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

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- Some of this work was previously presented in Hsinchu (fall 2004) & Changsha (fall 2005)


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## Goals

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

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## 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**

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## 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

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## 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)

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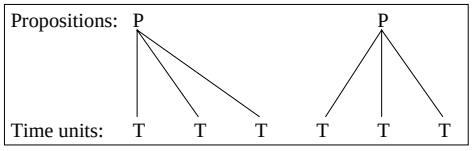
## Transmission efficiency

- The efficiency of the processor in conveying propositions in real time

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## 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

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## 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

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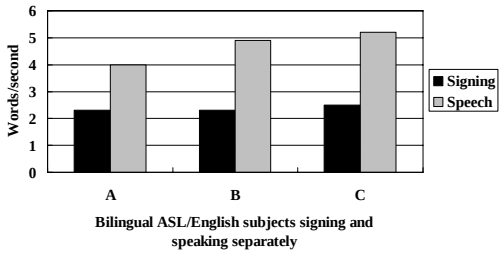
## ASL sign speed vs. English word speed

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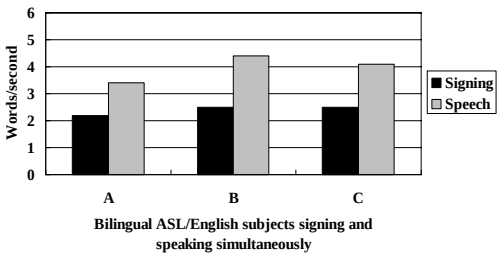
## Sign speed vs. word speed in simultaneous communication

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## 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)

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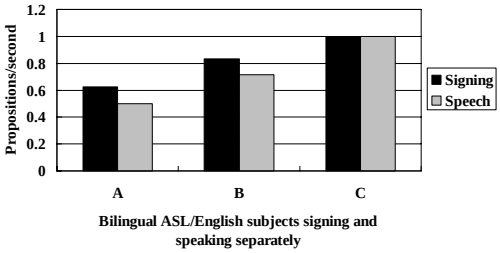
## Transmission efficiency in ASL vs. English




Bilingual ASL/English subjects signing and speaking separately

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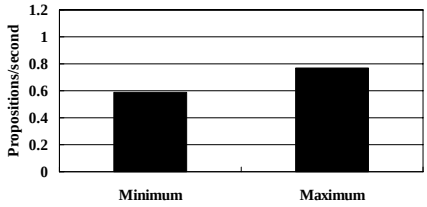
## Transmission efficiency for monolingual ASL signers

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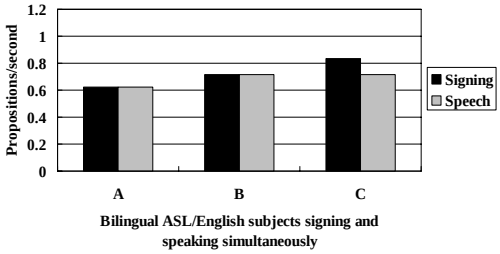
## Transmission efficiency in simultaneous communication




Bilingual ASL/English subjects signing and speaking simultaneously

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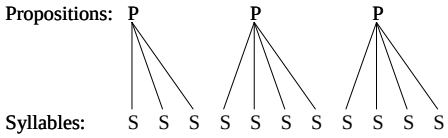
## Representational efficiency

- The efficiency of the grammar in mapping propositions into phonological structure

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## Measuring representational efficiency

- Propositions per syllable
- Defining the syllable in sign phonology:
  - A "movement excursion" (Wilbur & Nolen, 1986)
  - It's still controversial whether "syllable" is really the right notion here (cf. Channon, 2002)
- Signs are usually only "polysyllabic" through reduplication

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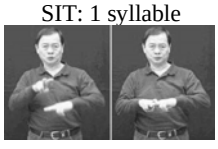
## Examples of "syllables" in TSL

SIT: 1 syllable



SHRIMP: 2 syllables

(from Lee, 2003)

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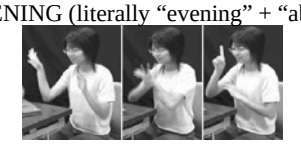
## TSL vs. Signed Chinese

EVENING (TSL)

EVENING (literally “evening” + “above”)



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## Our study

- Fixed discourse:


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

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## 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

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## 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

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## 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

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## Sample transcript

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Spoken:** | 有 | 個 | 小 | 男孩 | | 他 | 和 |
| | exist | class | small | boy | | he | and |
| **Signed:** | 有 | | | 男 | 孩 | | 和 |
| | exist | | | male | child | | and |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Spoken:** | 他 | 的 | 小 | 狗狗 | 養 | 了 | |
| | he | poss | small | dog | raise | compl.asp | |
| **Signed:** | | | | 狗 | 養 | | |
| | | | | dog | raise | | |

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## Sample transcript

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spoken:** | 一 | 隻 | 小 | 青蛙 | 把 | 牠 | 養在 |
| | one | class | small | frog | obj. | it | raise |
| **Signed:** | 一 | 瓶 | | 蛙 | | | |
| | one | bottle | | frog | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spoken:** | 瓶子 | 裡面 | 他們 | 常常 | 跟著 | 牠 | 說話 |
| | bottle | inside | they | often | follow | it | talk |
| **Signed:** | 瓶 | 內 | | | | | 說話 |
| | bottle | within | | | | | talk |

## 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

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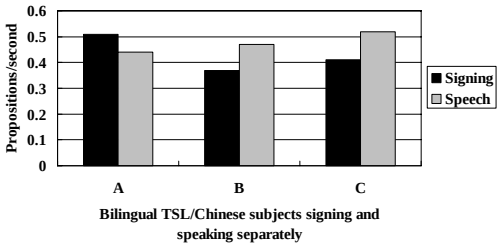
## Transmission efficiency for bilingual TSL/Chinese

