

Mechanical Tongue for use in Dysphagia Studies

Don Weier, Matthew Zanutelli, Lucas Haug, Naomi Humpal

Client: Professor JoAnne Robbins, Ph.D.

Director of UW/VA Swallowing Speech and Dining Enhancement Program

Advisor: Professor Thomas Yen, Ph.D.

Biomedical Engineering Design
University of Wisconsin – Madison
October 21st, 2011

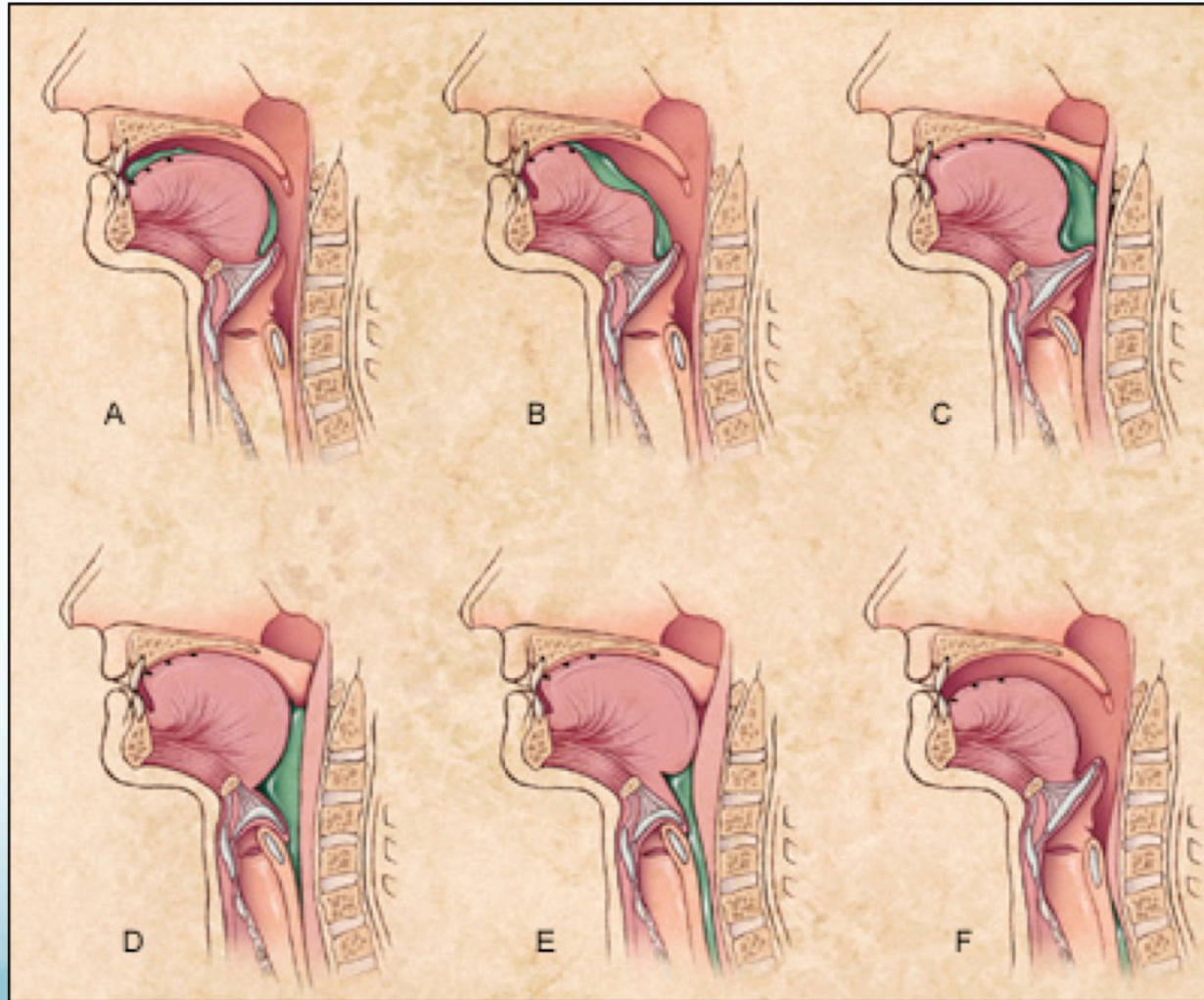
Background

- Dysphagia
 - The inability or difficulty for one to swallow properly
 - **Oropharyngeal Dysphagia**
 - **Esophageal Dysphagia**
- Causes of Dysphagia
 - Neurological Disorders
 - Stroke
 - Sarcopenia
 - And many others

Effects of Dysphagia

- Pneumonia
 - “Of the deleterious dysphagia-related health outcomes, pneumonia may be the most devastating—the fifth leading cause of death in those aged 65 and older and the third leading cause of death in those aged 85 and older” (Dr. JoAnne Robbins)
- Dehydration and Malnutrition

