

A New Vowel Normalization for Sociophonetics

Wilbert Heeringa & Hans Van de Velde



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Vowel formant normalization

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- Best method according to Adank et al. (2004), Fabricius et al. (2009), Kohn & Farrington(2012), Volín(2009) and Van der Harst (2011) is **Lobanov (1971)**.

Lobanov normalization

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all speakers' vowels get centered around the origin (0, 0).
2. divide resulting values by **standard deviation**:
makes the sizes of the speakers' vowel spaces more comparable (sd=1).

Lobanov normalization

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Lobanov normalization

- Lobanov's method is sensitive to the **distribution** of the vowels within the vowel space.
- We present a new method in which this problem is solved: **Heeringa & Van de Velde (II)**.

Replace ...

mean
of all points



centroid
of vowel space area

standard deviation
of all points



standard deviation
of points on the outline of vowel space

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centroid
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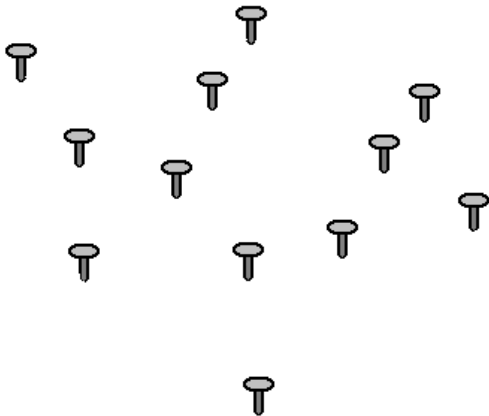
standard deviation
of all points



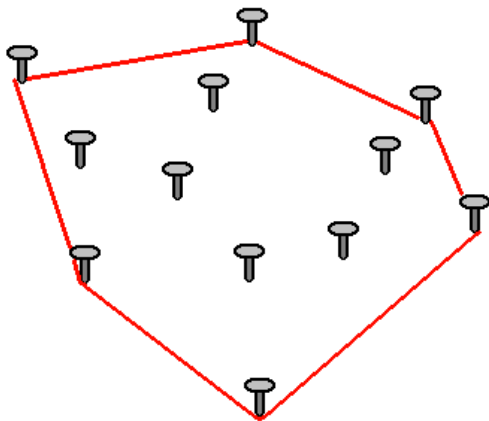
standard deviation
of points on the outline of vowel space

How do we find the centroid and the new standard deviation?

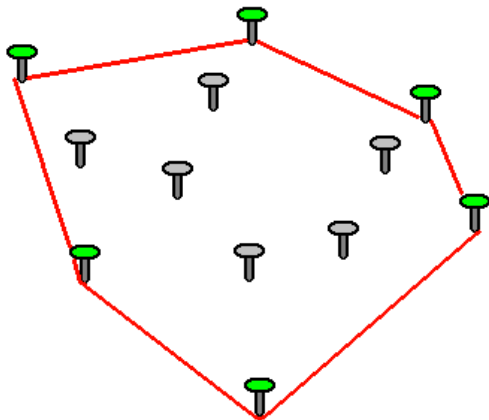
Finding the centroid



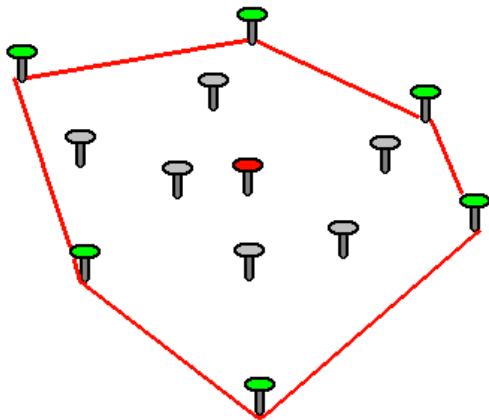
12 vowels represented as nails hammered in a wooden surface.



Stretch a rubber band around the nails.

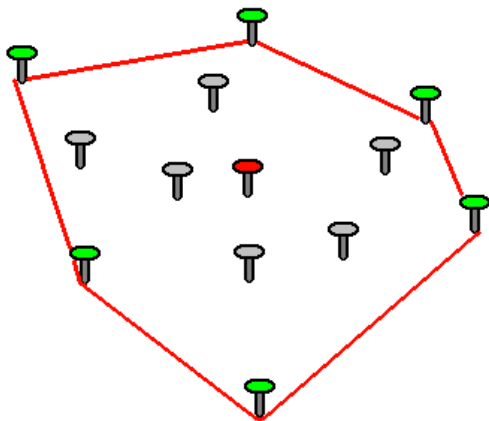


Only the green nails determine the convex hull.

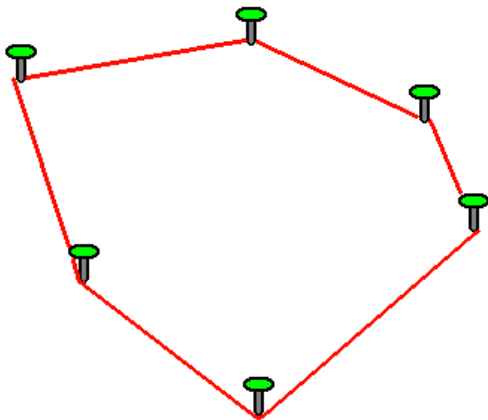


Find the **centroid** (center of mass) on the basis of the green nails.

