Measuring physiological speech entrainment with electromagnetic articulography (EMA)

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Setting up a dual EMA configuration for studying speaker interaction

Some EMA background

- A set of transmitter coils generates an alternating electromagnetic field at frequencies of about 10kHz
- ===> Induction of a position- and orientation-dependent signal in small sensors attached to the articulators
- Captures data for both visible (including head) and invisible articulators in readily analyzable form
- Good temporal resolution (samplerate typically > 200Hz)

First approach: Edinburgh Speech Production Facility

Two Carstens AG500 machines

Main drawback: Both systems use the same transmitter frequencies

==> interference ==> speakers must be at least 6m apart

==> in practice, in separate rooms (connected by CCTV)

Geng, C. et al. (2013) *Recording Speech Articulation in Dialogue: Evaluating a synchronized double Electromagnetic Articulography Setup*. J. Phonetics 41(6): 421-431.

Second Approach

1x Carstens AG500 with 1x NDI Wave

No mutual interference of transmitter frequencies

Speakers can be face-to-face, about 2m apart

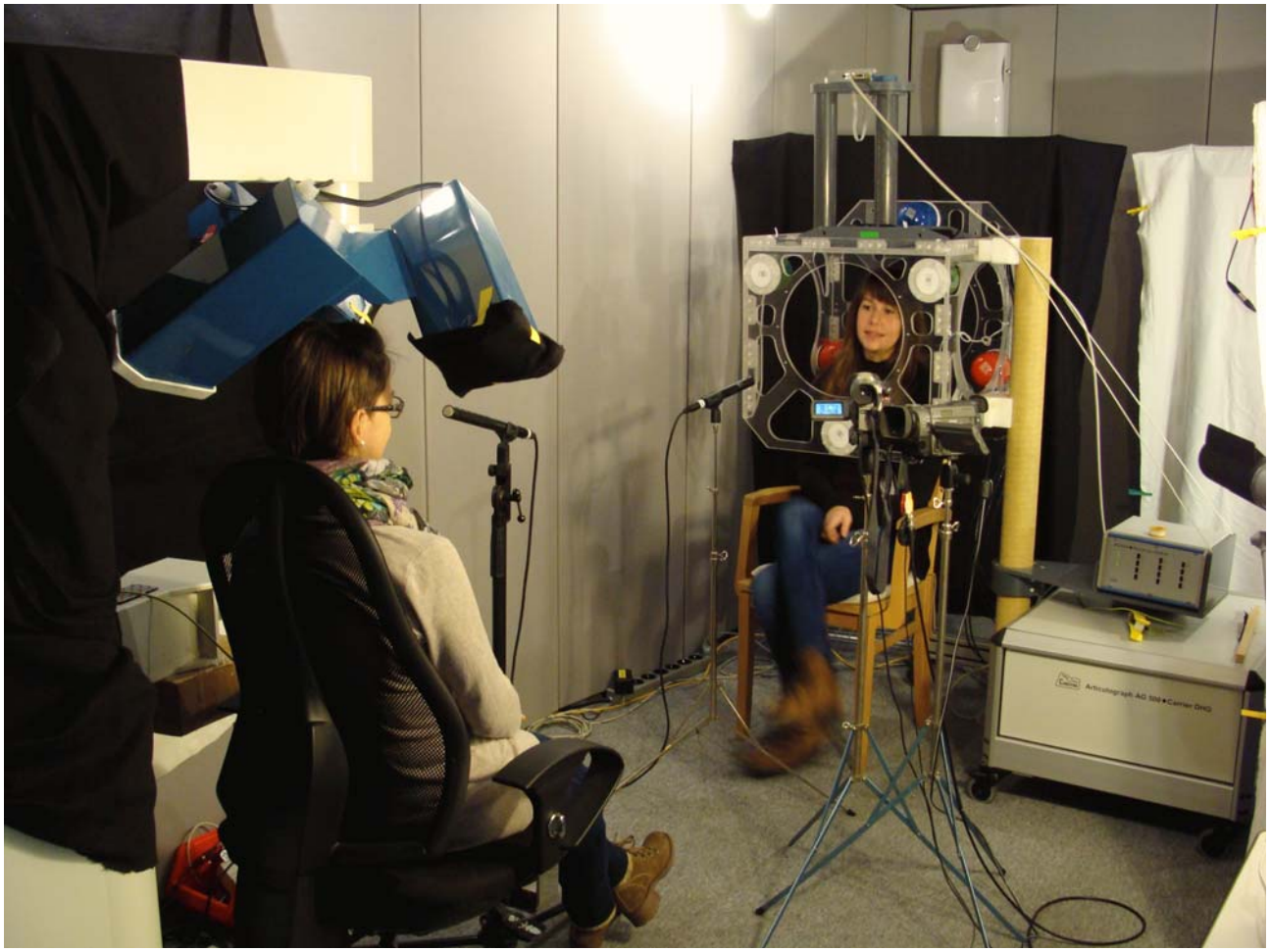
Pilot experiment at MARCS lab, Univ. W. Sydney:

