



Mixed Design ANOVA

Final obstruent voicing in whispered speech

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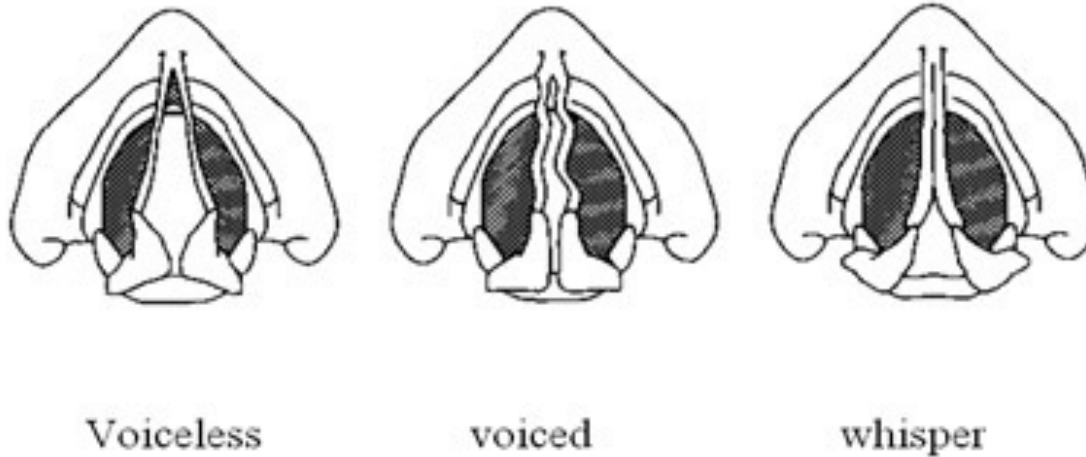


Phonated voicing contrast

- > e.g. *beat* vs *bead*
- > English:
 - Primary cue vs secondary cues
 - Preceding vowel length
 - Ratio of 2:1 to 3:2 (Hogan & Rozsypal, 1980; Raphael et al., 1975)
 - Physiological effort vs linguistically determined (Sharf, 1964)
 - More significant cue (Raphael et al., 1975)
- > Dutch:
 - Devoicing (Ernestus & Baayen, 2003)
 - No vowel length difference (Jongman et al., 1992)
- > English as an L2:
 - Identifying L2-sounds as L1-categories (Flege, 1987)

What's in a whisper?

- > Vocal fold vibration vs air exhalation (Collins & Mees, 2003)



- > Different acoustic characteristics
 - Reduced amplitude of voiced segments (Ito et al., 2005)
 - Amplitude vowels < amplitude consonants (Ito et al., 2005)



Whispered voicing contrast

- > Contrast can still be identified (Dannenbring, 1980; Tartter, 1989)
- > Learned as part of language structure (Sharf, 1964)
- > Heavy reliance (Higashikawa et al., 2003; Sharf, 1964)
 - Vowels are longer (Sharf, 1964)



Aim of the study

- > Investigate use of secondary acoustic cues
 - Whispered vs phonated
 - L1 vs L2
- > Production task



Participants

- > Two groups
- > Dutch L2 speakers of English
 - N=20 (10 male, 10 female)
 - (University) students
 - “normal” exposure to English
- > L1 speakers of English
 - N=8 (3 male, 5 female)
 - (University) students and teachers
 - Living in The Netherlands
- > No hearing or reading disabilities



Stimuli

- > Monosyllabic English minimal pairs
 - e.g. *beat* vs *bead*
 - pseudo words
 - phonated vs whispered

- > Obstruents
 - fricatives (/f, v, s, z/)
 - stops (/p, b, t, d/)

