Simulating Tonic/Postural Activations in Speech Production
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Biomechanical Modeling using Artisynth
- 3D finite-element method (FEM) model; www.artisynth.org [Bedi et al., 2012]
- FEM dynamics enables realistic collision detection and tissue compression

Simulation methods
- Vowels/sibilants:
  - Jaw-hyoid tongue model (Stavness et al. 2012)
  - Facial expression: FEM face model

Simulation results
- DR (R&E 2009) vs JP (R&E 2009)

Tonic/Postural Vowels (local overlap):
- V only

Tonic/Postural Sibilants (non-local overlap):
- Harmony can work the same way (cf. Turkish labial harmony, e.g. Boyce 1990)
- Segmental content of intervening material is irrelevant

Tonic/Postural Emotion Expression: Smile vs. Lip Closure (global overlap):
- Lip Closure with Neutral Expression
- Lip Muscles

Introduction: Synergies, Posture & Superposition
- Spatially Fixed Muscle Synergies (SFMS, Safavynia and Ting 2012)
- Neuromuscular modules are functionally defined in the nervous system to govern a basic, natural body action (e.g., Berinker et al., 2009).

- “Orality” as tonic setting (Benguerel 1977):
- Different temporal types:
  - Transient
  - Sequential

- Overlapping Innervation Wave Theory (Ioos, 1948)

We use biomechanical simulation to test superposition of tonic/postural devices in 3 contexts:
Local: coarticulation in adjacent sounds (e.g., a vs. i)
- Simulate/replicate EMA results of Recasens & Espinosa (2009)
Non-local: long-distance interactions (e.g., /s/ vs. /s/)
- Simulate effect across intervening segment(s)

Motion Expression:
- affects every sound in a language
- cf. articulatory setting (Gick et al. 2004)

References

Artisynth

Tonic/Postural Activations are pervasive in speech
- Superposition works across different scales with no extrinsic model of coarticulation
- Built-in mechanics of the human body can handle coarticulatory interactions with simple overlap
  - no advance planning
  - no contextual information
- Simple temporal overlap of muscle activations in a biomechanically realistic simulation produces plausible, idiosyncratic coarticulation patterns
  - Locally (shown for canonical VCV combinations)
  - Non-locally (shown for sibilant harmony)
  - Globally (shown for emotion expression)
- “Tug-of-war” requires greater activation to achieve lip closure

FUTURE WORK:
- Continue to seek examples of tonic/postural devices in speech
- Continue EMG validation studies
- Simulate a wider range of phenomena
(e.g., articulatory settings, laryngeal states, etc.)
- What about SUPPRESSION/INHIBITION?

Discussion
- Tonic/postural activations are pervasive in speech
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Acknowledgement
We acknowledge the contributions of our many collaborators, in particular, Ian Stavness (U. Saskatchewan), Sid Fels and members of the UBC HCI Lab, and members of the TRMC/IMAG lab and GISPA lab. Grenoble have contributed to Artisynth; also, Teriina Chan, Yang Fu, Bruce Furin and others of the UBC SRL have helped with validation. Research funded by NSERC and NIH.

NB: We use no explicit model of coarticulation – just a body