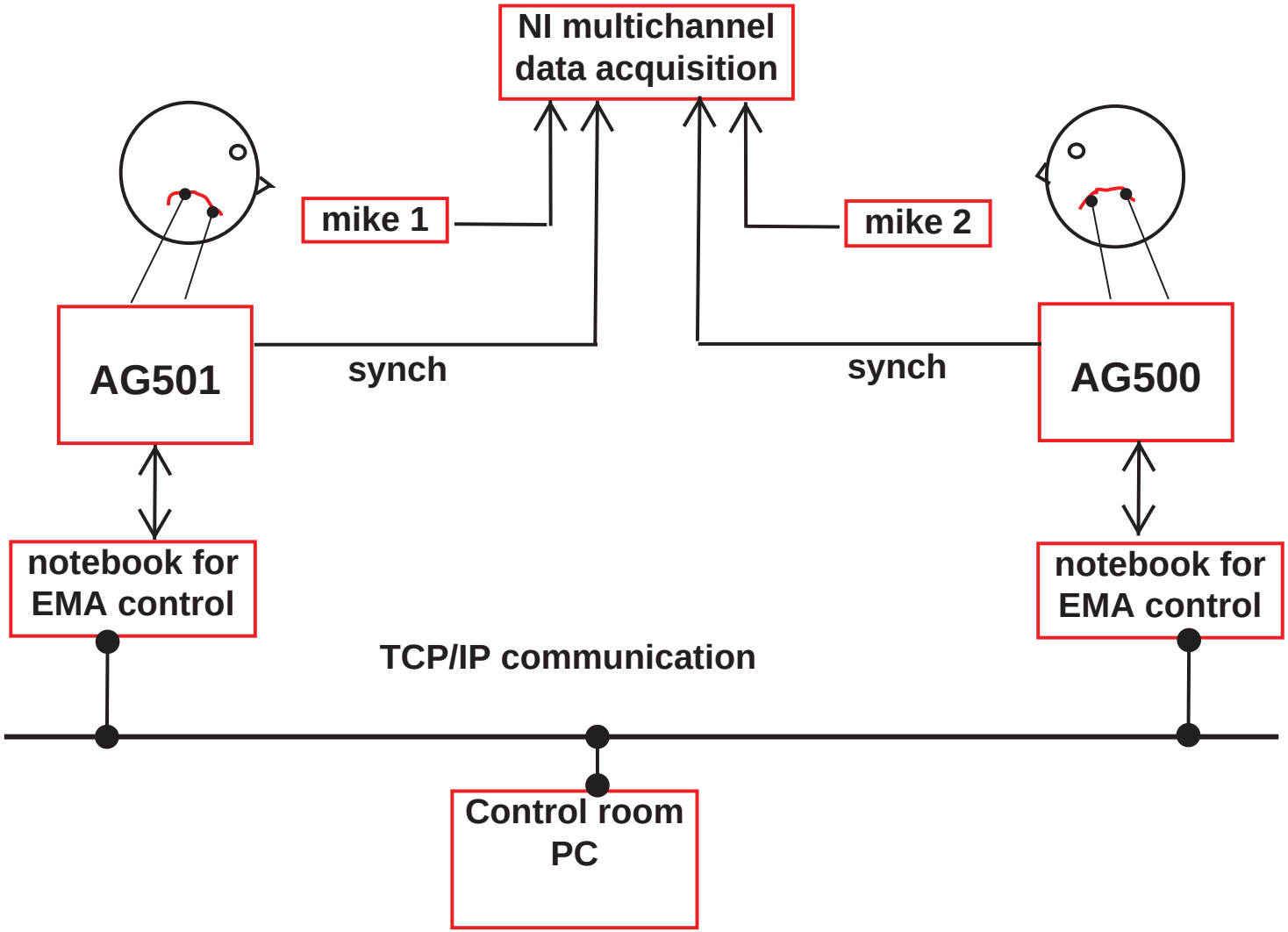
Tiede, M., Bundgaard-Nielsen, R., Kroos, C., Gibert, G., Attina, V., Kasisopa, B., Vatikiotis-Bateson, E. & Best, C. (2010). *Speech articulator movements recorded from facing talkers using two electromagnetic articulometer systems simultaneously*. Proceedings of Meetings on Acoustics, Vol. 11, 060007

