Functional Near-Infrared Spectroscopy

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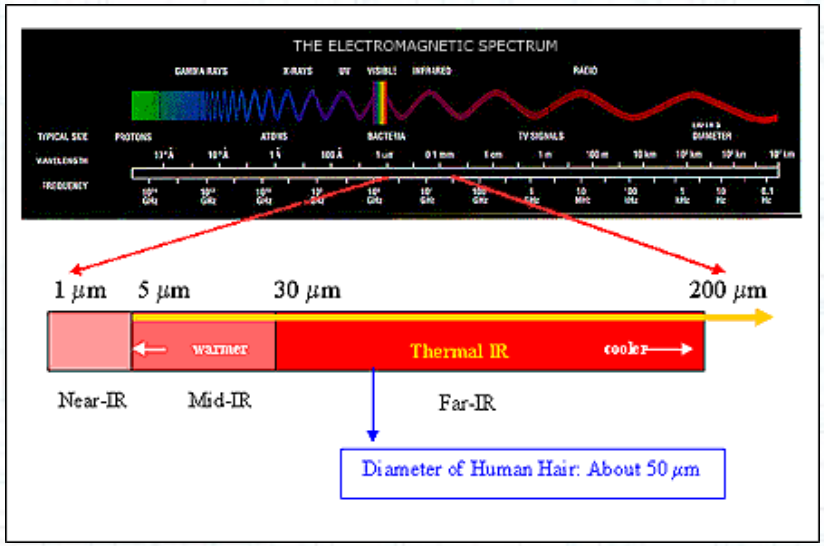
fNIRS - Outline

(Kuhl & Rivera-Gaxiola, 2008)

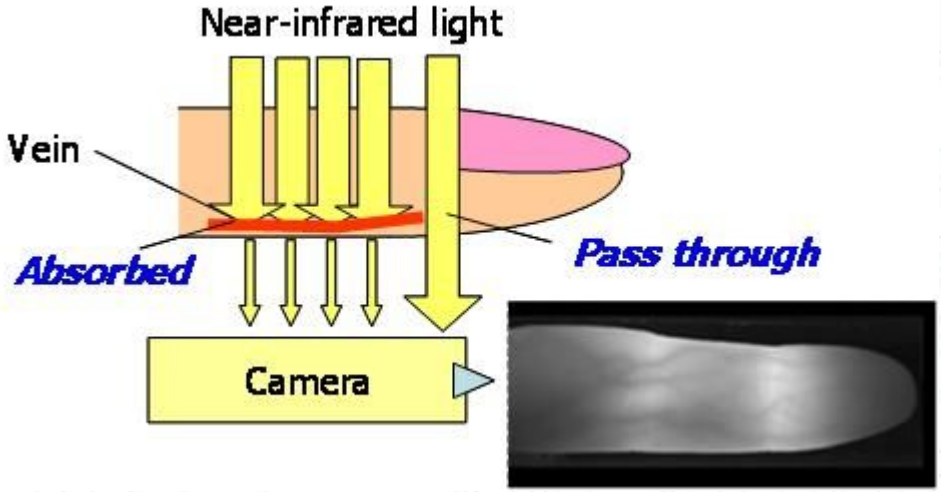
- What is (f)NIRS?
- Basic NIRS physics
- fNIRS system at Drexel
- A simple fNIRS design
- Lexical decision pilot and analysis walk-through
- Proposed study of bilingual lexical categorization

What is NIRS?

Measurement of scattered infrared light...

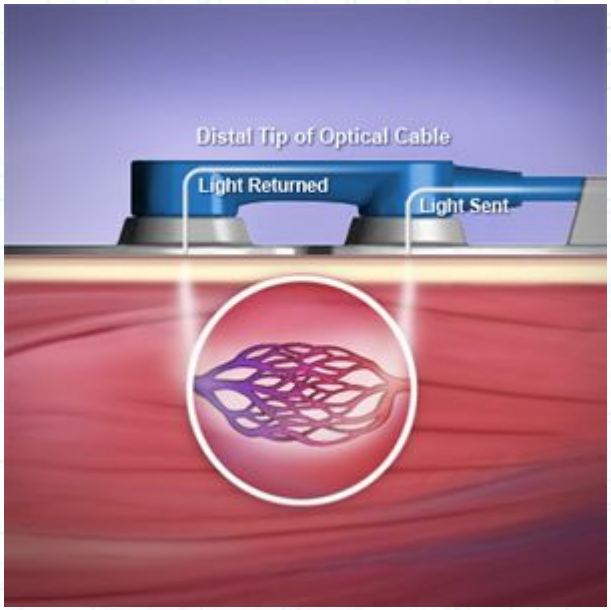


...to detect and measure hemoglobin.



