# HAS A SPLIT TONGUE ONE OR TWO TONGUE TIPS DURING ARTICULATION?

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## ABSTRACT

Towards the end of the 1990s a new trend in the culture of body modification arose: tongue splitting. The result of this body modification is a tongue tip split into two parts. The present paper reports a single-case study of articulation by a subject who underwent tongue bifurcation. We find that movement direction and the tongue's acceleration/deceleration behavior affected the degree of displacement of the right tongue tip relative to the left tongue tip. Potential explanations are discussed.

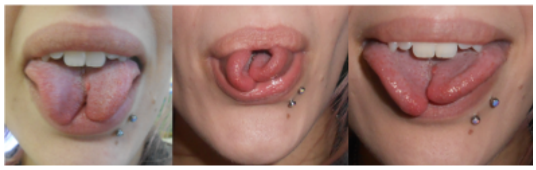
**Keywords:** articulography, split tongue, bifurcated tongue, adaptation

## 1. INTRODUCTION

During the last century, tongue modifications such as piercing of tongue, lips, face, genitals, scarring and "branding" of the skin have become recently very popular in Western societies. In the late 1990s, a new trend arose: Tongue splitting. So far, there is only one scientific paper that describes tongue splitting on an anecdotal basis [2] and another one which investigates its effects on articulation [3]. This is why the present paper has to rely partially on information found in the internet [9, 4, 7, 8].

Tongue splitting, also known as tongue bifurcation or forking is an extreme body modification during which the tip of the tongue is cut in half. Tongue splitting can be accomplished surgically using scalpels or argon lasers, cauterizing and suturing the two sides in order to prevent the two sides from growing back together. Generally, the wound is healed after two weeks [9]. Another method, advertized in online forums, is called the fishing-line-method. During this procedure a nylon line is threaded in a preexisting piercing hole and and knotted tightly together. In the course of 4 to 8 weeks the line has to be tighten repeatedly in order to extend the hole [4]. The split tongue procedure can be reversed, but has been described as extremly painful and long lasting [7].

**Figure 1:** Pictures of the subject's split tongue and movements. Left: seperating; center: roll; right: overlap.

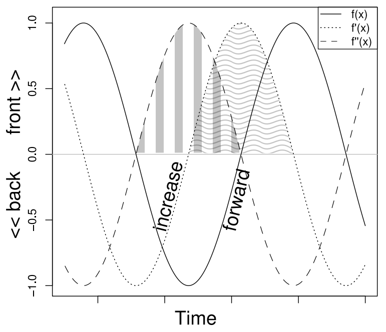


After the wound has healed, speakers with a bifurcated tongue are able to move the two halves independently in the horizontal and vertical direction (Fig. 1. The effects on speech production have been described as negligible [9]. Shannon [7] even reported in his online blog that unless he showed his tongue to his converstation partners, his modification was not noticed as he pressed the two tongue tips together during articulation.

Bressmann [3] reports a minimal reduction of the tongue's ability to move. The speech of his subject was rated as acceptable, although [s] and [z] were noted to be affected. By means of ultrasound, Bressmann could show that during the articulation of stead state coronal consonants the two sides were compressed together and functioned as one in single entity. However, he also noted that during motility assessement the two tongue tips had a tendency to drift apart from each other during extrem potrusion and elevation.

As only one subject has been investigated so far, the questions we raise in this paper are: How do the two tongue tips of a bifurcated tongue behave during speech production relativey to each other? More specifically, how are they coordinated? Will they act as a single unit, like [3] reported? Or will they move independently from each other insofar as there will be a primary half, which should always be ahead of the secondary half, thus guiding the movement? This paper investigates these question in a single case study of a subject with a bifurcated tongue, focusing on the articulation process during spontaneous speech.

**Figure 2:** Example of the categorization process of the trajectory's movement direction and velocity change. The x-axis represents time, the y-axis represents the horizontal movement. The solid line *f(x)* represents the articulatory trajectory. Whenever the first derivative *f'(x)*, i.e. velocity, was positive (vertically dashed area), the tongue moved forward. Similarily, whenever the second derivative *f"(x)* was positive (waved area), velocity was increasing.




