
  - We don’t expect it to affect representational efficiency, which is built into the system
  - But it should affect transmission efficiency, given Mayberry & Fischer (1989)
- What about simultaneous communication?
Statistical analyses

- Analysis of covariance (ANCOVA)
- Dependent variables (output):
  - Propositions/syllable
  - Propositions/second
- Independent variables (input):
  - Modality (signing vs. speech)
  - Deafness (deaf vs. hearing)
  - Age =
    * Age of acquisition of sign ("innate" factor) +
    * Years signing ("experiential" factor)
  - Simultaneity (separate vs. simultaneous)

Effect of modality on transmission efficiency

- (All 57 participants, with age factored out)

<table>
<thead>
<tr>
<th></th>
<th>Signing</th>
<th>Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propositions/second</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>(Not significant)</td>
<td></td>
</tr>
</tbody>
</table>

Effect of modality on representational efficiency

- (All 57 participants, with age factored out)

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</tr>
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<td>(Highly significant)</td>
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Nativity and representational efficiency

- Independent variables:
  - Age of acquisition × Years of experience × Deafness (ignoring modality)
- Only significant result:
  - Age of acquisition × Years of experience interaction
- Only early-learning signers benefited from experience in representing efficiently
- Caveat: Statistically weak; only solid influence on representational efficiency is modality

No effect of age of acquisition on representational efficiency

<table>
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Experience and representational efficiency in early vs. late signers

- Early learners benefited more from experience?
Nativity and transmission efficiency

- Same three independent variables
- More complex (and interesting) results
- Main effects:
  - Age of acquisition
  - Years of experience
- Interactions:
  - Age of acquisition \times Years of experience
  - Age of acquisition \times Deafness
  - Age of acquisition \times Years of experience \times Deafness

Effect of age of acquisition on transmission efficiency

Effect of experience on transmission efficiency

Experience and transmission efficiency in early vs. late signers

Late learners benefited more from experience?

Age of acquisition and transmission efficiency in deaf vs. hearing signers

With deafness as motivator, early acquisition is less crucial?

The effects of simultaneous communication

- Dependent variables:
  - Propositions/syllable
  - Propositions/second
- Independent variables:
  - Age of acquisition
  - Years of experience
  - Modality
  - Simultaneity
Effects on representational efficiency

- Modality (as usual):
  - Propositions/syllable lower for speech
- Modality × Age of acquisition:
  - For sign, the younger the more efficient
  - For speech, no effect (or slightly reversed)
- Thus again, only strong effect on representational efficiency is modality

Effects on transmission efficiency

- No effect of modality (as usual)
- Age of acquisition (as usual):
  - The younger, the more efficient
- Simultaneity also had a main effect:
  - Simultaneous communication less efficient than signing and speaking separately
- No Simultaneity × Modality interaction
  - Simultaneous communication is equally bad for both modalities

Simultaneous communication hurts transmission efficiency

![Graph showing transmission efficiency comparison between separately and simultaneously (0.5)](image)

Main conclusions

- Natural sign languages have evolved a high representational efficiency
- Spoken and sign languages have equal transmission efficiency
- Simultaneous communication has the lowest transmission efficiency
  - Because of need to process conflicting systems simultaneously?

Pedagogical implications

- Transmission efficiency affects how much can be taught in a school year
- For deaf students, natural sign languages have the highest transmission efficiency
  - Signing a spoken language slows transmission due to its lower representational efficiency
  - Simultaneous communication slows transmission still further

References

References (cont’d)