△ Hitachi

▷ MedGadget.com

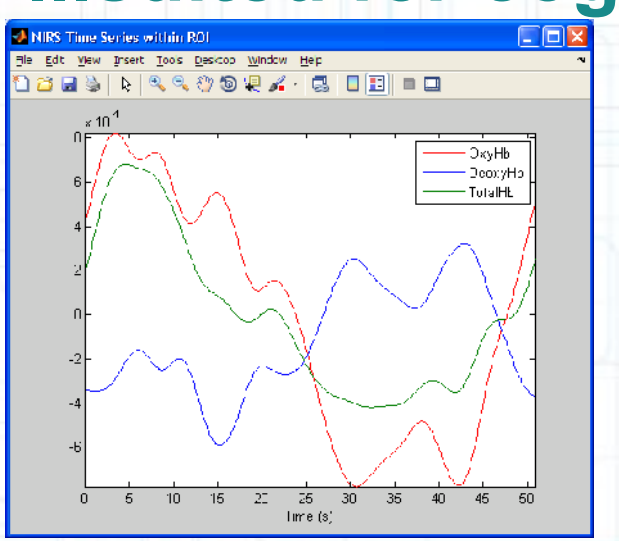


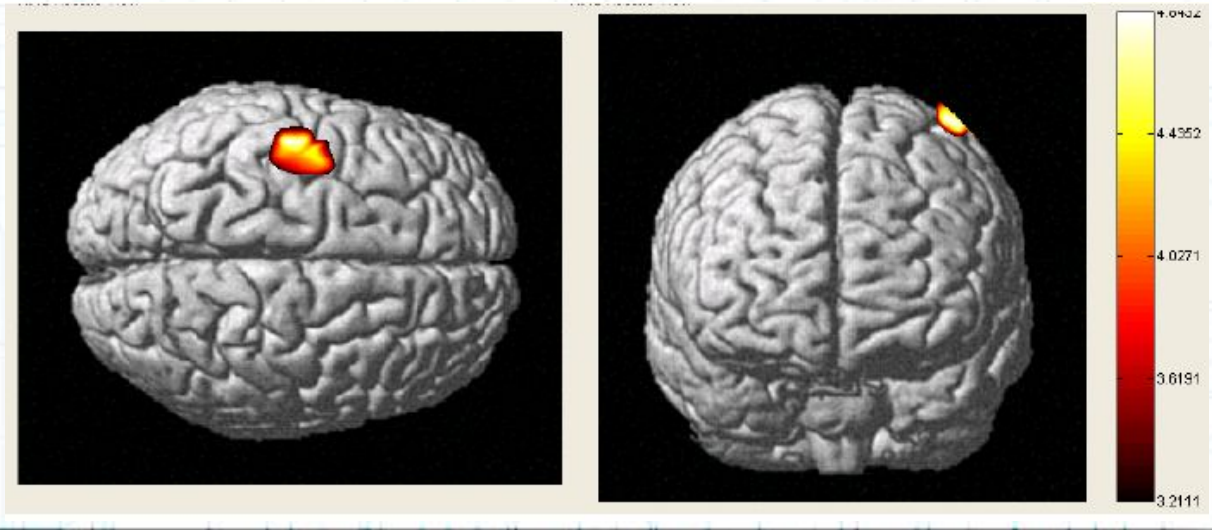
What is fNIRS?

A unique neuroimaging tool...

	Measures	Spatial Resolution	Temporal Resolution	Motion Sensitivity
EEG	Electrical potential	Very low	100s Hz	moderate
fMRI	Hemodynamic Response	A few mm	< 0.3 Hz	high
fNIRS	Hemodynamic Response	A few cm	2-10 Hz	moderate

...suited for cognitive neuroscience research.





Basic NIRS Physics

Most biological tissues are roughly transparent in the 700-900 nm range.

However, hemoglobin selectively absorbs near infra-red light within this optic window:

730 nm – Deoxy-Hb

850 nm – Oxy-Hb

Using the Modified Beer-Lambert Law, measurements of scattered light can be used to infer Hb levels along the “banana curve”

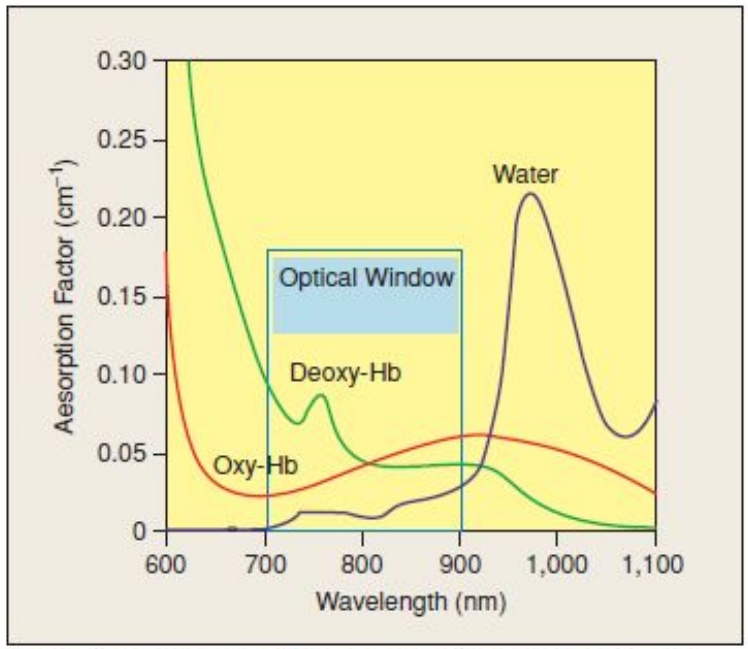


Fig. 1. Absorption spectrum in near-infrared (NIR) window.

