In vivo study combining sensory analysis and ultrasound imaging to investigate food texture perceptions related to tongue biomechanics

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Introduction

By continuously evaluating the mechanical and structural properties of food, the tongue rules the oral strategy and plays an important role in sensory experience and swallowing safety. Unraveling the links between tongue motions and texture perceptions requires the development of original instrumental and sensory methods.

Can ultrasound (US) imaging help monitoring tongue motions and investigating their links with texture perceptions?

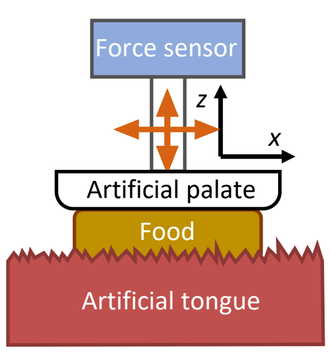
Materials and methods

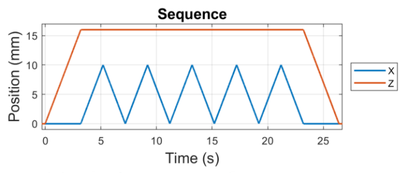
6 chocolate desserts

Trained sensory panel (n=16)

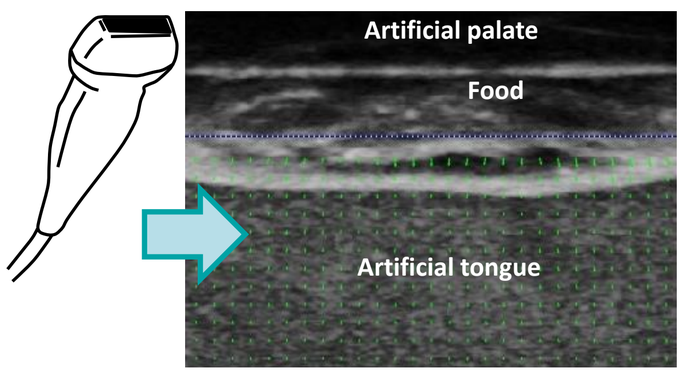
Profile + Temporal dominance of sensations & motions

Tongue-palate biomimetic device



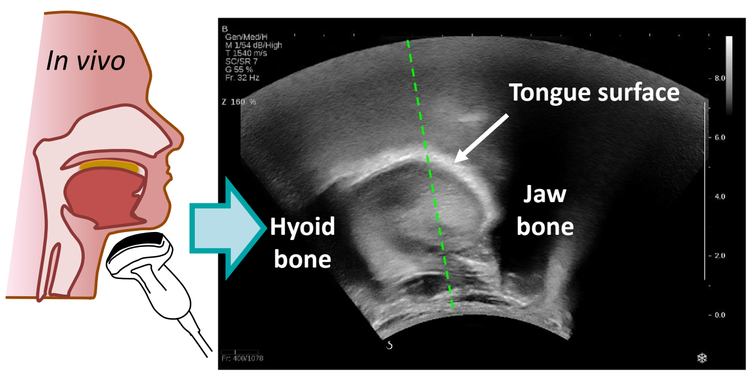


- Multi-axes force sensor
- Ultrasound imaging : Interface tracking + Particle image velocimetry



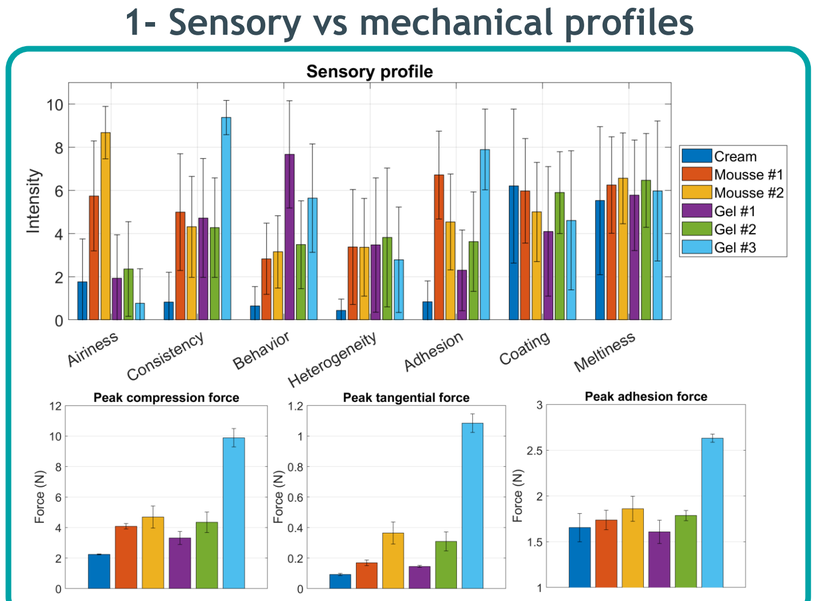
Feasibility *in vivo* imaging tests (n=10)

- Coupling ultrasound imaging with temporal sensory methods
- M-mode analysis for tracking tongue motions