# 2. METHODS

## 2.1. The Subject

The subject was Canadian with Canadian English as her native language. She was left handed. She was 22 years old at the time of recording and had her tongue bifurcated in three years earlier in a scalpel surgery. She reported that after surgery, the articulation of her [s] changed. It became more hissing and she started to lisp. She reported that her friends who knew her before and after the surgery, noticed that her speech became "mumbled".

**Table 1:** Fixed effects table. Rows show partial effects of velocity changes and movement directions for the TTl-TTr difference in both axes.

| a) Vertical | Estimate | Std. Error | t-value |
|---|---|---|---|
| (Intercept) | -0.341 | 0.072 | -4.748 |
| dir.vert rising | -0.031 | 0.053 | -0.583 |
| vel.vert accel | 0.244 | 0.041 | 5.910 |
| dir.hor forward | 0.194 | 0.042 | 4.588 |
| dir.vert rising* dir.hor forward | -0.146 | 0.059 | -2.484 |
| dir.vert rising* vel.vert accel | -0.151 | 0.05735 | -2.629 |

| b) Horizontal | Estimate | Std. Error | t-value |
|---|---|---|---|
| (Intercept) | -0.468 | 0.100 | -4.678 |
| dir.vert rising | 0.191 | 0.047 | 4.052 |
| vel.vert accel | 0.019 | 0.064 | 0.303 |
| dir.hor forward | 0.373 | 0.046 | 8.129 |
| vel.hor accel | 0.708 | 0.064 | 10.986 |
| vel.vert accel * vel.hor accel | -0.305 | 0.090 | -3.385 |

## 2.2. Recording

The recording was performed as part of a larger articulography experiment in May 2012 in Edmonton, Alberta. The subject had a spontaneous converstation with the author while her articulatory movements were recorded. Overall, 3 minutes and 20 seconds of spontaneous speech were recorded during which the subject articulated 385 words (in sum, 174 tokens and a total of 488 syllables).
The NDI wave articulograph was used to record tongue and lip movements (sampling rate of 100 Hz). Prior to attaching oral sensors, a reference sensor was placed on the subjects' foreheads to correct for head movements. The rotation of the reference sensor to a standardized coordinate system was measured, represented by bite plate in which three sensors were placed in a triangular configuration. Five additional sensors were attached: One on the left tongue tip (TTl), one on the right tongue tip (TTr), one on the tongue middle (TM), one on the upper lip (UL), one on the lower lip (LL).The analysis will be restricted to TTl and TTr.
Sensor positions were rotated so that tongue sensors were positioned in the vertical X/Z-plane. The X-axis determined horizontal forward-backward movements with larger X-values reprensenting more frontal positions. The Z-axis determined vertical upward-downward movements with larger Z-values higher positions.
For analysis, the articulatory trajectory was low pass filtered at 20 Hz. In order to investigate the behavior of the two tongue tips, the trajectory's movement direction and trajectory's velocity change in the horizontal and vertical axis were calculated. Regarding the trajectory's direction, forward/rising movement was present whenever the fist derivative (velocity) was positive; backward/falling movement was present whenever the first derivative was negative. This procedure provided two velocity factors, *dir.hor* and *dir.vert* with two levels each.
Regarding trajectory's velocity change, acceleration was present whenever the second derivative (acceleration) was positive; deceleration was present whenever the second derivative was negative. This procedure provided two factors *vel.hor* and *vel.vert* with two levels each. See Fig. 2 for a categorization example.

## 2.3. Analysis

For the analysis, the average difference between TTl and TTr was subtracted from the TTl in every axis in order to take into account possible displacement

**Figure 3:** TTr's displacement relative to TTl in coronal segments in both axes. Difference was measured when the tongue was located at its highest position within the acoustic boundaries of the segments. All Y-axes scales are in mm; confidence intervals represent one standard error. Legend: D = [d], L = [l], N = [n], NG = [ŋ], R = [ɹ], S = [s], SH = [ʃ], T = [t], TH = [θ, ð], Z = [z].