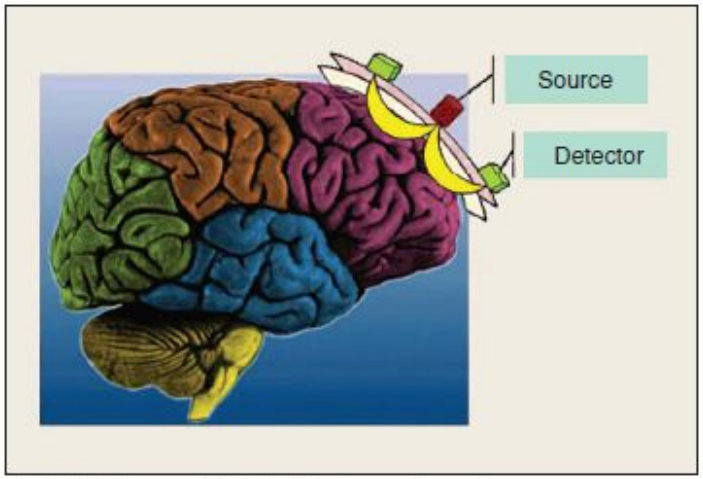


Fig. 2. Photon path inside the human head.

Basic NIRS Physics (supplemental)

Raw data collected:
light intensity (I) at 730 and 850 nm

$$I = GI_o e - (\alpha_{HB} C_{HB} + \alpha_{HBO2} C_{HBO2}) \times L$$

$$\Delta OD = \log_{10} \frac{I_b}{I} = \alpha_{HB} \Delta C_{HB} + \alpha_{HBO2} \Delta C_{HBO2}$$

$$Oxygenation = \Delta C_{HBO2} - \Delta C_{HB}$$

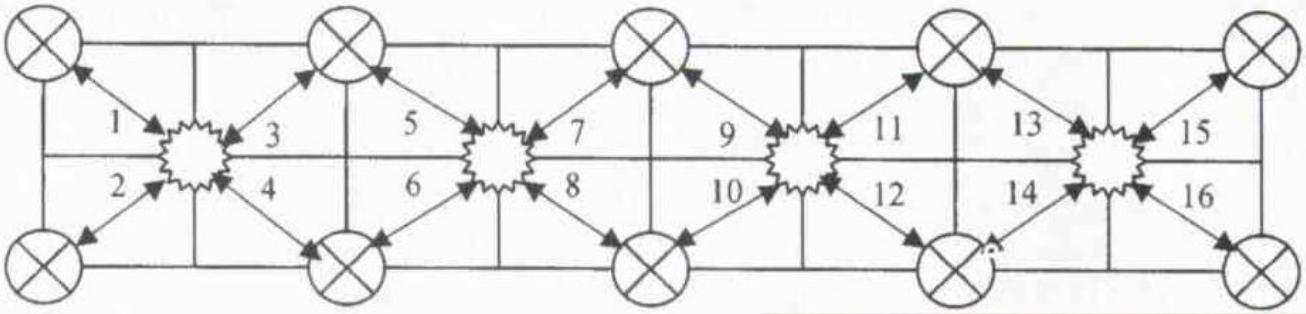
$$BloodVolume = \Delta C_{HBO2} + \Delta C_{HB}$$

Processed data (usually done by software):
OxyHb, DeoxyHb, Total Hb

fNIRS Applications

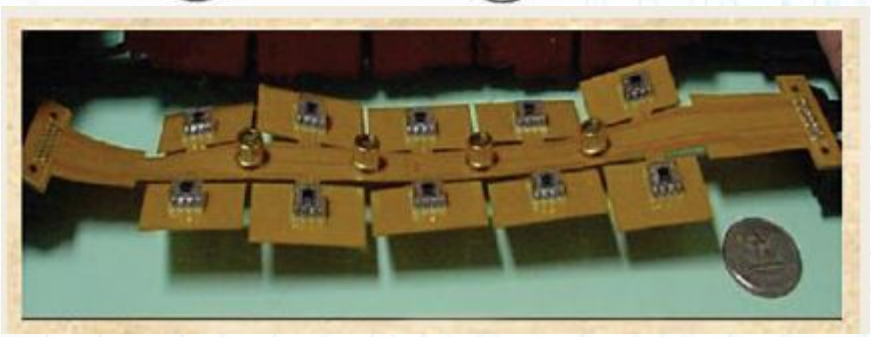
- Brain-Computer Interface (Ayaz et al, 2009)
- Working memory (Itzzetoglu et al, 2007)
- Situational awareness (Menda et al, 2010)
- Pain Response (Barati et al, in prep)
- Bilingual Processing (Kovelman et al, 2008)
- Hematoma Detection (Zhang et al, 2000)

fNIR at the CONQUER Collaborative (Drexel Univ)