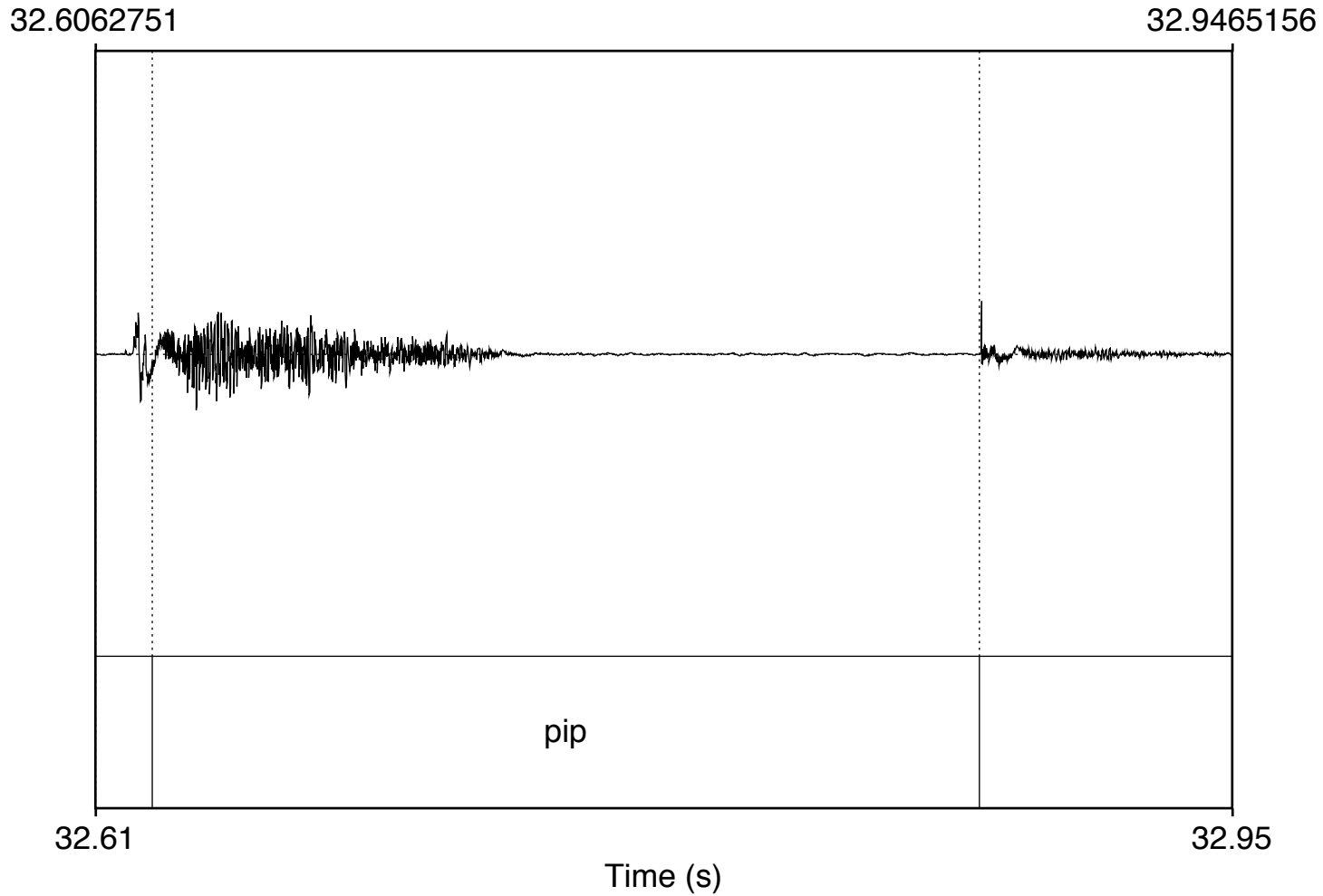
- > Vowels
 - KIT
 - FLEECE

- > Total of 32 target words

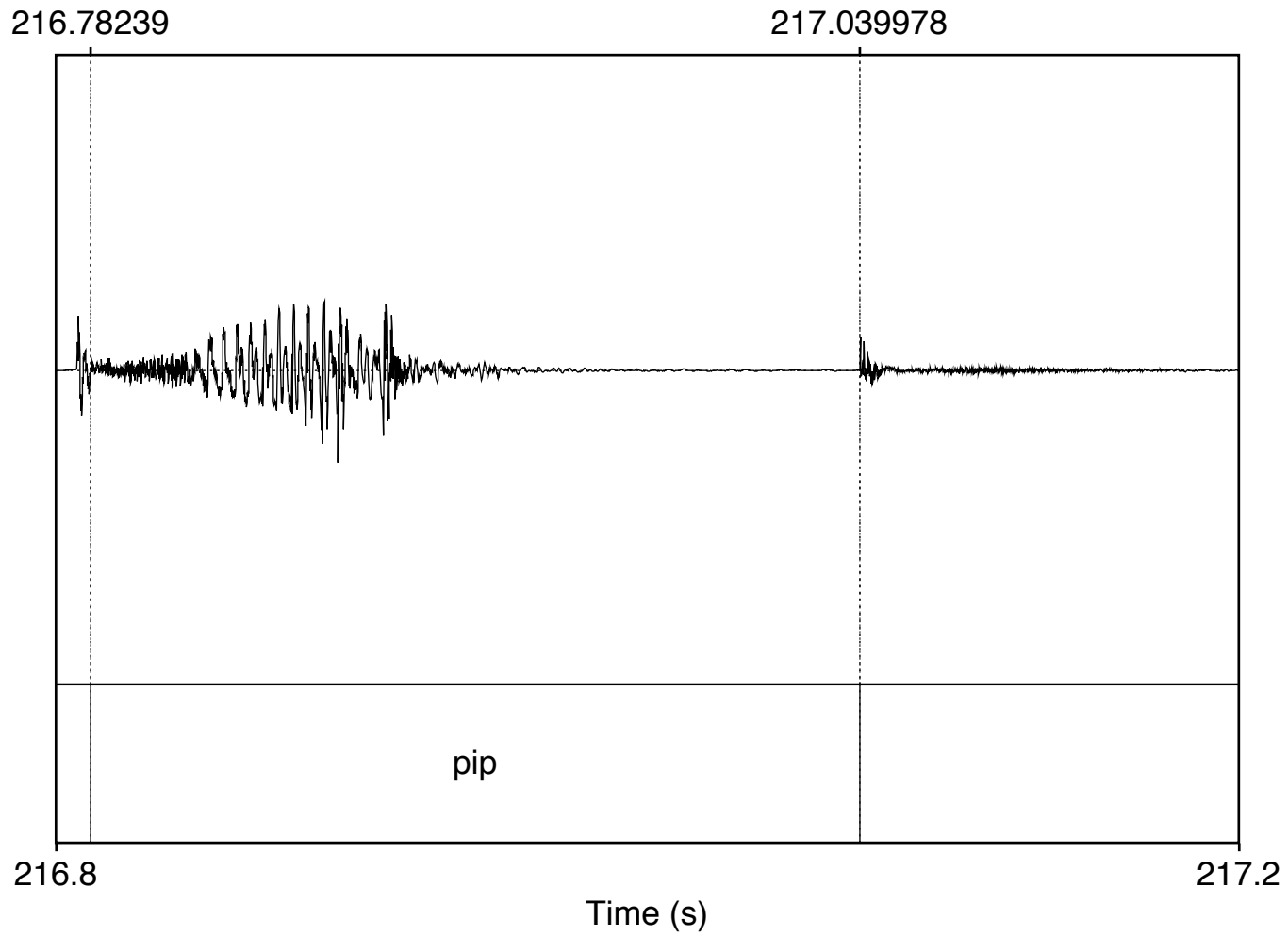


Analysis

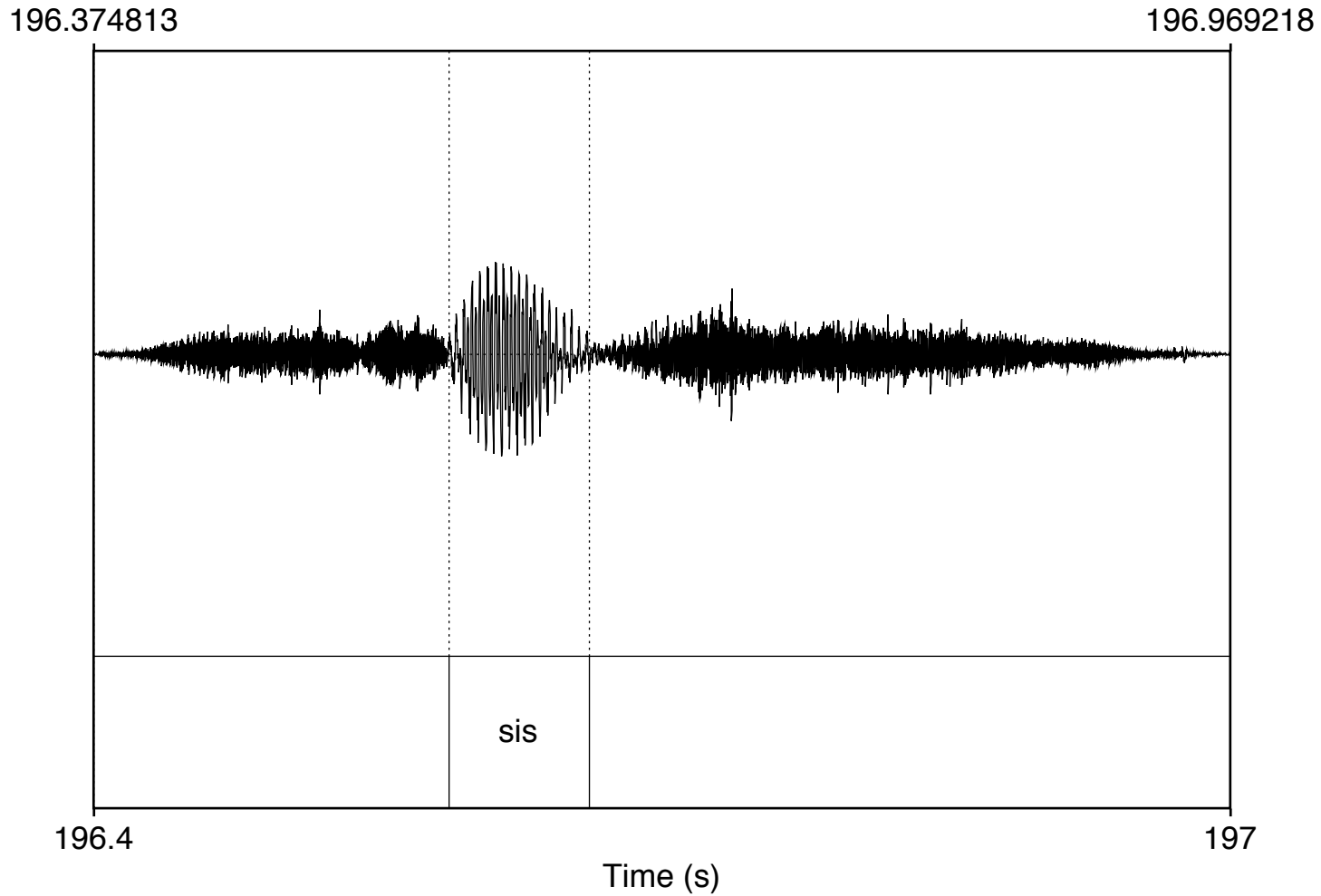
- > Boundary placements
 - Praat
 - Phonated vs whispered