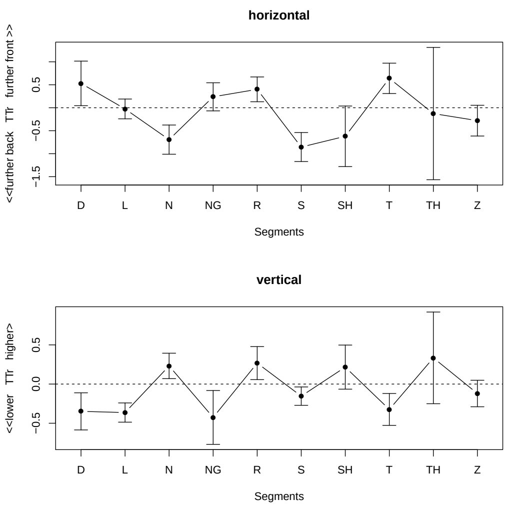
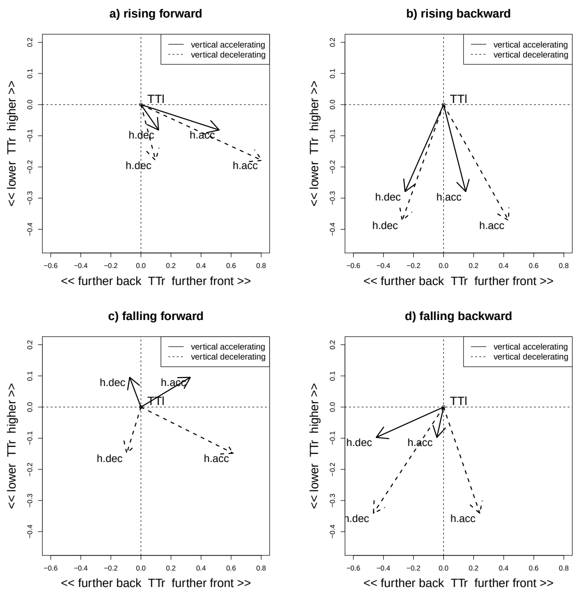



**Figure 4:** Summary of results. The circle located at (0,0) represents TTl; the end of the arrows represents TTr's displacement relative to TTl. Each plot represents movement direction. Arrow line type codes vertical velocity change. Horizontal velocity change is indicated at the end of the arrow. Legend: acc = accelerating; dec = decelerating. Scales are in mm.




differences between TTl and TTr due to glueing. Only portions of the recording have been considered where the subject was talking (2 min 50 seconds).
Two analyses were performed: one descriptive to replicate [3]'s findings in steady state. A second, statistical, analysis investigated the effects of movement direction and velocity change. For this, two random-effects mixed models (using the lme4 package [1] in R (3.1.1)[6]) were fitted, one to horizontal movements, one to vertical movements. The dependent variable was the position of TTr relative to TTl, calculated by means of the difference between TTl and TTr. If in the vertical axis the TTl-TTr-difference was smaller than 0, TTr was lower than TTl; if it was larger than 0, TTr was higher than TTl. If in the horizontal axis the TTl-TTr difference was smaller than 0, TTr was further back; if it was larger than 0, TTr was further front than TTl.
As fixed effects, a four-way interaction between dir.hor, dir.vert, vel.hor and vel.vert were introduced to the model. Segment identity was included as random intercepts. Temporal information for segments was found by means of an automatically created and manually corrected (at word level) annotation of the transcribed conversation [11]. After fitting the full model, the step function *bfFixefLMER_F.fnc* provided by the LMERConvenienceFunctions package [10] was used to find the final model.

## 3. RESULTS

Fig. 3 shows the TTr's mean displacement relative to TTl measured when the tongue was located at the highest position within the acoustic boundaries of coronal segments (and, additionaly, the velar [ŋ] like in [3]'s study). The analysis has also been performed with all movement positions within a segment's boundaries. This did not affect the effect size, but reduced confidence intervals. A segment was considered to have an significant effect on TTr's displacement when zero is not located within the confidence intervals. Regarding the horizontal axis, TTr was further back than TTl during the articulation of segments [n, ʃ], further front in [d, ɹ, t] and had no effect in [l, ŋ, ʃ, θ]. Regarding the vertical axis, TTr was lower than TTl in segments [d, l, ŋ, s, t], higher in [n, ɹ] and had no effect in [ʃ, θ, z].