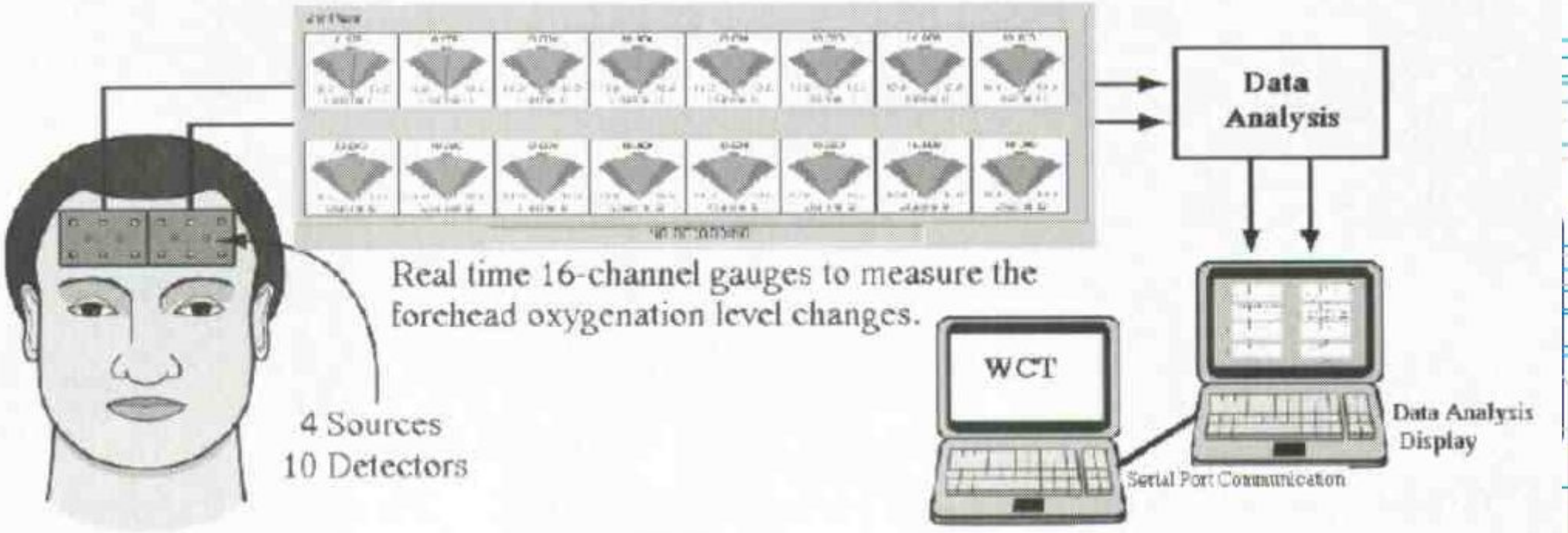
: source

: detector



- 16 channels @ ~2Hz
- 2 cm source-to-detector
- Fast & easy deployment
- Limited to mPFC

fNIR at the CONQUER Collaborative (Drexel Univ)



- fNIR Data Processing:
  Probe → Signal Amplifier → Analysis Display
- Event Marking:
  Task computer → Analysis Display (via serial port)

fNIR at the CONQUER Collaborative (Drexel Univ)

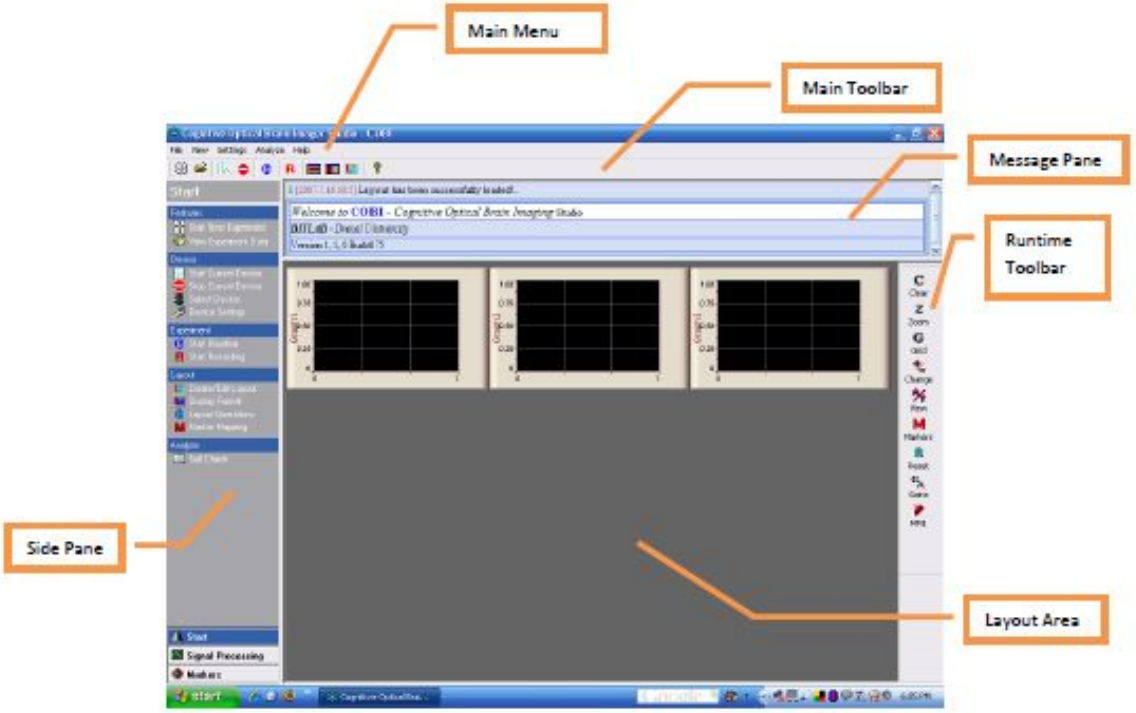
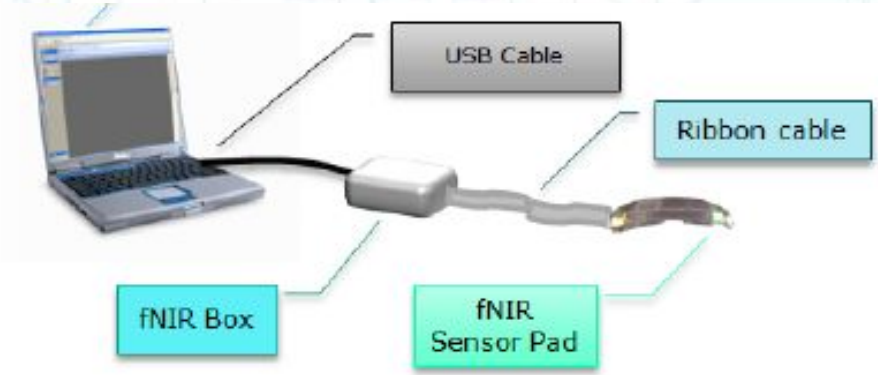


