Investigating articulatory differences between upright and supine posture using 3D EMA

Ingmar Steiner[1,2], **Slim Ouni**[1,3]

[1]LORIA Speech Group

[2]INRIA Grand Est

[3]Université Nancy 2
Bat. C, 615 Rue du Jardin Botanique, 54600 Villers-lès-Nancy, France

Firstname.Lastname@loria.fr

Abstract

It is well-known that gravity and head position can have a significant influence on vocal tract shape. This *posture effect* has been observed by contrasting articulatory data obtained from the same speakers in different postures within or across acquisition modalities.

Previous studies have compared velum height during English vowels using upright cineradiography and supine MRI (Whalen, 1990); vowels and running speech using upright and supine EMA (Tiede et al., 1997); jaw movement during CVC sequences in upright, supine, and prone position using optical point-tracking (Shiller et al., 1999); Japanese vowels, CV sequences, and running speech using upright and supine X-ray microbeam (Tiede et al., 2000); English word sequences using upright and supine ultrasound tongue imaging (Stone et al., 2002, 2007); Japanese vowels using upright and supine MRI in an *open* scanner (Kitamura et al., 2005); and Swedish vowels and sustained consonants using supine and prone MRI (Engwall, 2006).

While this prior work indicates that for some speakers, gravity and posture have a pronounced effect on articulation, the exact nature of this effect is not always fully explored. In particular, acoustic feedback, as well as the relevance of individual articulators for a given vocal tract target configuration, may have an impact on how the posture effect manifests.

In this study, we systematically explore the posture effect using 3D electromagnetic articulography (EMA) data of sustained and dynamic speech produced in upright and supine position, taking articulatory relevance into account. In fact, one goal is to replicate as closely as possible the MRI acquisition procedure to show the main effects on articulation and acoustic during the production of sustained vowels.

In this work, we present the experimental setup to acquire EMA data in both upright and supine position. We focus particularly on the main differences in both positions regarding the place of articulation and the dynamics (the characteristics of the shifting in articulatory trajectories).

Since our final goal is to define a mapping function by which data from one posture may be transformed into another, this study provides helpful insight toward this goal. In fact, the posture effect should be accounted for in any speech production research involving the spatial alignment (registration) of data obtained from modalities with different posture (even from the same speaker), and we expect that our results may facilitate such registration procedures.

References

Engwall, O. Assessing Magnetic Resonance Imaging measurements: Effects of sustenation, gravitation, and coarticulation. In Harrington, J. and Tabain, M., editors, *Speech Production: Models, Phonetic Processes, and Techniques*, Macquarie Monographs in Cognitive Science, chapter 17, pages 301–313. Psychology Press, New York, NY, May 2006.

Kitamura, T., Takemoto, H., Honda, K., Shimada, Y., Fujimoto, I., Syakudo, Y., Masaki, S., Kuroda, K., Oku-Uchi, N., and Senda, M. Difference in vocal tract shape between upright and supine postures: Observations by an open-type MRI scanner. *Acoustical Science and Technology*, 26(5):465–468, 2005. doi:10.1250/ast.26.465.

Shiller, D. M., Ostry, D. J., and Gribble, P. L. Effects of gravitational load on jaw movements in speech. *Journal of Neuroscience*, 19(20):9073–9080, December 1999. URL `http://www.jneurosci.org/cgi/content/abstract/19/20/9073`.

Stone, M., Crouse, U., and Sutton, M. Exploring the effects of gravity on tongue motion using ultrasound image sequences. *Journal of the Acoustical Society of America*, 111 (5):2476–2477, May 2002.

Stone, M., Stock, G., Bunin, K., Kumar, K., Epstein, M. A., Kambhamettu, C., Li, M., Parthasarathy, V., and Prince, J. L. Comparison of speech production in upright and supine position. *Journal of the Acoustical Society of America*, 122(1):532–541, July 2007. doi:10.1121/1.2715659.

Tiede, M. K., Masaki, S., and Vatikiotis-Bateson, E. Contrasts in speech articulation observed in sitting and supine conditions. In Hoole, P., editor, *Proc. 5th Seminar on Speech Production*, page 25–28, Kloster Seeon, Germany, May 2000. URL `http://www.phonetik.uni-muenchen.de/institut/veranstaltungen/SPS5/abstracts/60_abs.html`.

Tiede, M. K., Masaki, S., Wakumoto, M., and Vatikiotis-Bateson, E. Magnetometer observation of articulation in sitting and supine conditions. *Journal of the Acoustical Society of America*, 102(5):3166, November 1997. doi:10.1121/1.420773.

Whalen, D. H. Intrinsic velar height in supine vowels. *Journal of the Acoustical Society of America*, 88(S1):S54, November 1990. doi:10.1121/1.2029052.