Fig. 4 illustrates TTr's displacement relative to TTl found by means of the statistical analysis of movement direction and velocity change. In general, TTr was lower than TTl (Fig. 4a,b,d). The vertical displacement was smaller when the tongue accelerated than when it decelerated in the vertical

axis (apart from Fig. 4c, where TTr was above TTl during vertical acceleration). The displacement effect was larger when the tongue was moving forward than when it was moving backward. Also, TTr's location was higher during vertical accelerating as compared to vertical deceleration. See partial effect sizes and t-values in Table 1a).
Regarding horizontal displacement, TTr was in general further front when the tongue accelerated in the horzontal axis than when it decelerated. The interaction between vertical and horizontal velocity change did not affect this main effect (Table 1b). Whether it was in front of TTr or behind it depended on movement direction. Only when the tongue was rising and moving forward, TTr was always in front of TTl (Fig. 4a). Otherwise it was in behind TTr, when the tongue decelerated in the horizontal axis and it was front of TTr, when the tongue accelerated in the horizontal position.

## 4. DISCUSSION

The present paper investigated how a split tongue affects the coordination of the two tongue tips during articulation. In contrast to [3], the left and right tongue tips were continuously displaced relatively to each other in the horizontal and vertical axis during the articulation of coronal consonants as well as of the velar [ŋ]. There was no apparent pattern in direction of the displacement, e.g. depending on place or manner of articulation. It seems, as though different sounds prefer different lateral positions. Insofar, we should investigate articulatory movements in the future in the third dimension in contrast to two dimensional recordings, which have been performed so far.
Whereas [3] analyzed only steady state articulations, we investigated the tongue's movement direction and velocity changes. In general, the right tongue tip was lower than the left tongue tip (Fig. 4). Although we already took into account that different positions of the two sensors on the two tongue tips might bias the displacement of the sensors relatively to each other, we cannot absolutely exclude erroneously placed sensors as a possible confound.
Regarding the effects of movement directions and velocity changes, there is no clear correlate between movement direction/velocity change and displacement direction, as the displacement patterns differ between vertical and horizontal axis. Comparing rising in contrast to falling movement it seems as though the right tongue tip was contiuously lagging behind during acceleration, although it was nearer to the left tongue tip during acceleration than during deceleration. As for the horizontal movements, the right tongue tip was in general in front of the left tongue tip during horizontal acceleration, and behind the left tongue tip during deceleration. Horizontal movement direction simply affected the extent of the displacement to the front.
There is no primary tongue tip which guides the movement (If there were, the primary tongue tip should always be before/above the secondary during forward/rising movement). Rather, the extent of the displacement is affected by movement direction and, more importantly, velocity change. Why should the two tongue tips behave in such an unexpected manner? At this point, we can only speculate about the reasons and will provide explanatory approaches.
It is possible that the subject's tongue was not bifurcated into two perfect halves (which is suggested by Fig. 1, left). Rather, one was larger (and longer). This imbalance would increase the mass of this tongue tip, making it slower for direction changes. Another possibility is that muscular activity differs between the two tips. Gracco [5], for example, investigated the correlation between lip movements and muscle activity. He found that acceleration of the articulator was accompanied with more muscle activity, deceleration with decreasing muscular activity. Thus, the differences in displacement of the right tongue tip might be a result of different muscular activity during changing velocity. It is possible that higher muscular activity stretches the right tongue tip more forward (as it is slightly bigger), simultaneously compressing it so that it is located nearer toward the left tongue tip. This would at least explain the results of the tongue tip's behavior during accelerated rise and forward/backward movement.
Concluding, a midline section of the tongue will affect the production of the speaker's sibilants according to previous reports [9, 4, 3] as well as the subject's own statement. Furthermore, it will affect the behavior of the tongue tip during its movement through the oral cavity. For future studies investigating split tongues more precise biometric measures of the tongue and the palate should be taken. Also pre and post surgical recordings would be of interest.

## 5. ACKNOWLEDGEMENTS

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