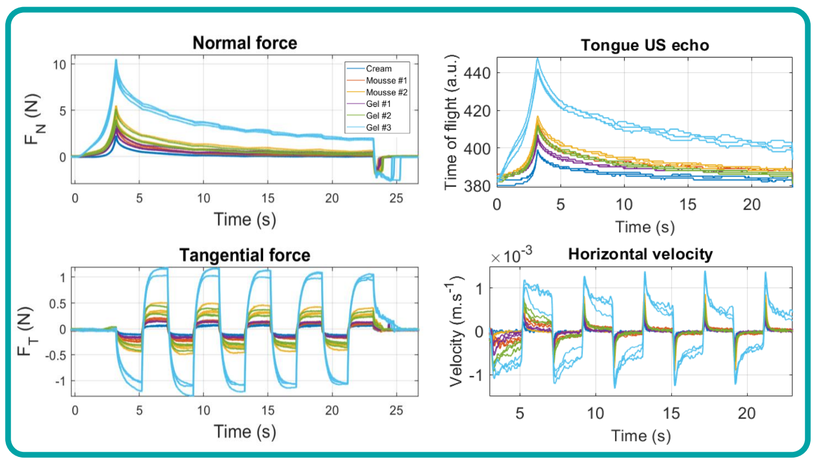


Results

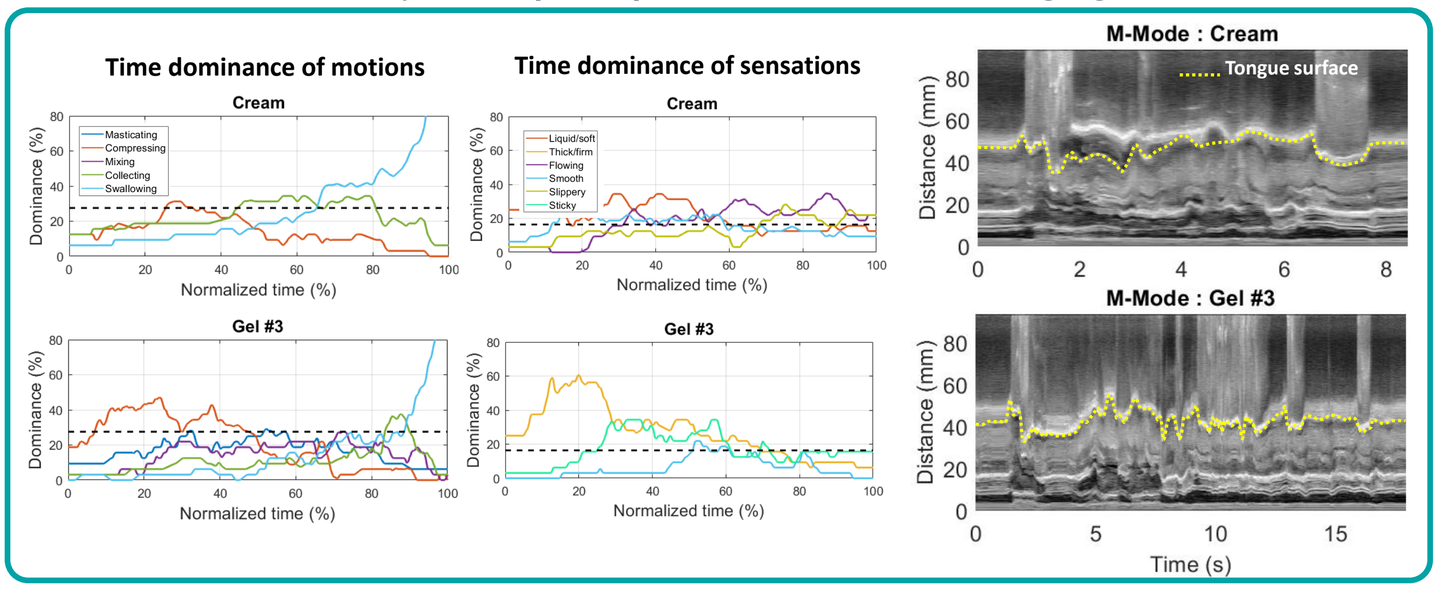
1- Sensory vs mechanical profiles



2 - Mechanics vs *in vitro* US imaging



3 - Dynamic perceptions vs *in vivo* US imaging



1 - Various sensory profiles and mechanical properties were reported across the 6 products. Highest contrasts between “Cream” and “Gel #3” in terms of consistency (soft vs firm), behavior (liquid vs brittle) and adhesion (slippery vs sticky).

2 - Ultrasound time of flight of tongue surface echo was consistent with normal force measurements, reflecting the deformations undergone by the artificial tongue as a function of time. Average horizontal velocity measured by particle image velocimetry in the bulk of the artificial tongues was complementary to tangential forces measurements.

3 - Highly contrasting patterns of sensory perceptions and of oral motions could be reported throughout the 6 products. The analysis of M-Mode images via the manual detection of tongue contours enables a qualitative analysis of tongue motions.

Conclusions

The use of ultrasound imaging methods on the biomimetic device offers original possibilities for characterizing tongue-palate interactions in physiologically relevant conditions. In particular, the method provides access to strain rate gradients in the bulk of the tongue, which contribute to stimulating the mechanoreceptors.

Realistic expectations regarding the development of ultrasound imaging methods *in vivo* require taking into account the complexity of US images, in particular because of high inter individual differences in anatomy. Nevertheless, ultrasound imaging are promising for qualitatively characterizing tongue movement sequences during food oral processing.

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