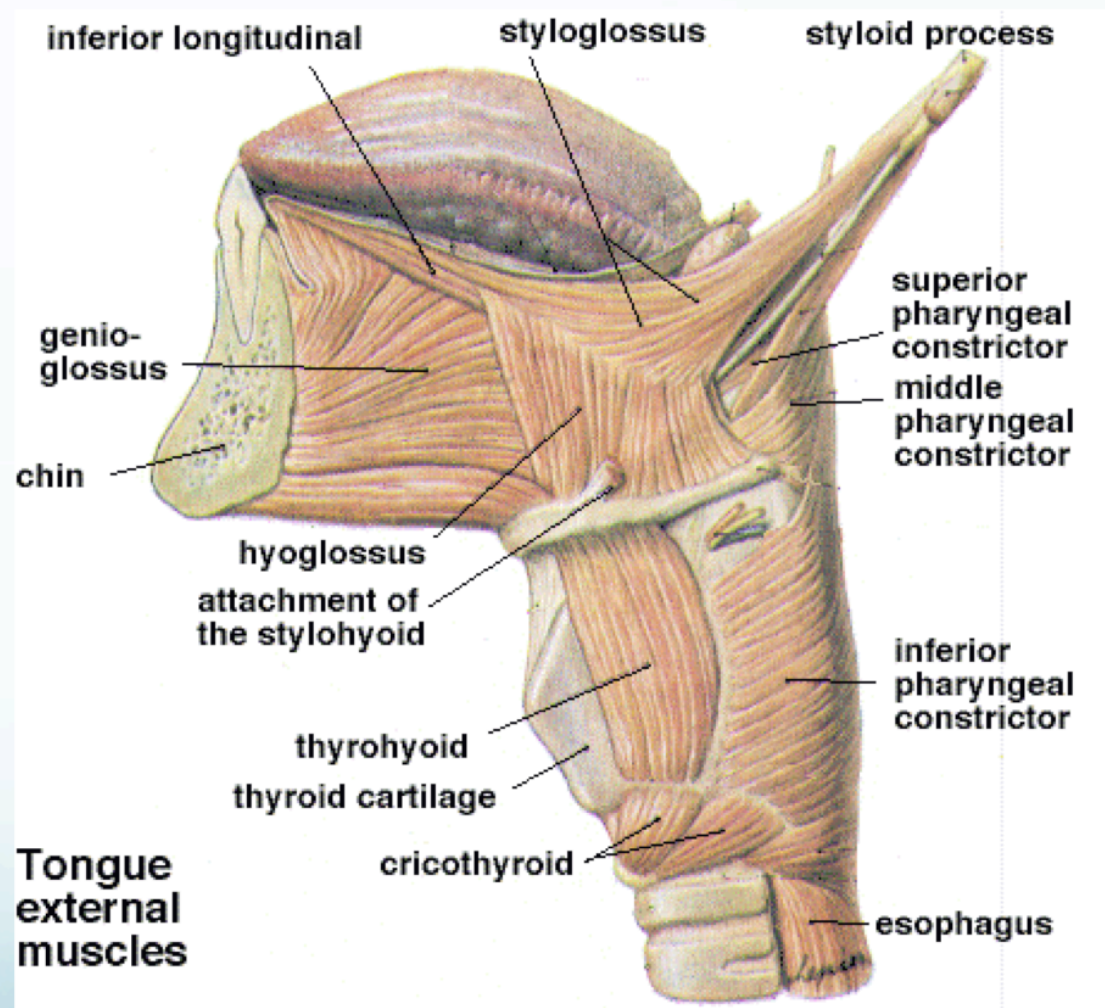
The Swallowing Process





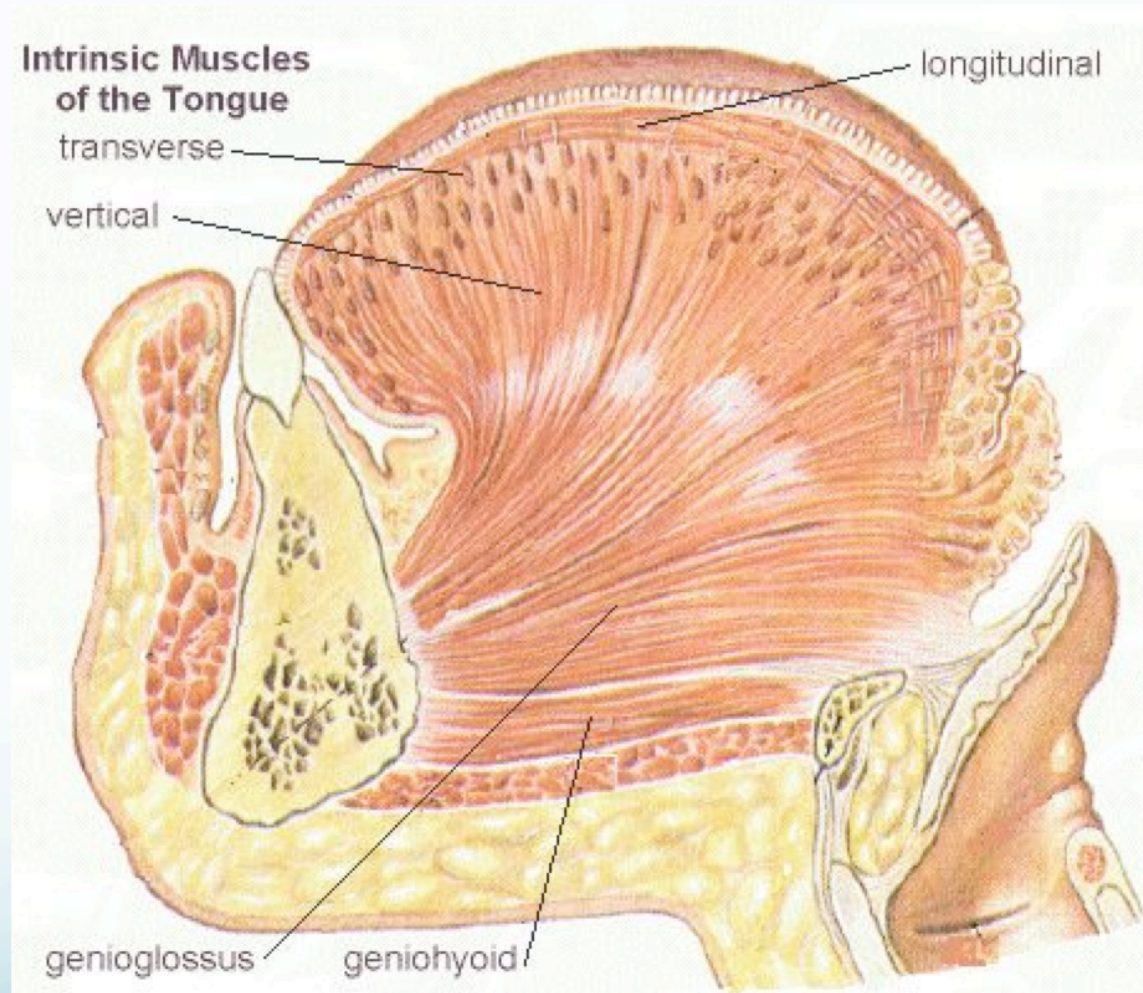
Tongue Extrinsic Muscles

- Genioglossus
- Styloglossus
- Palatoglossus
- Hyoglossus



Tongue Intrinsic

- Inferior and Superior Longitudinal Muscle
- Transverse Muscle
- Vertical Muscle



Problem Motivation

- Dysphagia affects more than 18 million in the U.S. alone
- When untreated, can lead to other lethal complications