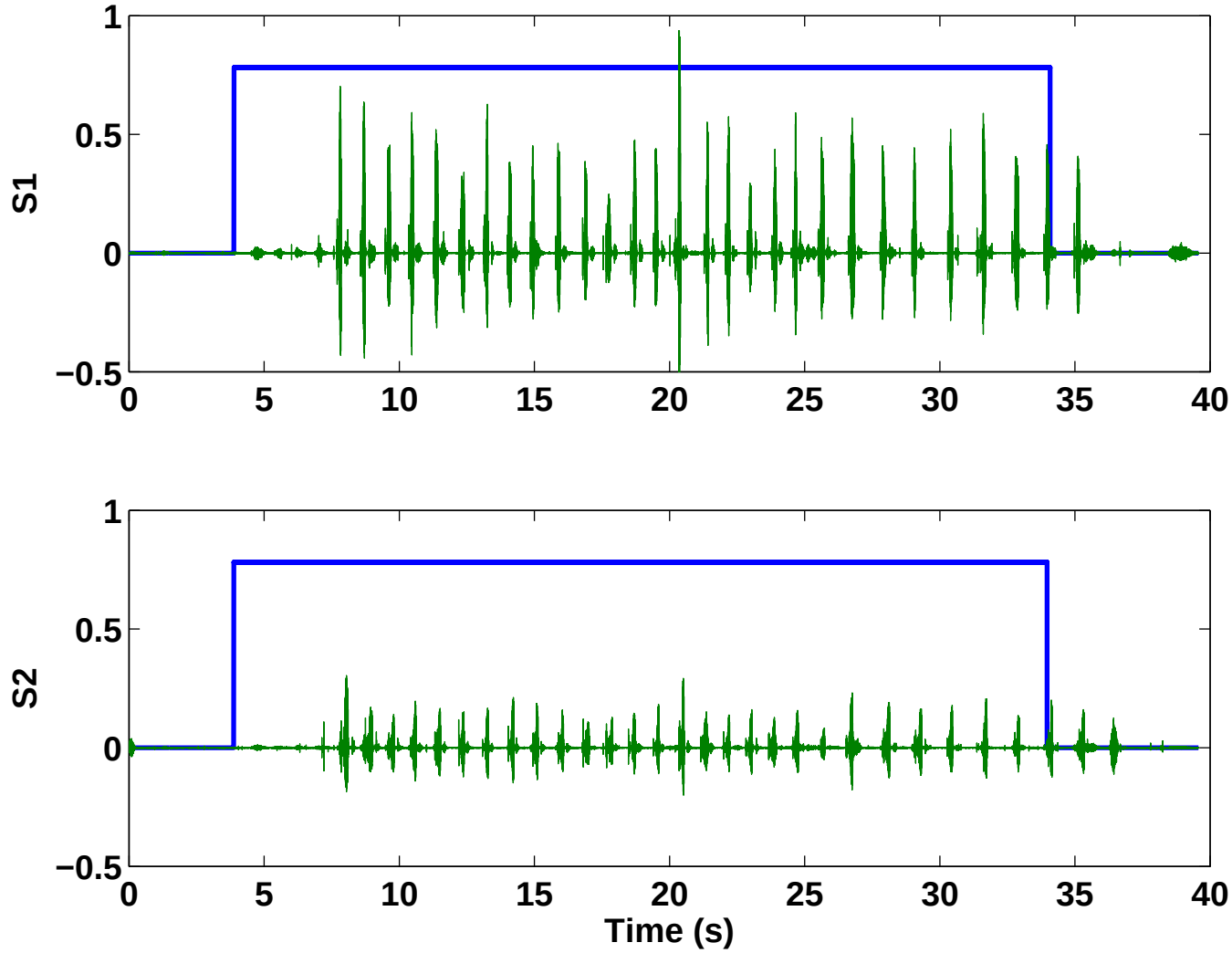
Vatikiotis-Bateson, E., Barbosa, A. V. & Best, C. (2014). *Articulatory coordination of two vocal tracts*. J. Phonetics 44, 167-181.