Whispered stop



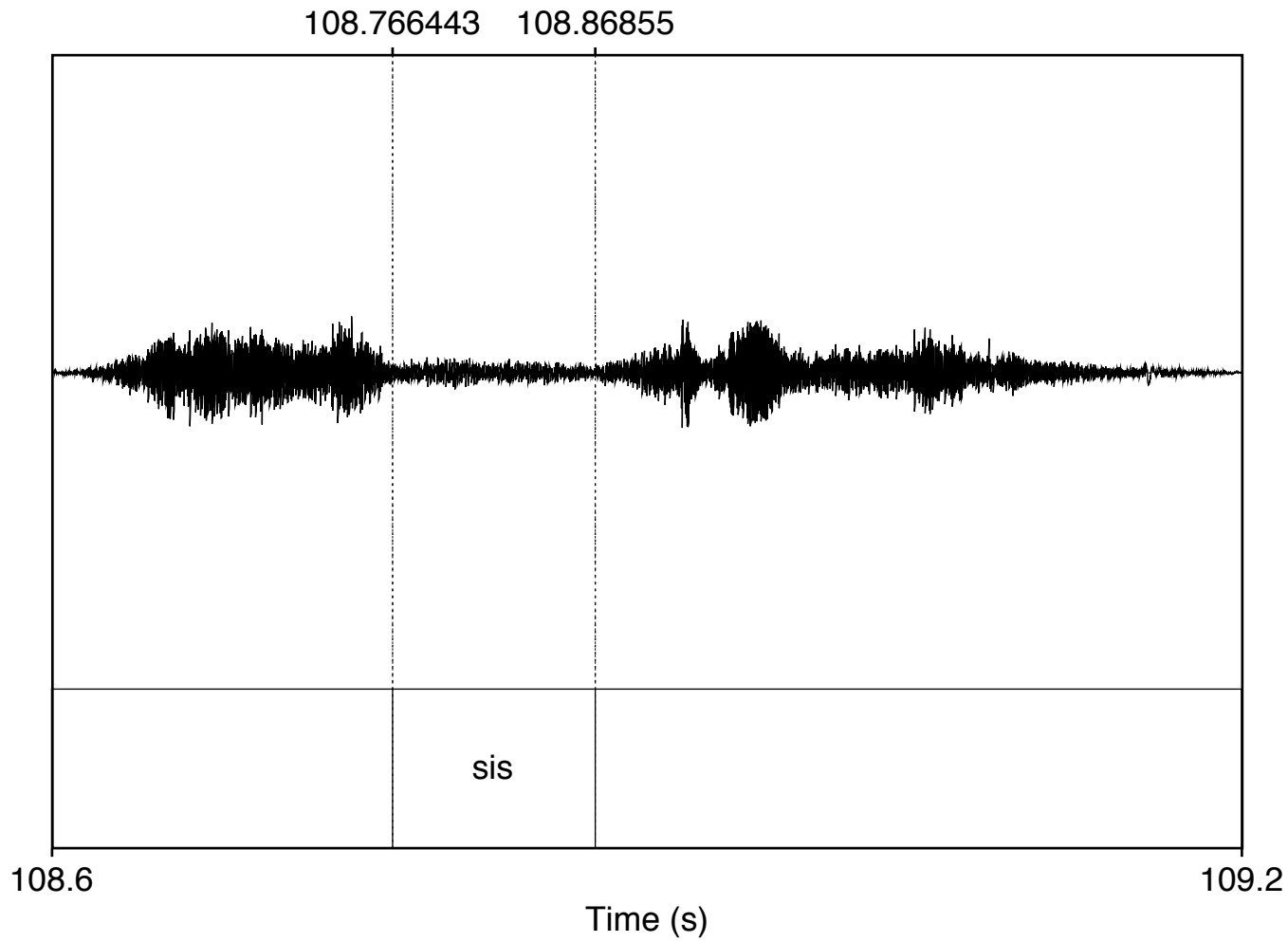
Phonated stop



Phonated fricative



Whispered fricative





Analysis

- > Boundary placements
 - Praat
 - Phonated vs whispered

- > Vowel length measurements
 - Praat (script)

- > Mixed-design ANOVA



Mixed-design ANOVA

- > Dependent variable
 - Mean Vowel Length (ms)

- > Independent variables
 - Between subject
 - Group (NS vs NNS)
 - Within subject
 - Whisper (+Wh vs -Wh)
 - Obstruent (+Ct vs -Ct)
 - Voicing (+V vs -V)



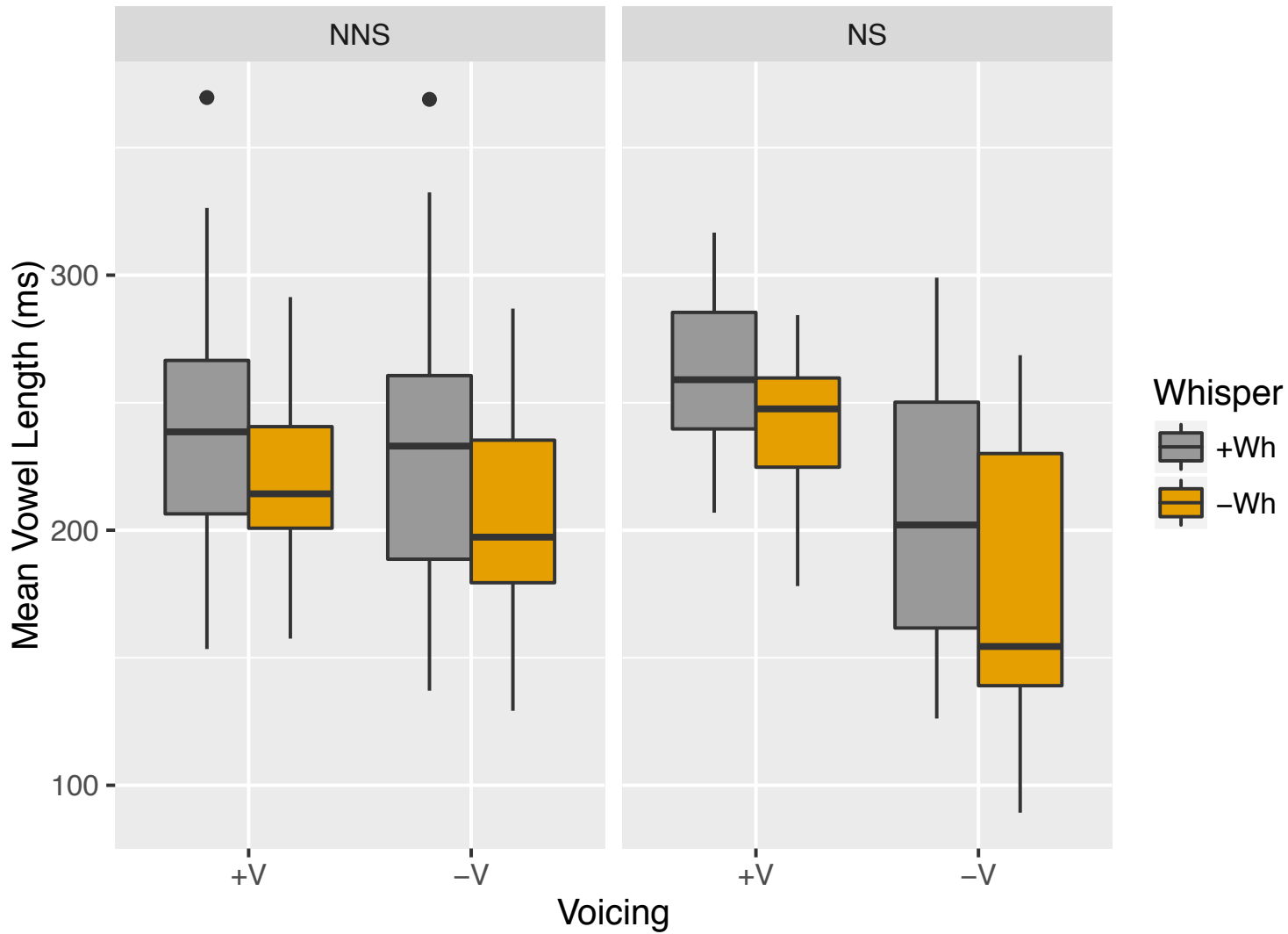
Mixed-design ANOVA

> str(WhisperData)