 - Pneumonia
 - Malnutrition
 - Dehydration
- A phantom mouth model needs to be constructed
- This semester's focus: mechanical tongue

Mechanical Tongue

- Tongue and its attachments to other oropharyngeal structures are critical to swallowing function
 - Propelling a bolus of food or liquid
- Needs to:
 - Mimic swallowing motions of human tongue
 - Have accurate pressure distributions

Current Devices

- No device has been specifically created to study swallowing
- Other animatronic devices have been developed
 - Robotic dental test dummies
 - Model of the human tongue and the vocal tracts
 - Hollywood special effects (i.e. robotic animals)

Robotic Dental Test Dummies

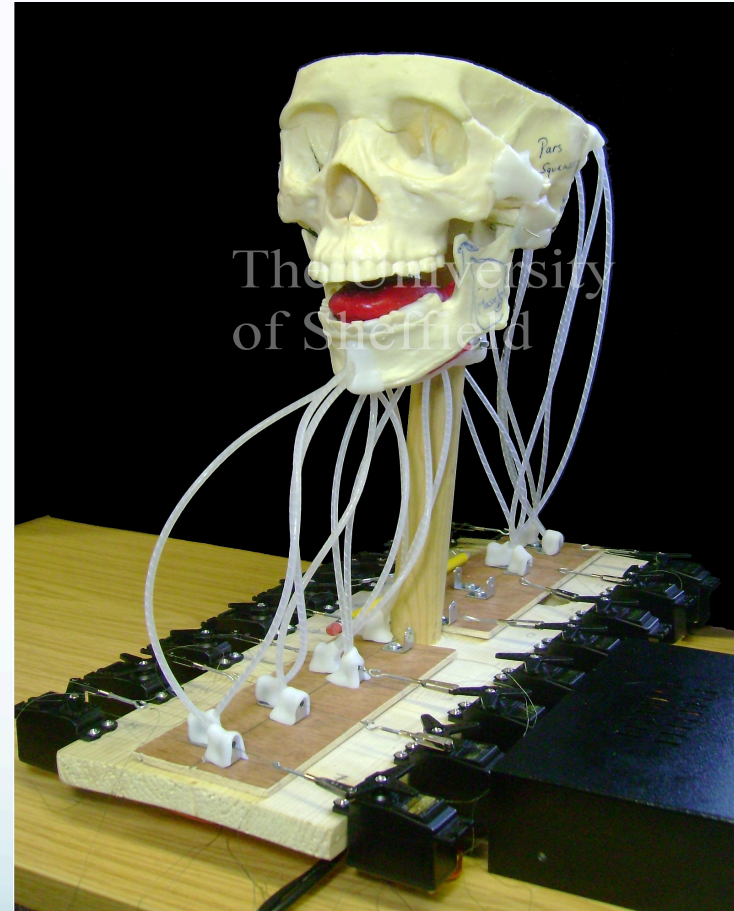
- Showa Hanko 2
- Human-like movements of the mouth and tongue
 - Only two degrees of tongue motions
- Reacts to pain