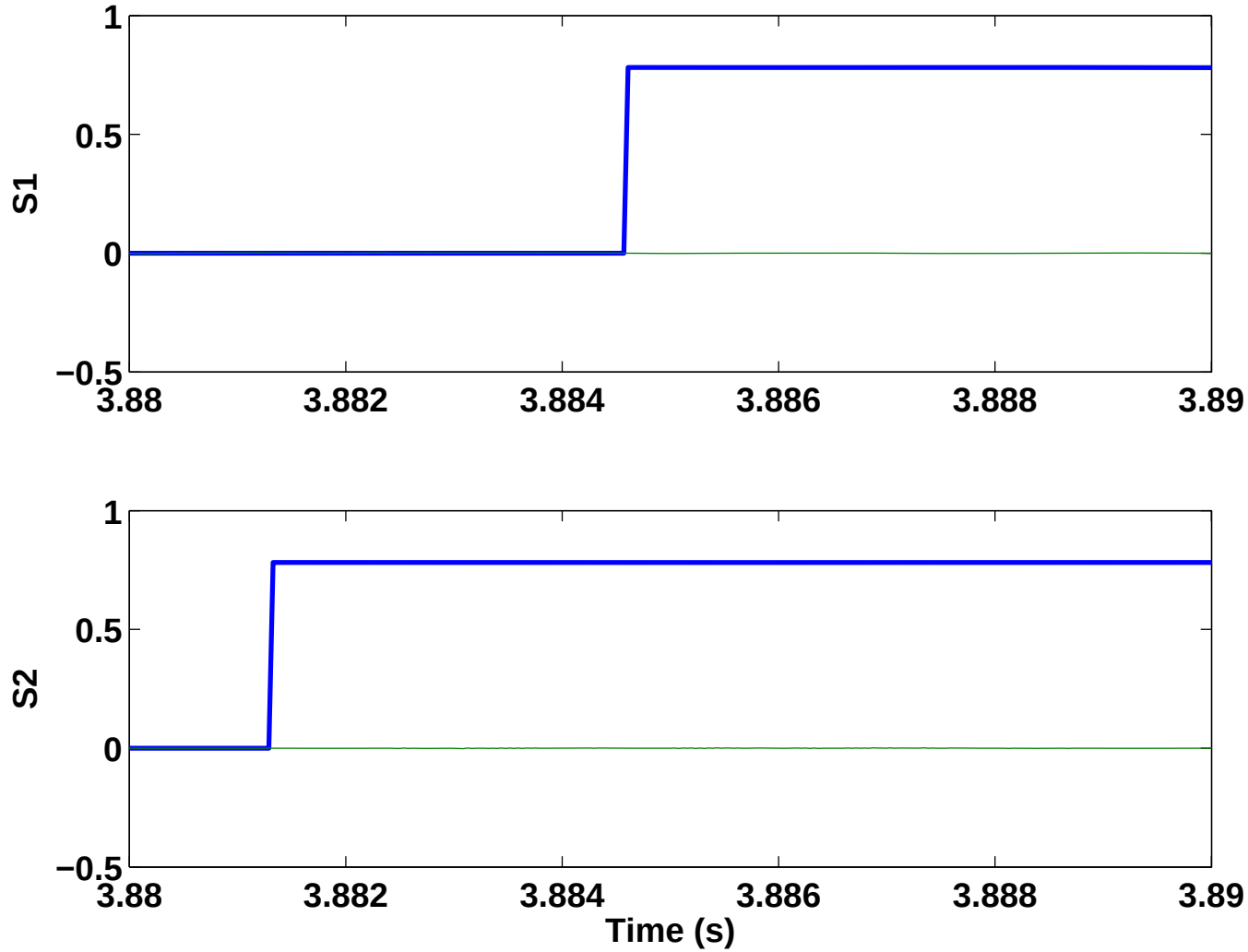
Our setup: 1 x Carstens AG501 with 1x Carstens AG500