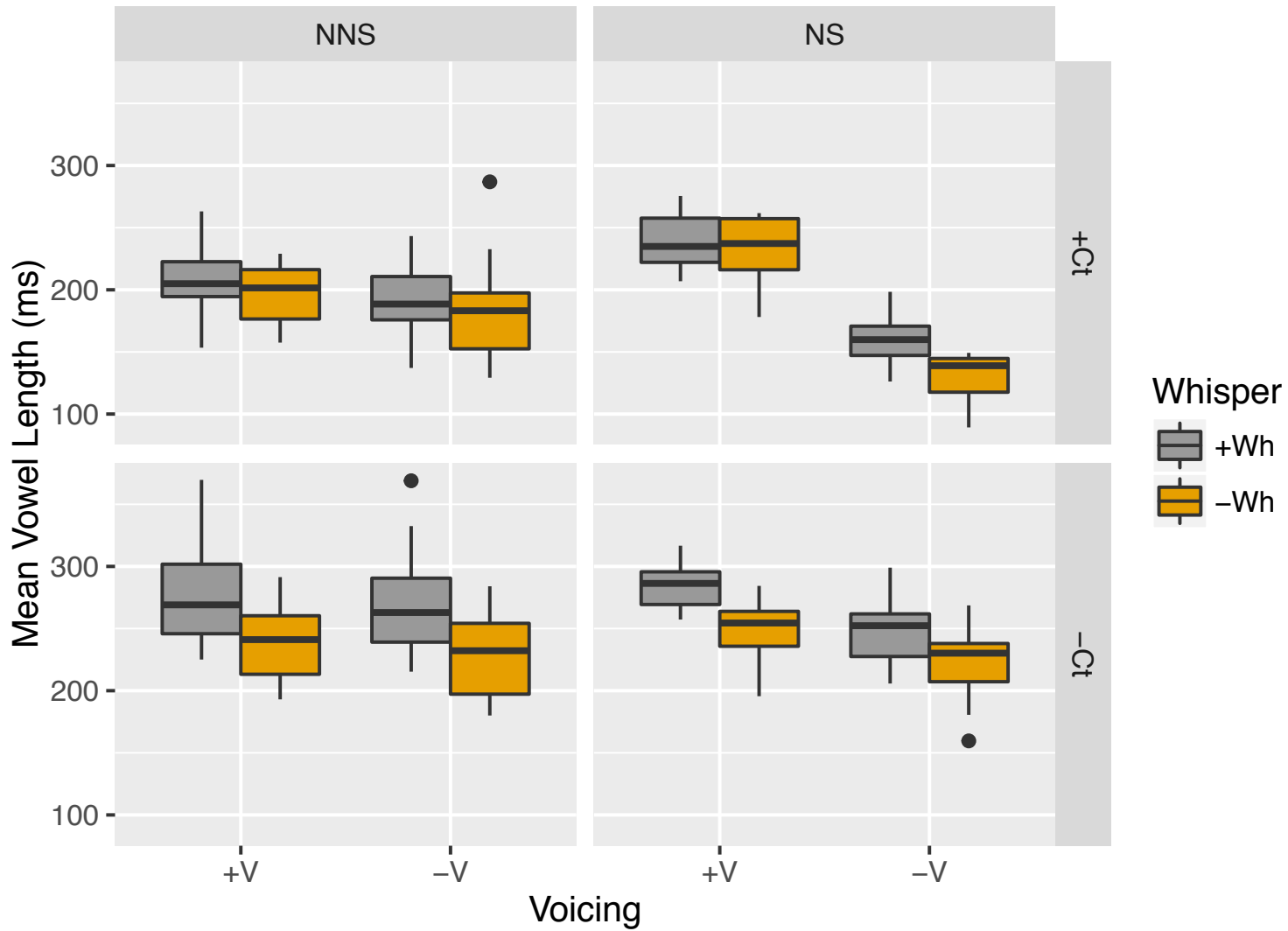
```
'data.frame':      224 obs. of  6 variables:
 $ Participant    : Factor w/ 28 levels "F1AH36","F1AM27",...: 1 1 1 1 1 1 1 1 1 2 2 ...
 $ Group         : Factor w/ 2 levels "NNS","NS": 2 2 2 2 2 2 2 2 2 2 2 ...
 $ Whisper       : Factor w/ 2 levels "+Wh","-Wh": 1 1 1 1 2 2 2 2 1 1 ...
 $ Obstruent     : Factor w/ 2 levels "+Ct","-Ct": 1 1 2 2 1 1 2 2 1 1 ...
 $ Voicing       : Factor w/ 2 levels "+V","-V": 1 2 1 2 1 2 1 2 1 2 ...
 $ Vowel         : num  257 142 311 258 262 ...
```

> head(WhisperData, 8)

	Group	Participant	Whisper	Obstruent	Voicing	Vowel
1	NS	F1AH36	+Wh	+Ct	+V	257.29
29	NS	F1AH36	+Wh	+Ct	-V	142.50
57	NS	F1AH36	+Wh	-Ct	+V	311.00
85	NS	F1AH36	+Wh	-Ct	-V	258.47
113	NS	F1AH36	-Wh	+Ct	+V	261.69
141	NS	F1AH36	-Wh	+Ct	-V	125.33
169	NS	F1AH36	-Wh	-Ct	+V	264.03
197	NS	F1AH36	-Wh	-Ct	-V	230.43



Boxplot



Boxplot (with obstruents)



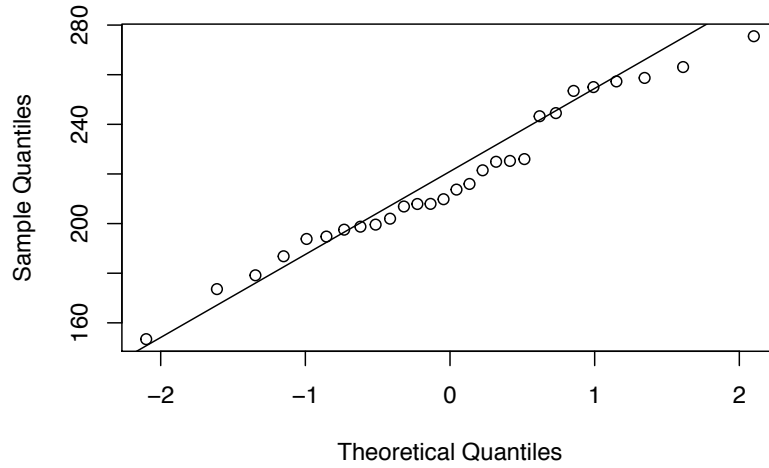
Assumptions - Normality

> Shapiro-Wilk's test

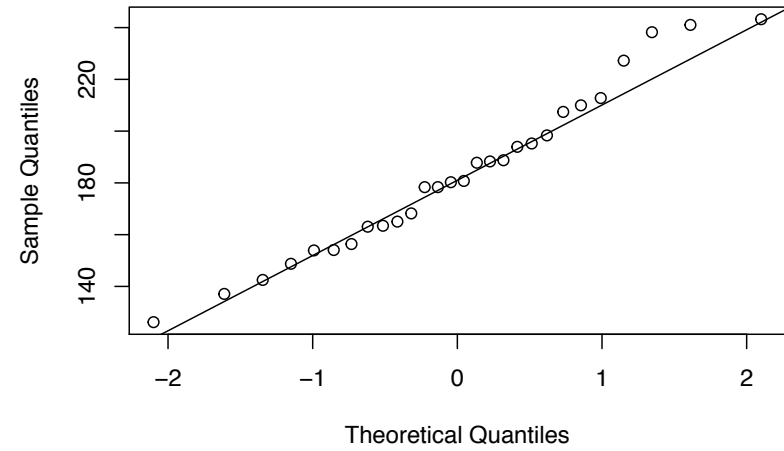
		Shapiro-Wilk	N	p-value
+Wh+Ct+V	NS	0,944	8	0,647
	NNS	0,961	20	0,566
+Wh+Ct-V	NS	0,971	8	0,909
	NNS	0,964	20	0,636
+Wh-Ct+V	NS	0,938	8	0,589
	NNS	0,937	20	0,215
+Wh-Ct-V	NS	0,980	8	0,962
	NNS	0,942	20	0,267
-Wh+Ct+V	NS	0,880	8	0,190
	NNS	0,940	20	0,236
-Wh+Ct-V	NS	0,800	8	0,029
	NNS	0,907	20	0,056
-Wh-Ct+V	NS	0,944	8	0,648
	NNS	0,953	20	0,407
-Wh-Ct-V	NS	0,933	8	0,543
	NNS	0,942	20	0,263