Source: <http://www.itsanews.com/2011/07/robotic-doll-will-teach-dentists-in.html>

AnTon Model of a Human Tongue and Vocal Tract

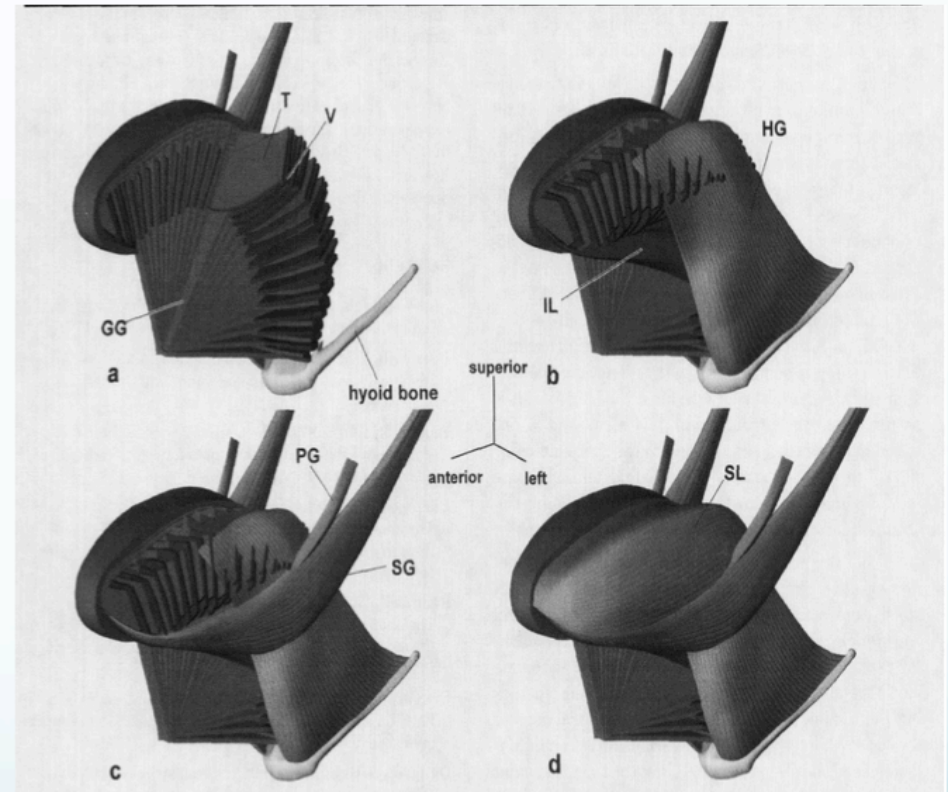
- Comprised of moveable tongue and jaw model
- Operated by servo motors
- Only designed to mimic vocal movements



Source: *Towards an investigation of speech energetics using 'AnTon': an animatronic model of a human tongue and vocal tract*

Design Requirements

- Long term Model
- Actuator coordination
- Healthy Force 40-80 kPa
- 180 N (40 lb) Failure
- True Lines of Action
- Materials
- Sterilization
- Safety



Design Alternatives: Air Muscle Model

- Air bladders in a Mesh Coat
- Mimic muscle attachments and interactions
- Actuators create the tongue
- Individual air compressors