Figure 2. COBI main window and components

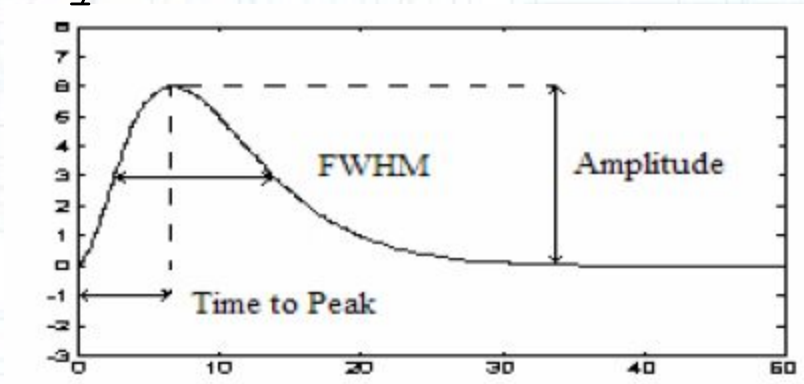
- COBI Studio: Stand-alone fNIR data collection platform
- Option for highly portable fNIR experiments (and more to come...)

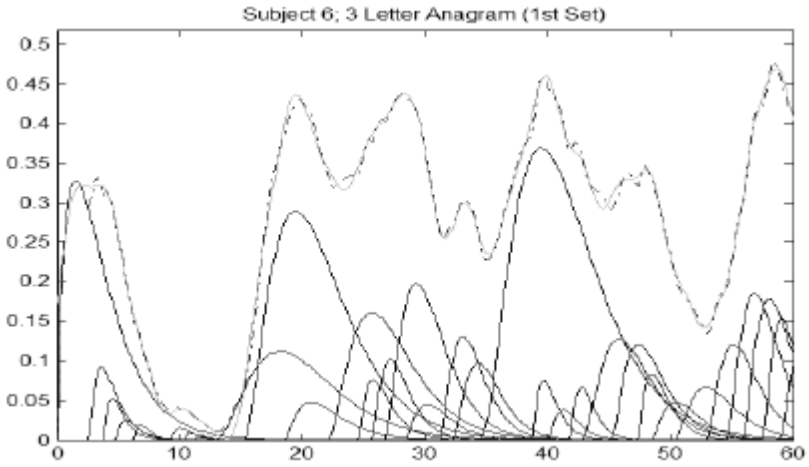


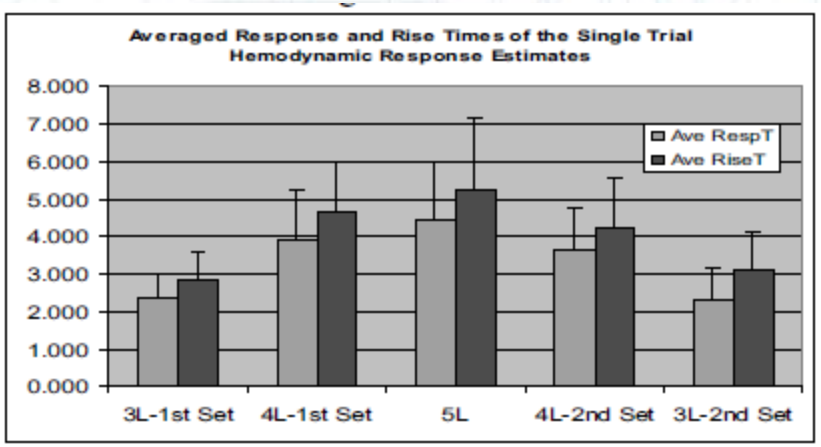
Anagram Study – Event Related Analysis

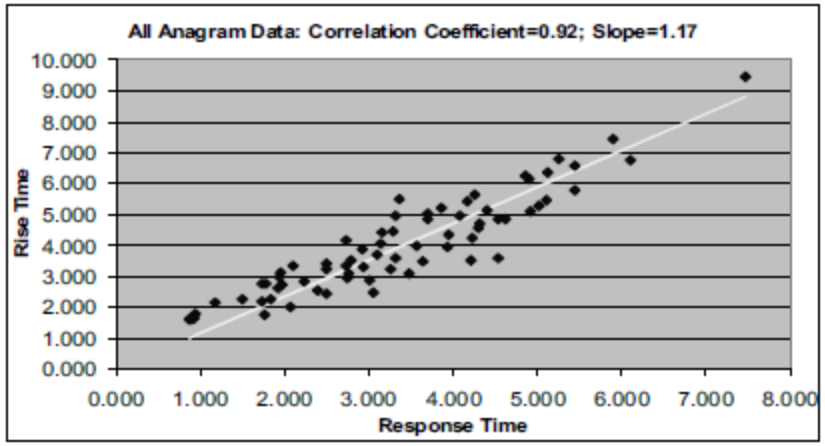
$hrf(t) = A*t^{\alpha}*e^{t\beta}$

$Oxy = \Sigma hrf$









Izzetoglu, M., Nioka, S., Chance, B., & Onaral, B. (2005). Single trial hemodynamic response estimation in a block anagram solution study using fNIR spectroscopy. IEEE, 633-636.