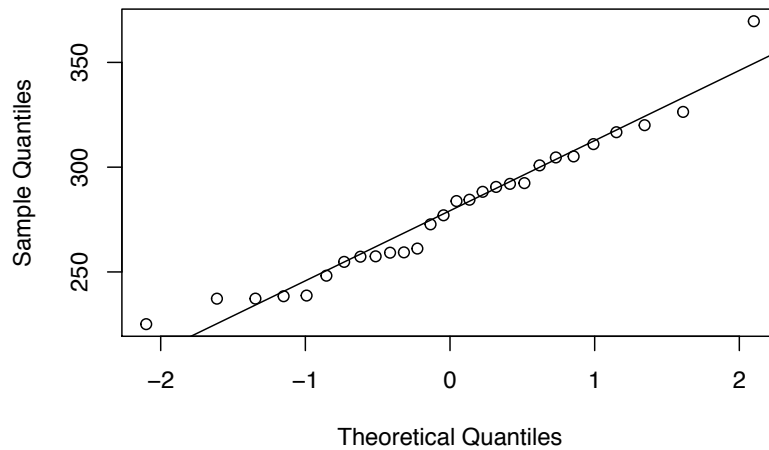
+Wh+Ct+V



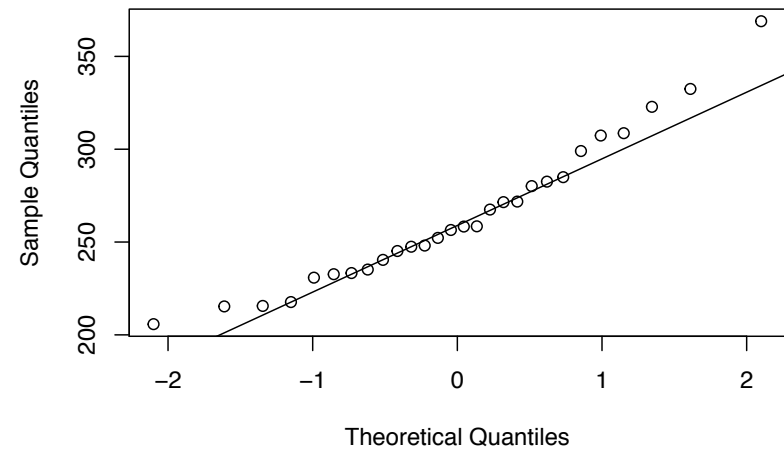
+Wh+Ct-V



+Wh-Ct+V

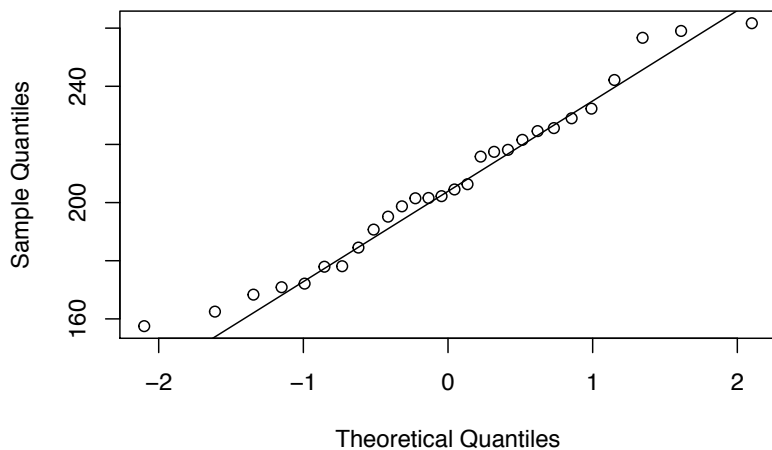


+Wh-Ct-V

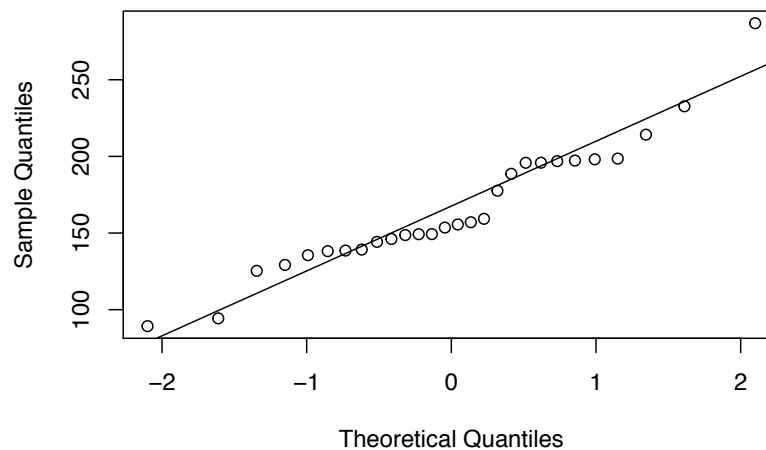




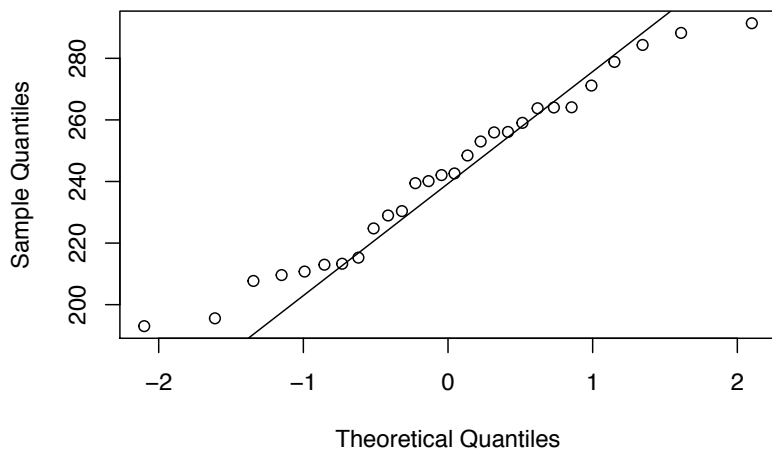
-Wh+Ct+V



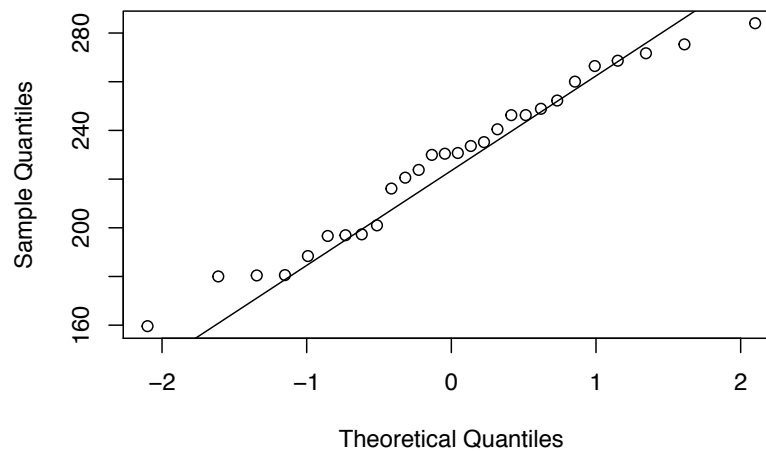
-Wh+Ct-V



-Wh-Ct+V



-Wh-Ct-V





Assumptions - Homogeneity

- > Variance of between-subject
- > Levene's test
 - `leveneTest(WhisperData$Vowel ~ WhisperData$Group)`

Levene's Test for Homogeneity of Variance (center = median)

	Df	F value	Pr(>F)
group	1	2.1806	0.1412
	222		



Assumptions - Sphericity

- > Variance of within-subject
 - Only 2 levels
 - “a within-subject factor with $df=1$ will always satisfy the sphericity condition” (Rietveld & van Hout, 1993).