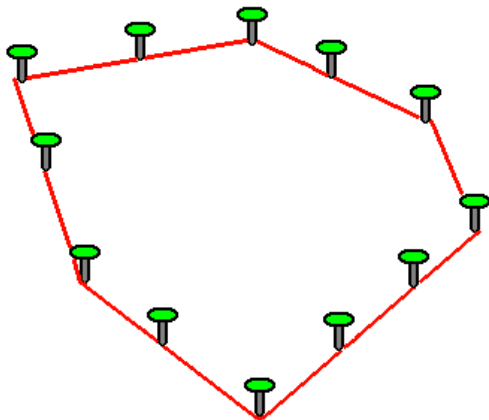
Finding the standard deviation



Focus only on the green nails.



Make the distribution more regular by interpolation/resampling.



Find the **sd**'s for F1 and F2 resp. on the basis of the green nails.

Evaluation

- Compare Heeringa & Van de Velde to Lobanov's method.

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- Compare Heeringa & Van de Velde to Lobanov's method.
- Two evaluation methods of Fabricius et al. (2009):
 1. Examine the reduction of variance in the speakers' vowel space areas.
 2. Measure the amount of overlap among the speakers' vowel space areas.

1. Variance reduction

- For each speaker calculate the area on the basis of the convex hull that encloses the speaker's vowel space.

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- Proportional reduction in variance:

$$1 - \left(\frac{SCV_{normalized\ measurements}}{SCV_{measurements\ in\ Hz}} \right)$$

2. Overlap

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- For each speaker calculate the area on the basis of the convex hull that encloses the speaker's vowel space.
- Divide the area of the **intersection** of the vowel spaces of all speakers by the area of the **union** of the vowel spaces of all speakers (Flynn & Foulkes 2011).

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- For each speaker calculate the area on the basis of the convex hull that encloses the speaker's vowel space.
- Divide the area of the **intersection** of the vowel spaces of all speakers by the area of the **union** of the vowel spaces of all speakers (Flynn & Foulkes 2011).
- A higher proportion shows a better alignment.

Data sets

- Peterson & Barney (1952), General American English, 76 speakers, 10 different vowels.

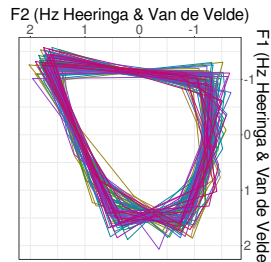
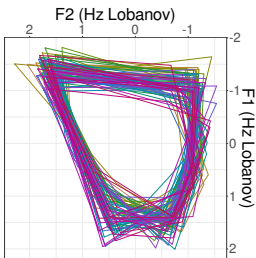
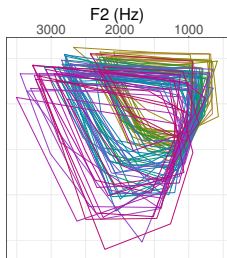
Data sets

- Peterson & Barney (1952), General American English, 76 speakers, 10 different vowels.
- Van der Harst (2011), Netherlandic and Belgian Dutch, 160 speakers, 15 different vowels.

Results

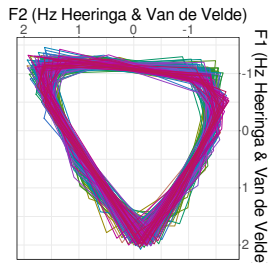
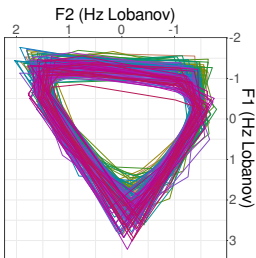
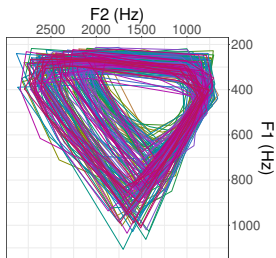
source	% variance reduction		% overlap	
	Lobanov	H&VdV	Lobanov	H&VdV
Peterson & Barney	97.4	99.51	31.7	45.8
Van der Harst	95.2	99.4	29.8	50.8

Peterson & Barney (1952)



Overlaying vowel space convex hulls of speakers

Van der Harst (2011)



Overlaying vowel space convex hulls of speakers

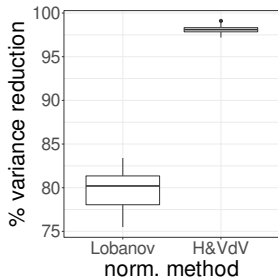
Data sets

- Compare on the basis of randomly generated data sets.

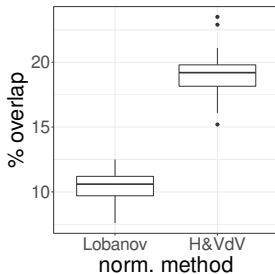
Data sets

- Compare on the basis of randomly generated data sets.
- 20 data sets in which formant values were randomly generated, 160 speakers, 15 different vowels.

Results



$t=-33.78$, $df=20.568$
 $p < 0.001$



$t=-16.701$, $df=32.223$
 $p < 0.001$

Conclusion

- Replacing mean and standard deviation in Lobanov's method by the centroid and standard deviation of the points on the convex hull makes the vowel spaces of speakers more comparable, both in size and in overlap.
- The size and shape of the vowel space is more important than the distribution of vowels within the vowel space.

Availability

The new normalization
method is available at:

`visiblevowels.org`

and in the R package

`visvow.`

Thanks!