LDT: Event-Related Design

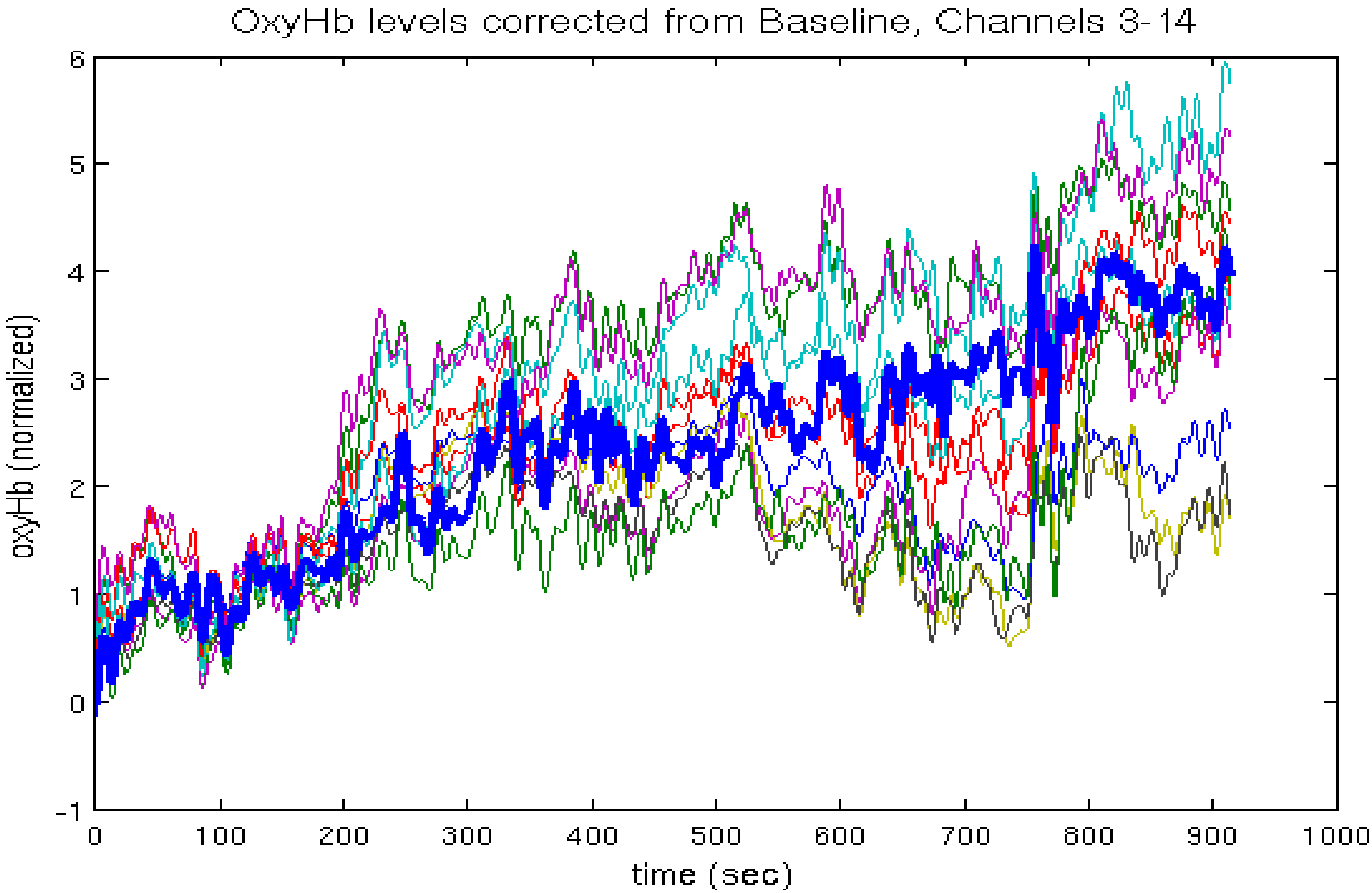
Task: Word/Pseudoword lexical decision

Protocol:

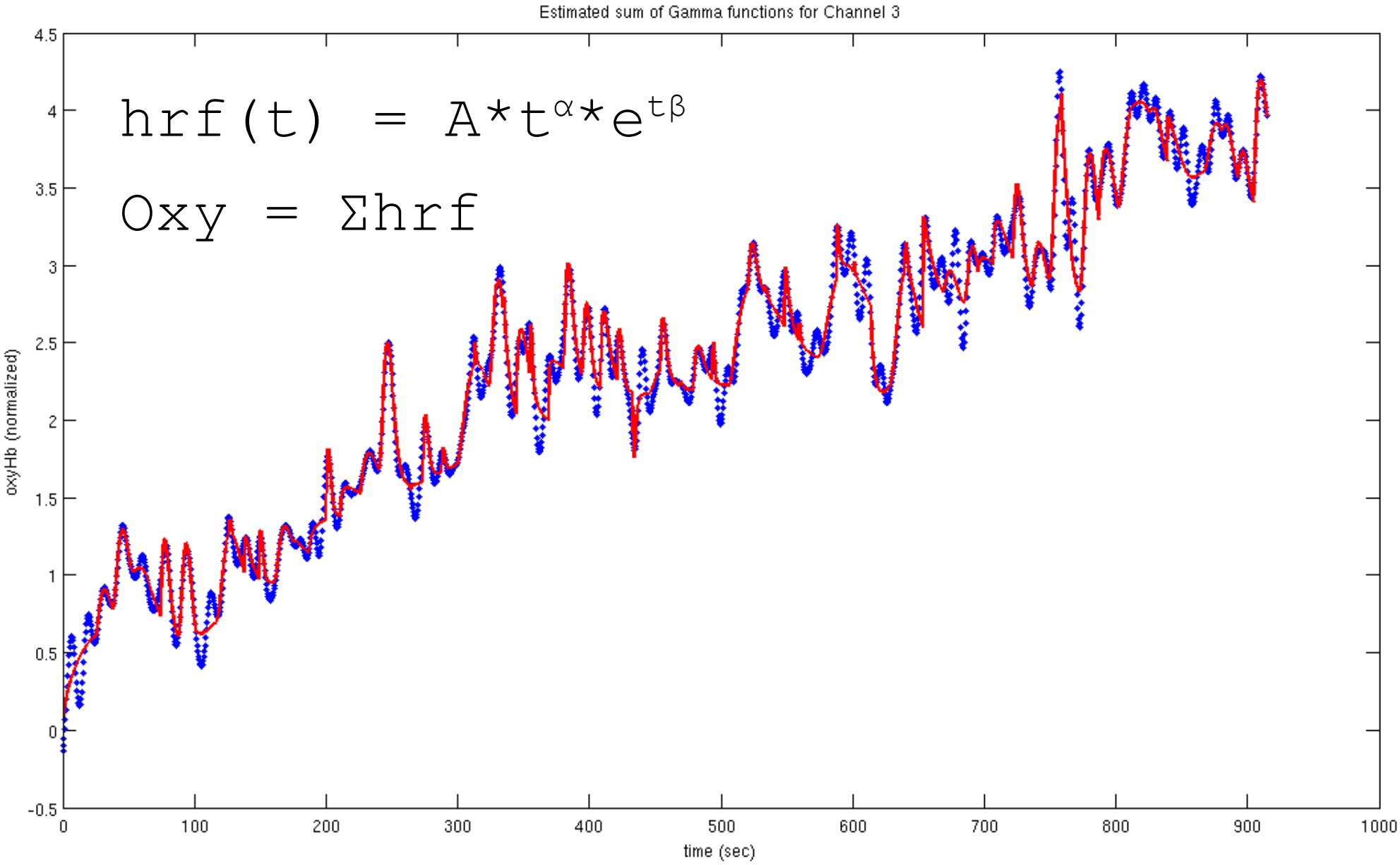
- random-ordered presentation of w/p's in E-Prime 2.0
  - Stimulus duration: 200ms
  - Response duration: 2000ms
  - Inter-stimulus interval: U-dist 6-14sec
- continuous fNIRS data collection for OxyHB, DeoxyHB, Blood volume

Hypothesis: Increased PFC activitation for semantic processing in p condition. Based on Blumenfeld, Booth, and Burman (2006)