Mixed-design ANOVA

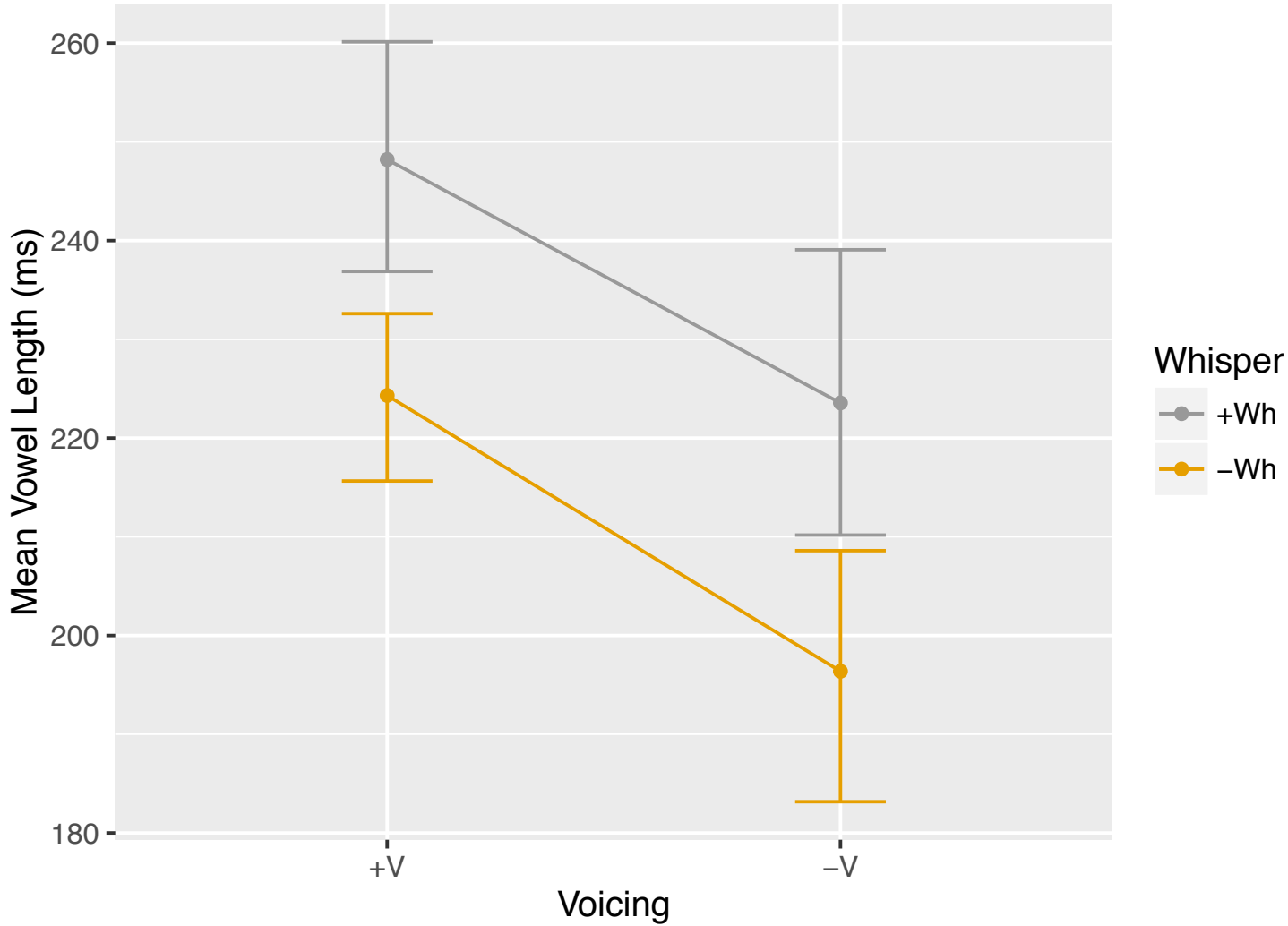
- > WhisperModel = ezANOVA(data=WhisperData, dv=.(Vowel), wid=.(Participant), between=.(Group), within=.(Whisper, Obstruent, Voicing), type=3, detailed=TRUE)
- > WhisperModel

	Effect	DFn	DFd	SSn	SSd	F	p	p<.05	ges
1	(Intercept)	1	26	9,027597E+06	148467,872	1,580931E+03	8,133055E-25	*	9,774751E-01
2	Group	1	26	8,448149E+02	148467,872	1,479457E-01	7,036345E-01		4,044565E-03
3	Whisper	1	26	3,041496E+04	22644,198	3,492236E+01	3,109997E-06	*	1,275545E-01
5	Obstruent	1	26	1,659554E+05	13476,766	3,201687E+02	3,889494E-16	*	4,437462E-01
7	Voicing	1	26	6,133432E+04	9669,445	1,649208E+02	9,187883E-13	*	2,276988E-01
4	Group:Whisper	1	26	1,610589E+01	22644,198	1,849274E-02	8,928782E-01		7,741438E-05
6	Group:Obstruent	1	26	2,014766E+01	13476,766	3,886979E-02	8,452400E-01		9,683958E-05
8	Group:Voicing	1	26	2,656715E+04	9669,445	7,143595E+01	6,215816E-09	*	1,132450E-01
9	Whisper:Obstruent	1	26	4,250359E+03	4883,006	2,263142E+01	6,378791E-05	*	2,002222E-02
11	Whisper:Voicing	1	26	2,415395E+02	2460,529	2,552308E+00	1,222172E-01		1,159724E-03
13	Obstruent:Voicing	1	26	1,260756E+04	4297,582	7,627465E+01	3,284698E-09	*	5,714104E-02
10	Group:Whisper:Obstruent	1	26	5,539962E+02	4883,006	2,949802E+00	9,777838E-02		2,655964E-03
12	Group:Whisper:Voicing	1	26	1,071175E+02	2460,529	1,131893E+00	2,971535E-01		5,146445E-04
14	Group:Obstruent:Voicing	1	26	7,132076E+03	4297,582	4,314844E+01	5,770960E-07	*	3,314719E-02
15	Whisper:Obstruent:Voicing	1	26	6,294280E+02	2132,346	7,674707E+00	1,019996E-02	*	3,016508E-03
16	Group:Whisper:Obstruent:Voicing	1	26	1,142286E+03	2132,346	1,392806E+01	9,366409E-04	*	5,460935E-03