No mutual interference at inter-speaker distances > 2m




NI multichannel
data acquisition
mike 1
mike 2
AG501
AG500
synch
synch
notebook for
EMA control
notebook for
EMA control
TCP/IP communication
Control room
PC


S1
S2
1
0.5
0
−0.5
0
5
10
15
20
25
30
35
40
Time (s)



Detailed view of the two synch signals at trial onset

Further features of recording setup

- No noisy equipment in recording booth
- HDV video: merged view of 2 cameras plus control PC monitor
- Additional synchronized measurement signal are easy to record

Pilot experiment based on Tiede et al. experiment at MARCS

EMA sensors

articulators: tongue tip, tongue body, upper lip, lower lip

head: upper incisors, bridge of nose, behind left and right ear

After recording, head sensors used

(1) to factor out head movement from articulator sensors

(2) to calculate the rigid-body parameters of head movement (3 translations, 3 rotations)

Subjects spoke alternating word sequences for 30s, e.g.

S1: “Topf Kopf Topf Kopf ......”

S2: “Kopf Topf Kopf Topf ......”

sometimes “disturbed” by instructions from investigator to speed up or slow down.

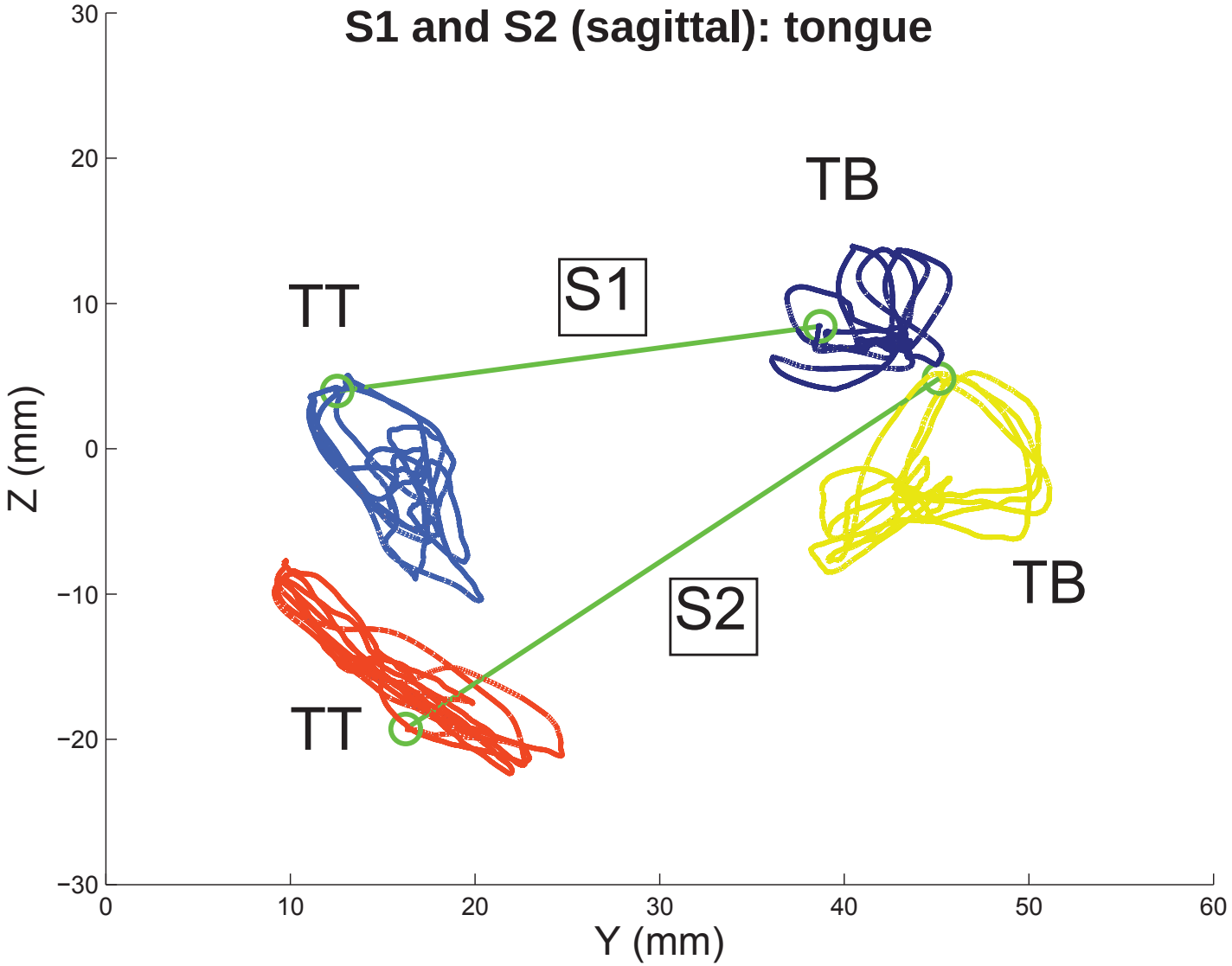
cf. Goldstein, L., Pouplier, M., Chen, L., Saltzman, E. & Byrd, D. (2007). *Dynamic action units slip in speech production errors*. Cognition 103, 386-412.

[some non-alternating sequences also recorded, e.g.