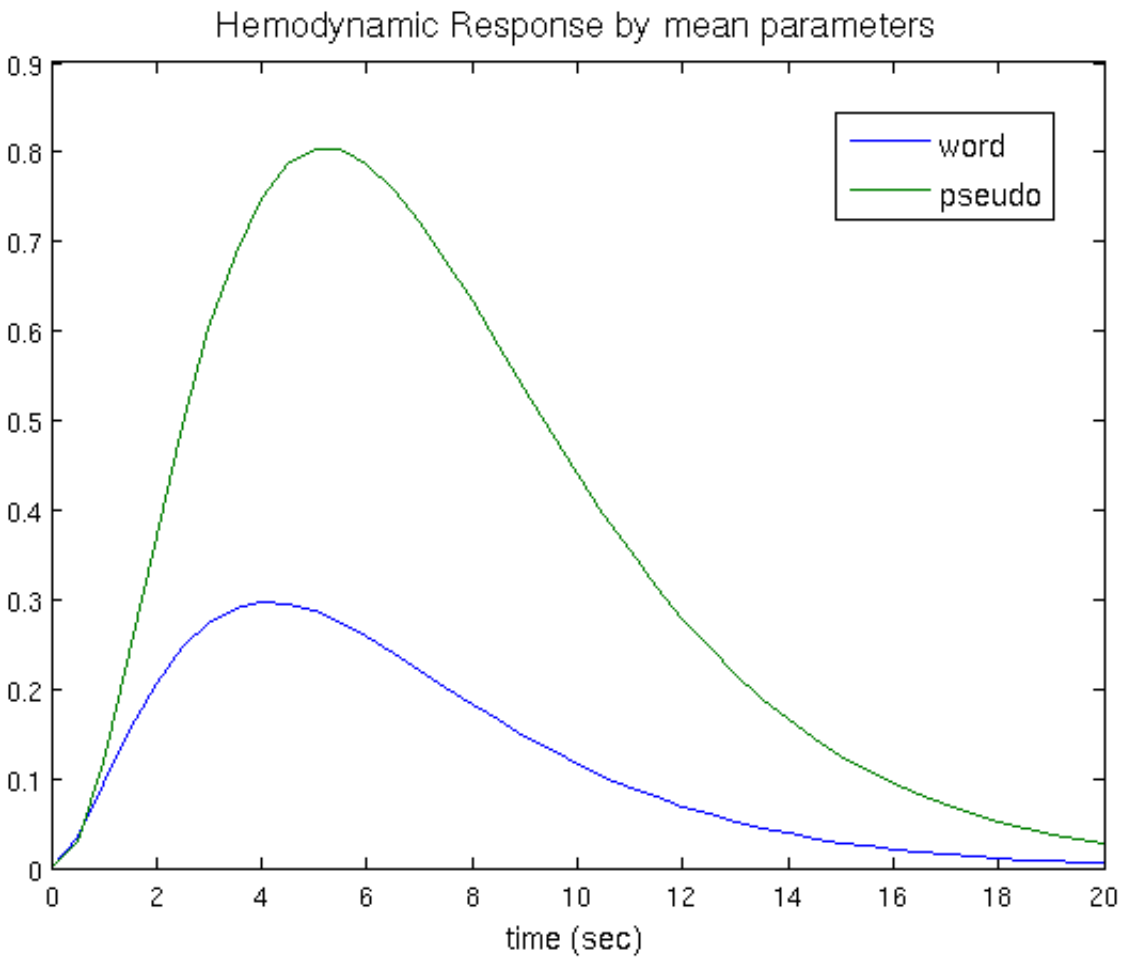
Data Analysis



Data Analysis – event related



Data Analysis – event related



Lexical Categorization (English Monolingual)

Cup

Bottle

Mug

Lexical Categorization (CE Bilingual)

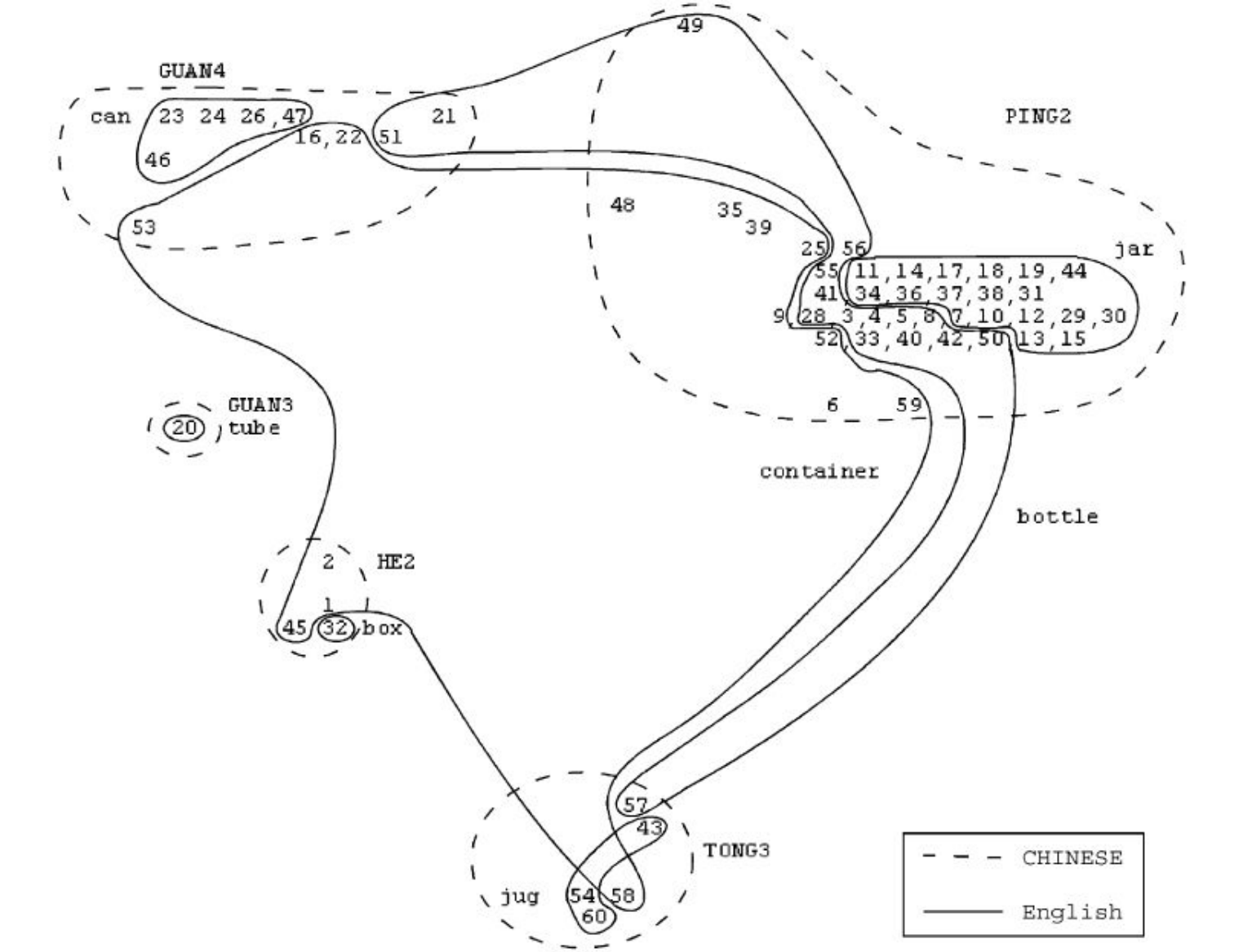


Fig. 3. Chinese–English comparison (with Chinese providing the spatial layout).

Lexical categories aren't universal between languages.

Future Work

Medial prefrontal activation as a predictor of lexical categorization shifts.

Task: Picture naming in L1

Protocol:

- random-ordered presentation of objects in self-paced naming
- objects differ in X-linguistic agreement
- continuous fNIRS data collection for OxyHB

Hypothesis: Increased mPFC oxygenation in CE-bilinguals for x-linguistically conflicting items

Thanks

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