Voicing - Whisper

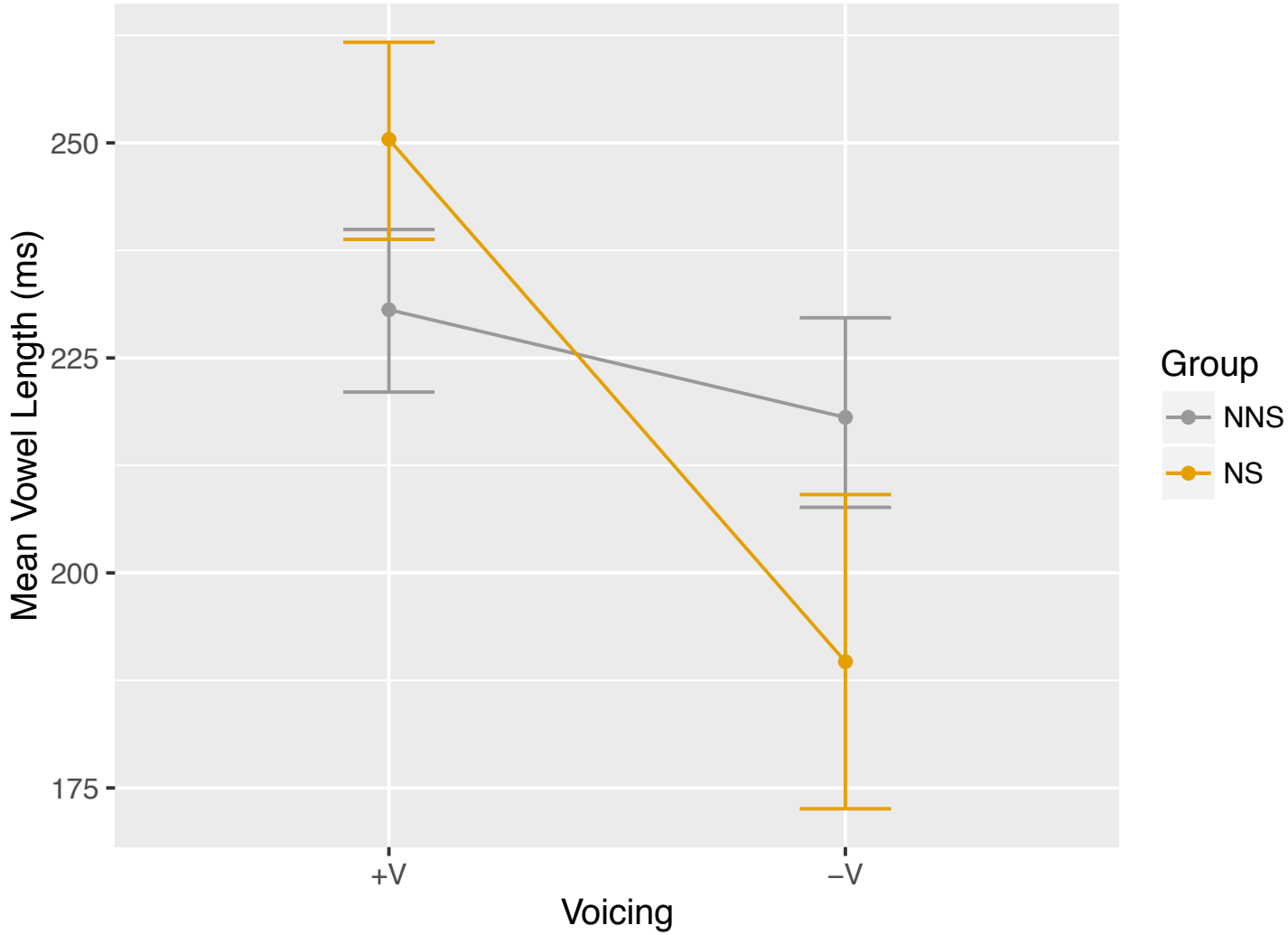
$F(1, 26) = 2.55, p = .122, \eta^2 = 1.16e^{-03}$





Voicing - Group

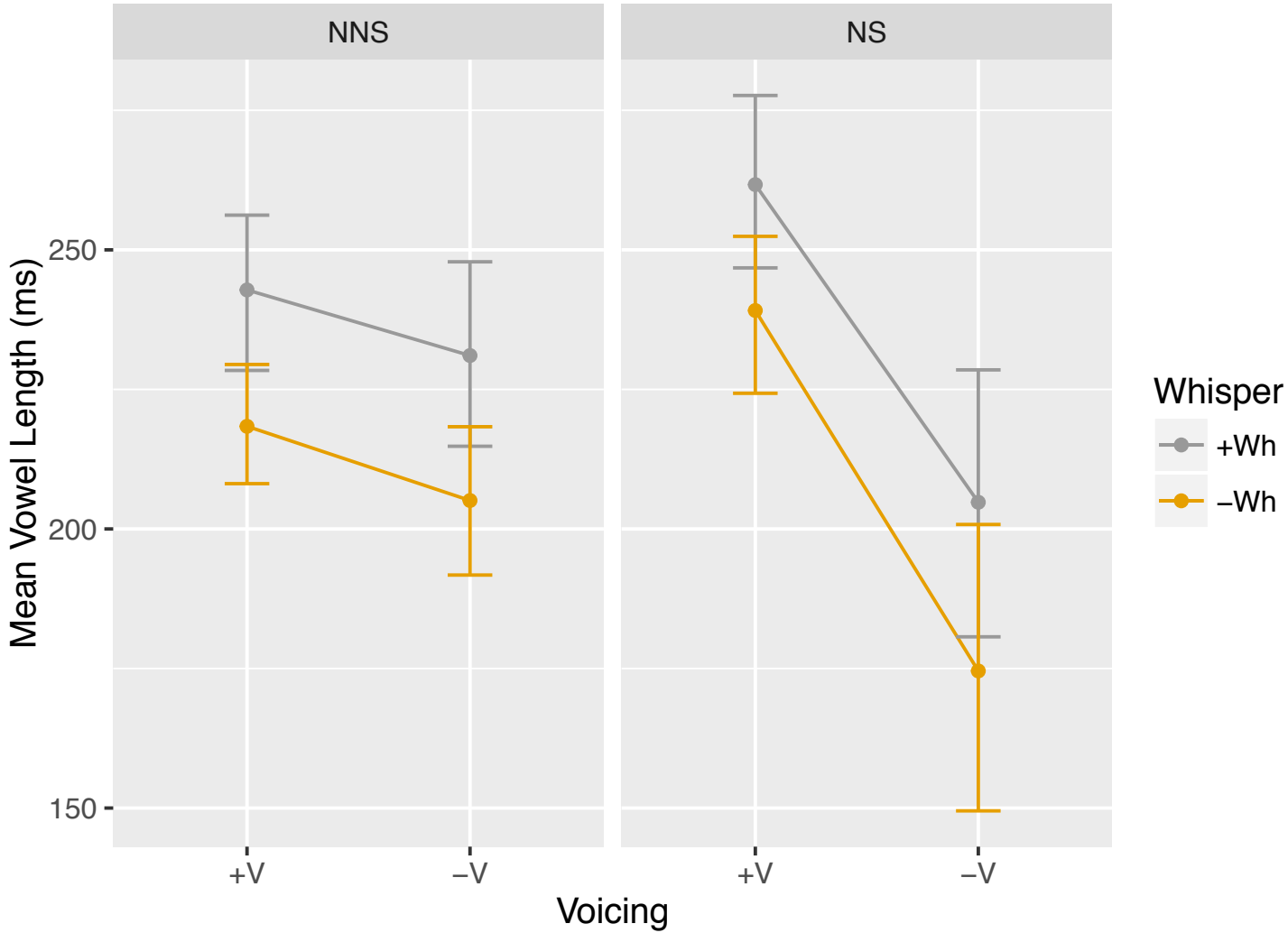
$F(1, 26) = 7.14e+01, p < .01, \eta^2 = 1.13e-01$