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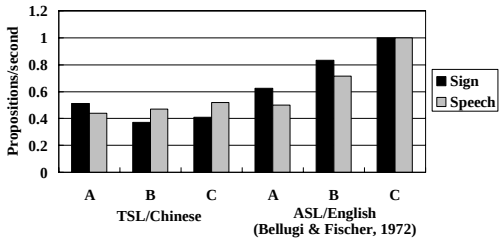
## Transmission efficiency in TSL/Chinese vs. ASL/English

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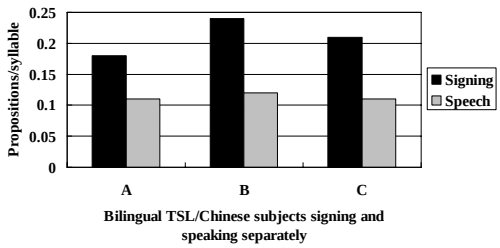
## Representational efficiency for bilingual TSL/Chinese

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## 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?

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## 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)

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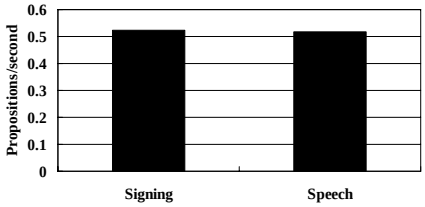
## Effect of modality on transmission efficiency

- (All 57 participants, with age factored out)




(Not significant)

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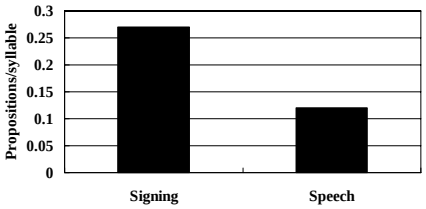
## Effect of modality on representational efficiency

- (All 57 participants, with age factored out)




(Highly significant)

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## Nativeness 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

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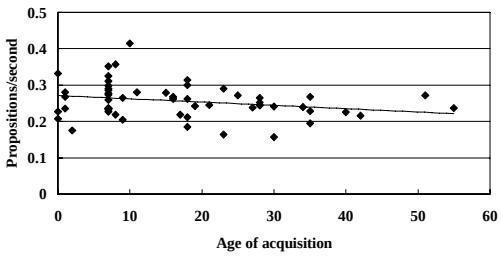
## No effect of age of acquisition on representational efficiency

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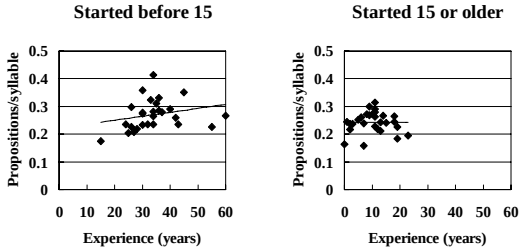
## Experience and representational efficiency in early vs. late signers




Early learners benefited more from experience?

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## Nativeness and transmission efficiency

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

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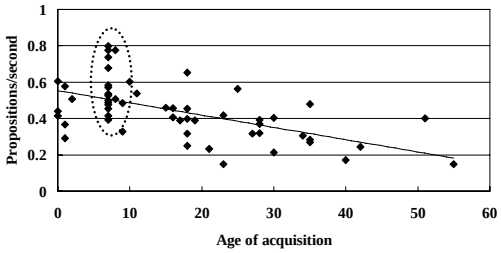
## Effect of age of acquisition on transmission efficiency

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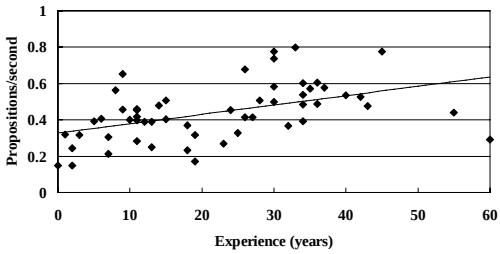
## Effect of experience on transmission efficiency

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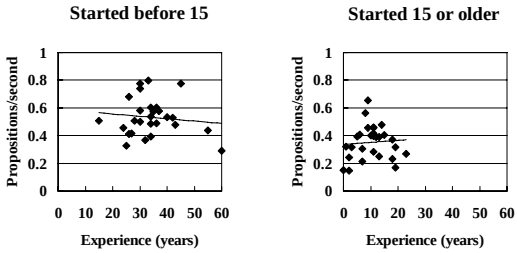
## Experience and transmission efficiency in early vs. late signers




Late learners benefited more from experience?

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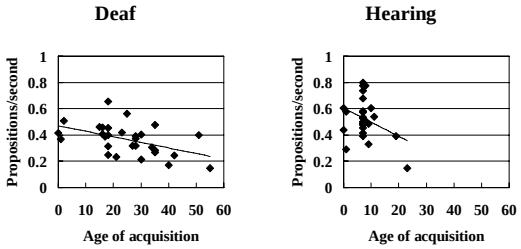
## Age of acquisition and transmission efficiency in deaf vs. hearing signers




With deafness as motivator, early acquisition is less crucial?

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## The effects of simultaneous communication

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

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## 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

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## 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

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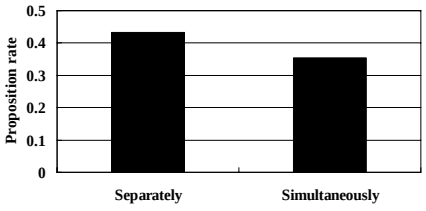
## Simultaneous communication hurts transmission efficiency

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## 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?

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## 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

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