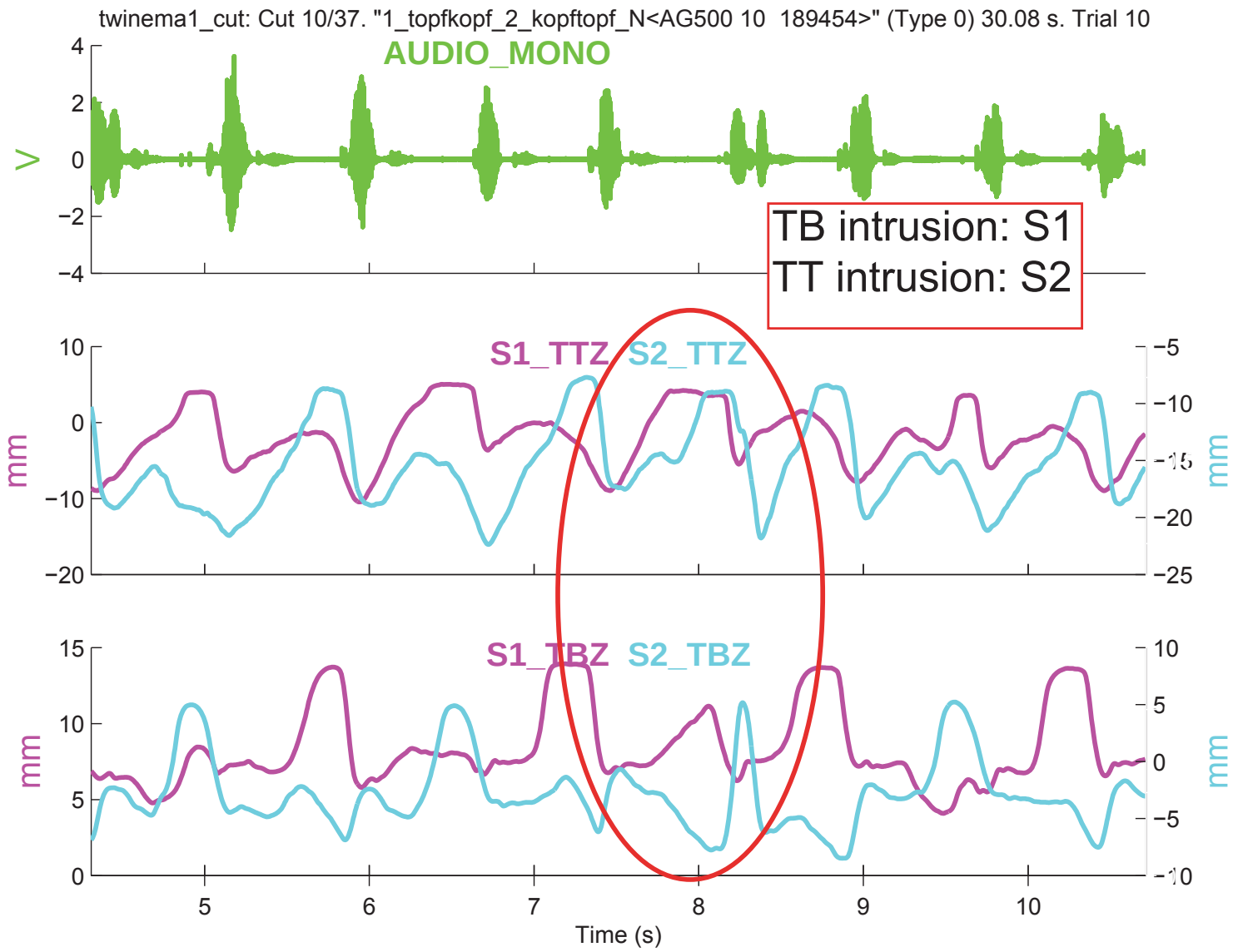
S1: “Topf Topf Topf Topf ......”

S2: “Kopf Kopf Kopf Kopf ......”

]


S1 and S2 (sagittal): tongue
TB
TT
S1
TB
S2
TT
Z (mm)
Y (mm)
30
20
10
0
−10
−20
−30
0
10
20
30
40
50
60

Movie demo


twinema1_cut: Cut 10/37. "1_topfkopf_2_kopftopf_N<AG500 10 189454>" (Type 0) 30.08 s. Trial 10
AUDIO_MONO
V
TB intrusion: S1
TT intrusion: S2
S1_TTZ
S2_TTZ
mm
S1_TBZ
S2_TBZ
Time (s)

Final comments

Examples of entrainment in this presentation based on rhythmic utterances (“speech-error” paradigm).

But Tiede & Mooshammer have recently applied the dual-EMA setup to a more traditional phonetic convergence paradigm.

Kinematic properties of velar consonants in test items more similar after a period of face-to-face interaction.

Tiede, M. & Mooshammer, C. (2013) *Evidence for an articulatory component of phonetic convergence from dual electromagnetic articulometer observation of interacting talkers*. Proceedings of Meetings on Acoustics, Vol. 19, 060138

Outlook

Upgrade AG500 to AG501 (2x AG501 setup is possible because AG501 can be configured to different transmitter frequencies)

Advantages of AG501:

- data-processing much less time-consuming
- large head-movements captured with much less measurement error
- subject less enclosed (easier to combine with optical systems)
- ===> improved possibilities for more natural subject interaction

Other labs (e.g. USC) are exploring use of dual NDI Wave systems.