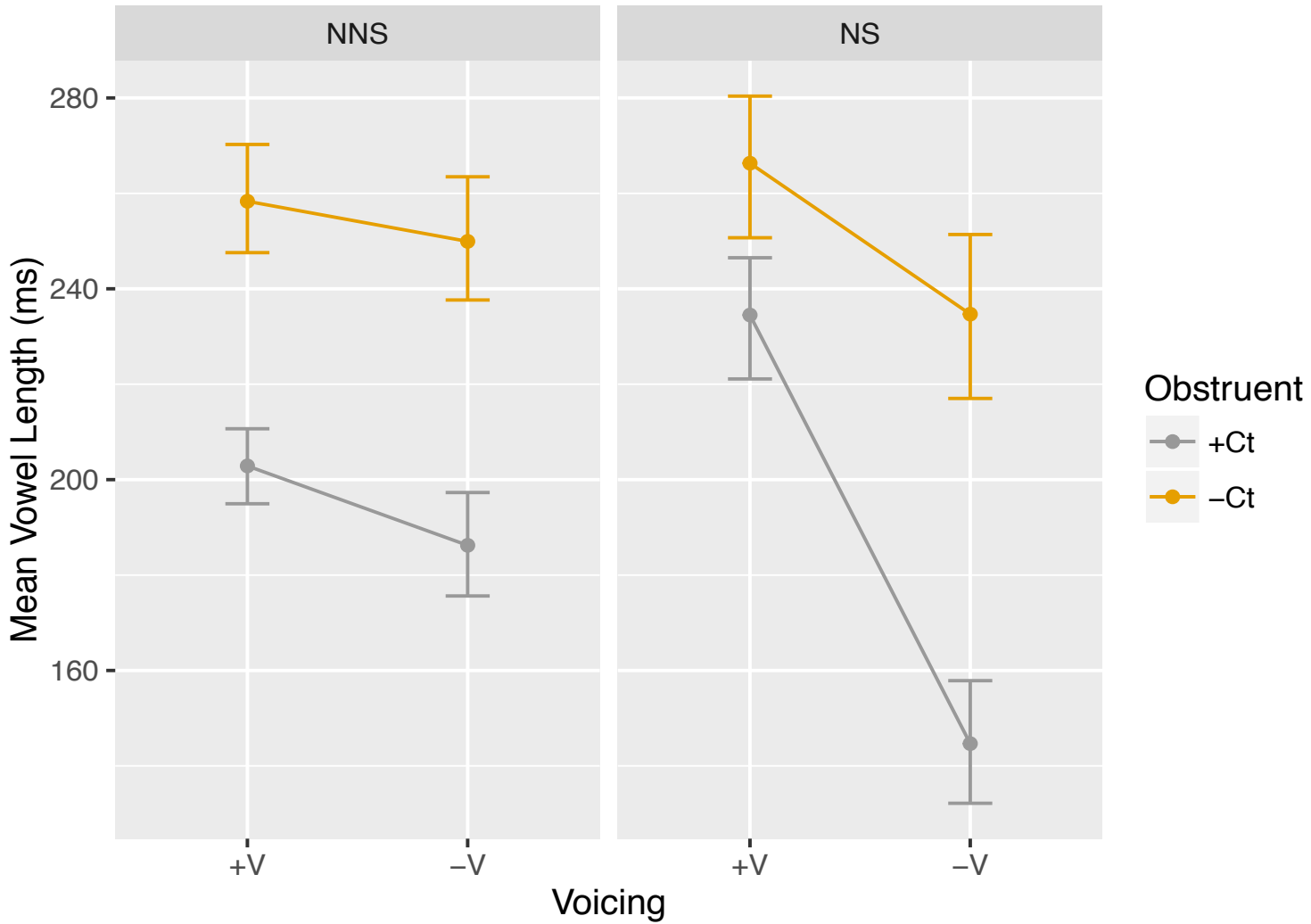




Voicing - Whisper - Group

$F(1, 26) = 1.13e+00, p = .297, \eta^2 = 5.15e-04$





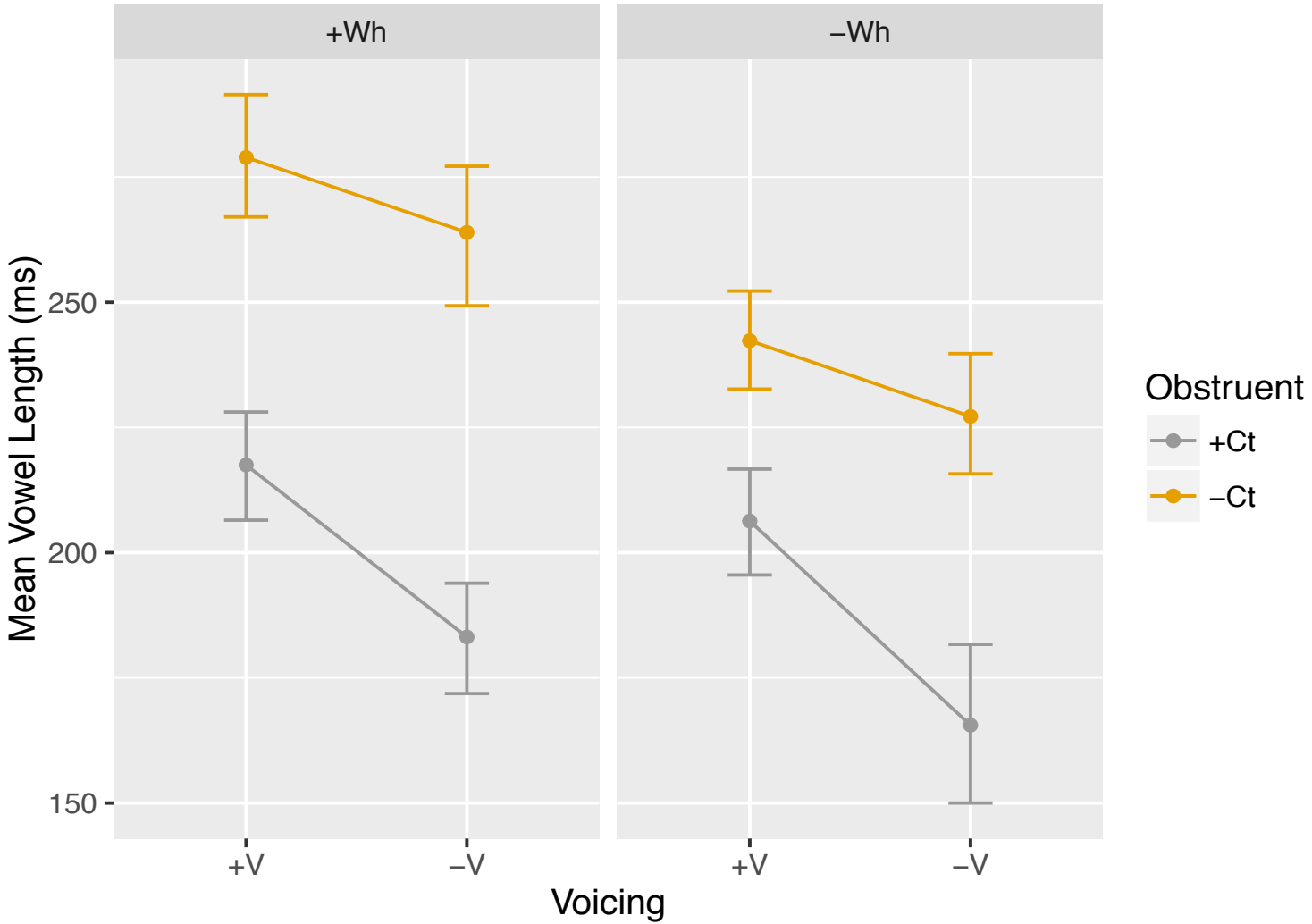
$F(1, 26) = 4.31e^{+01}, p < .01, \eta^2 = 3.31e^{-02}$

Voicing - Obstruent - Group



Voicing - Obstruent - Whisper

$F(1, 26) = 7.67e+00, p < .05, \eta^2 = 3.02e-03$





Conclusions

- > Whispered vs phonated speech
 - No difference

- > L1 vs L2 speakers of English
 - Significant difference

- > Future research
 - Perception
 - Other cues



Thank you
for your
attention

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