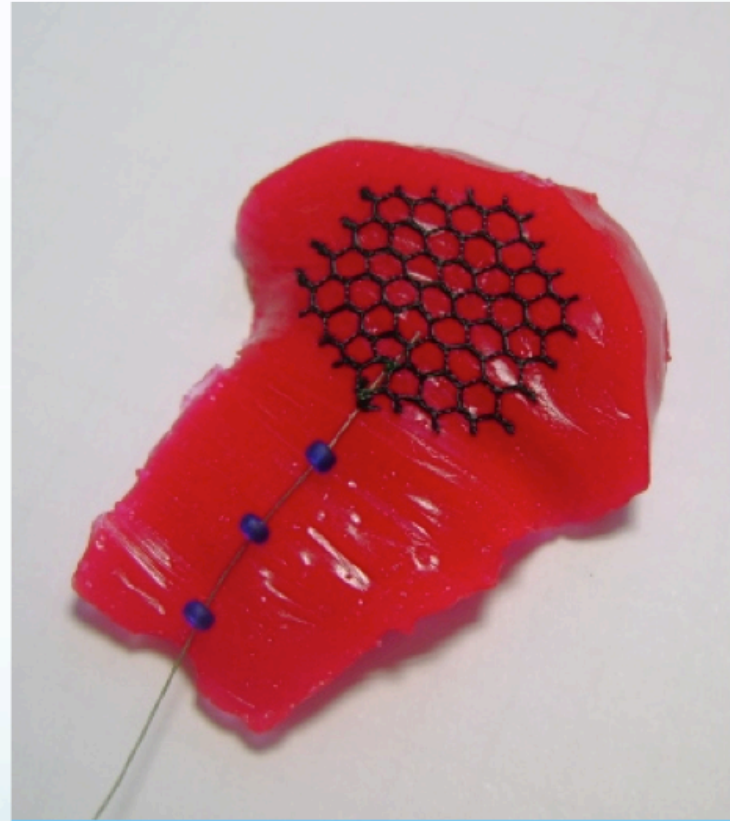
<http://www.youtube.com/watch?v=NgDPerAjVBw>

Design Alternatives: Hydraulic Muscle System

- Modified Air Muscle System
- Closed Fluid Dynamic System
- Pump Array

Design Alternatives: Cable Model

- System of Cables
- Actuators do not create the shape
- Mostly tension forces



From AnTon's construction, this filament acts as the anterior genioglossus [1]

Design Matrix

	Air Muscle Model	Hydraulic System Model	Cable Model
Functionality in Real Time (20 points)	14	14	18
Accuracy and Precision of Motion (20 Points)	15	15	18
Durability (15 Points)	10	9	12
Force Generation (10 Points)	8	9	7
Ease of Coordination (10 Points)	6	6	8
Ease of Assembly (10 Points)	8	7	9
Part Replacement (5 Points)	2	2	2
Cost (5 Points)	2	2	5
Power System (5 Points)	1	3	5
Total Points (100)	66	67	84

Future Work – This Semester

- Order materials
- Design attachment points for cables
- Mold tongue
- Mount on skull

Future Work – Future Semesters

- Add automatic system
- Add other parts to the mouth model
- Testing

Questions



References

- "AnTon - Tongue." DCS Intranet. Web. 19 Oct. 2011. <http://staffwww.dcs.shef.ac.uk/people/R.Hofe/anton/tongue.html>.
- Hofe, Robin and Moore, Roger K.: *Towards an investigation of speech energetics using 'AnTon': an animatronic model of a human tongue and vocal tract*, Connection Science, 20 (4): 319-336, December 2008, DOI: 10.1080/09540090802413251.
- "How to Make Air Muscles!" Instructables - Make, How To, and DIY. Web. 19 Oct. 2011. <<http://instructables.com>>.
- "Latest Dental News : Latest News in Dentistry : Stem Cells Research." *Dental Tourism:Advertising in Dental India:Latest in Dentistry*. Web. 19 Oct. 2011. <<http://www.dentalindia.com/latnews.html>>.
- "Robotic Doll Will Teach Dentists In Training." *[IAN] Today's Internet News: World, Showbiz, Sports, Technology, Politics, Business and Health*. Web. 19 Oct. 2011. <<http://www.itsanews.com/2011/07/robotic-doll-will-teach-dentists-in.html>>.
- Takemoto, Hironori. "Morphological Analyses of the Human Tongue Musculature for Three-Dimensional Modeling -- Takemoto 44 (1): 95." *Journal of Speech, Language, and Hearing Research*. Web. 19 Oct. 2011.