# Experimental evidence for vowel-to-vowel dissimilation

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# Background

## Vowel-to-vowel coarticulation

- What is it?
  - an assimilatory influence upon the articulatory movements of one vowel due to a nearby vowel.

  - can be anticipatory or carryover. Öhman (1966) observed both types in English and Swedish consonant-vowel and vowel-consonant transitions, and subsequent research has found the phenomenon in numerous other languages (cf. Manuel 1999 for an extensive review)

  - language-/speaker-specificity in the extents of anticipatory and carryover V-to-V coarticulation (Beddor et. al. 2002; Manuel 1999).

  - can have 2-syllable range: over two unstressed vowels (Fowler 1981); between two stressed vowels separated by an unstressed vowel (Magen 1997).

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# Background

## Vowel-to-vowel coarticulation

- What causes it?
  - *Physical constraints*. e.g. mechanico-inertial restrictions on the speed with which articulators (esp. the tongue dorsum) can be moved from one articulatory target to another. Recasens (1984) and Recasens et. al. (1997) has argued that such factors play a role in vowel-to-vowel coarticulation.

  - *Cognitive mechanisms*.
    - Gestural overlap: blending of motor commands sent to the articulators. (Saltzman & Munhall 1989; Browman & Goldstein 1990).

vs.

    - Pre-motor interactions between contemporaneously-active planning systems, affecting the formation of articulatory targets.

# Background

## Vowel-to-vowel coarticulation

- What limits it?
  - *vowel inventory:* less V-to-V coarticulation in languages with more crowded vowel spaces (Manuel 1990, 1999).
  - *prosodic strengthening:* stressed vowels, phrase-initial and phrase-final vowels exhibit less coarticulation than their unstressed and phrase-medial counterparts (Cho 2004).
  - *intergestural phasing:* relative phases of gestures are specified in a representation (Browman & Goldstein 1990).
  - preservation of contrast, lexical faithfulness
    – but what cognitive mechanism accomplishes this?

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# Method

## Vowel response-priming

plan $V_1$ → plan & produce $V_2$

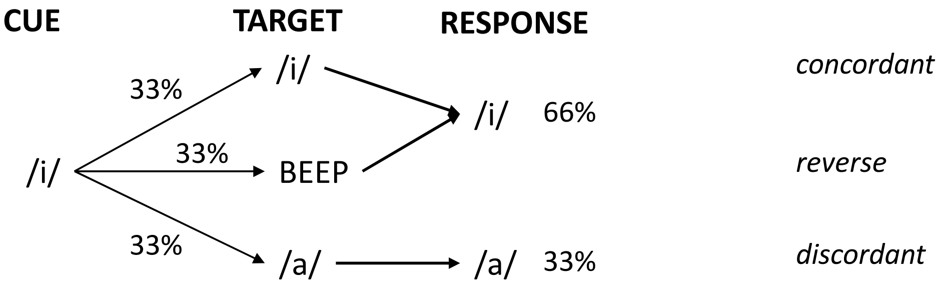
$V_1$ delay $V_2$

Design of vowel response-priming trials

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Trial Type | Noise | Cue | Delay | Target | Response |
| Concordant | “shh” | $V_1$ | 100/800 ms | $V_2$ (=$V_1$) | $V_1$/$V_2$ |
| Discordant | “shh” | $V_1$ | 100/800 ms | $V_2$ (≠$V_1$) | $V_2$ |
| Reverse | “shh” | $V_1$ | 100/800 ms | BEEP | $V_1$ |

# Method

-- vowel stimuli: /a/ and /i/



**CUE** **TARGET** **RESPONSE**

/i/ → 33% → /i/ → /i/ 66% *concordant*

/i/ → 33% → BEEP → /i/ 66% *reverse*

/i/ → 33% → /a/ → /a/ 33% *discordant*

-- on discordant trials, one vowel is planned but the other is produced.
-- analogous to carryover V-to-V coarticulation, except the first vowel is not articulated.
-- not articulating $V_1$ removes potential effects of physical constraints and gestural overlap

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# Method

- Stimuli

Mean LPC-estimated formants of stimuli

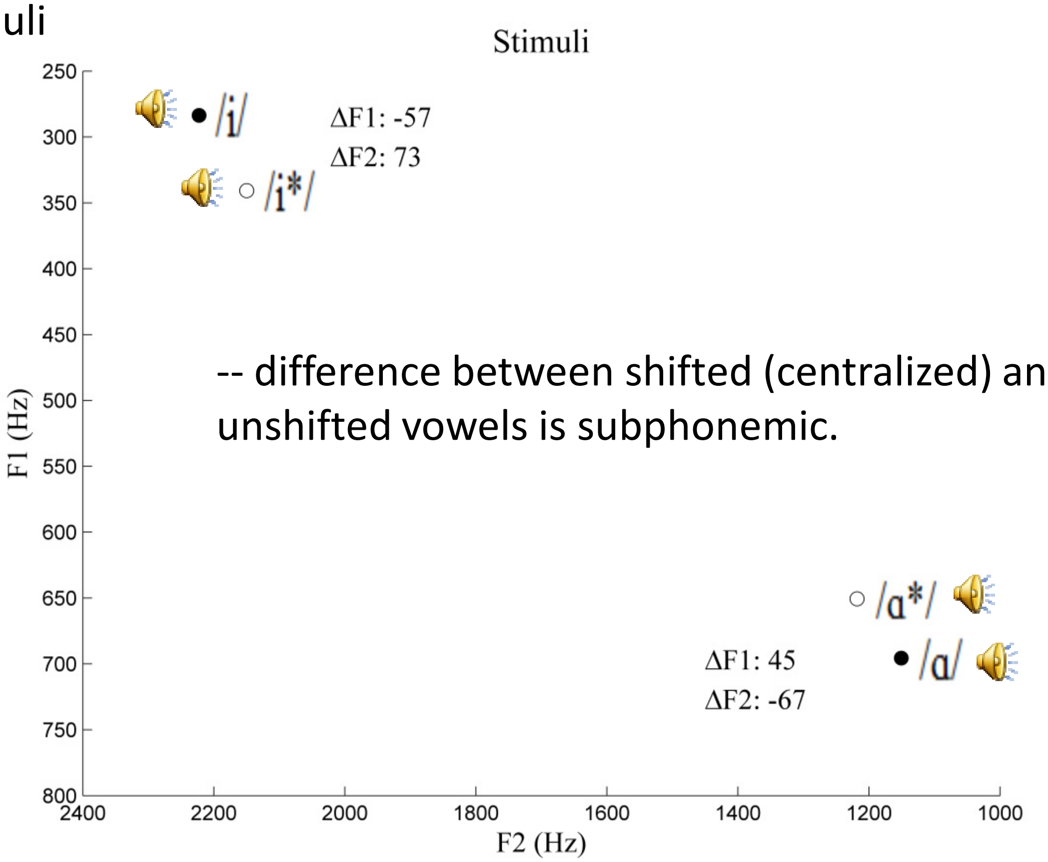
|  | F1 | F2 |  | F1 | F2 |
|---|---|---|---|---|---|
| [ɑ] | 696 | 1151 | [i] | 284 | 2223 |
| [ɑ*] | 651 | 1218 | [i*] | 341 | 2150 |
| Shift: | -45 | 67 | Shift: | 57 | -73 |

-- Formants shifted by synthesis of bandstop- and bandpass-filtered versions of the unshifted vowels (Purcell & Munhall 2006)

-- duration, pitch, energy normalization

# Method

- Stimuli



-- difference between shifted (centralized) and unshifted vowels is subphonemic.

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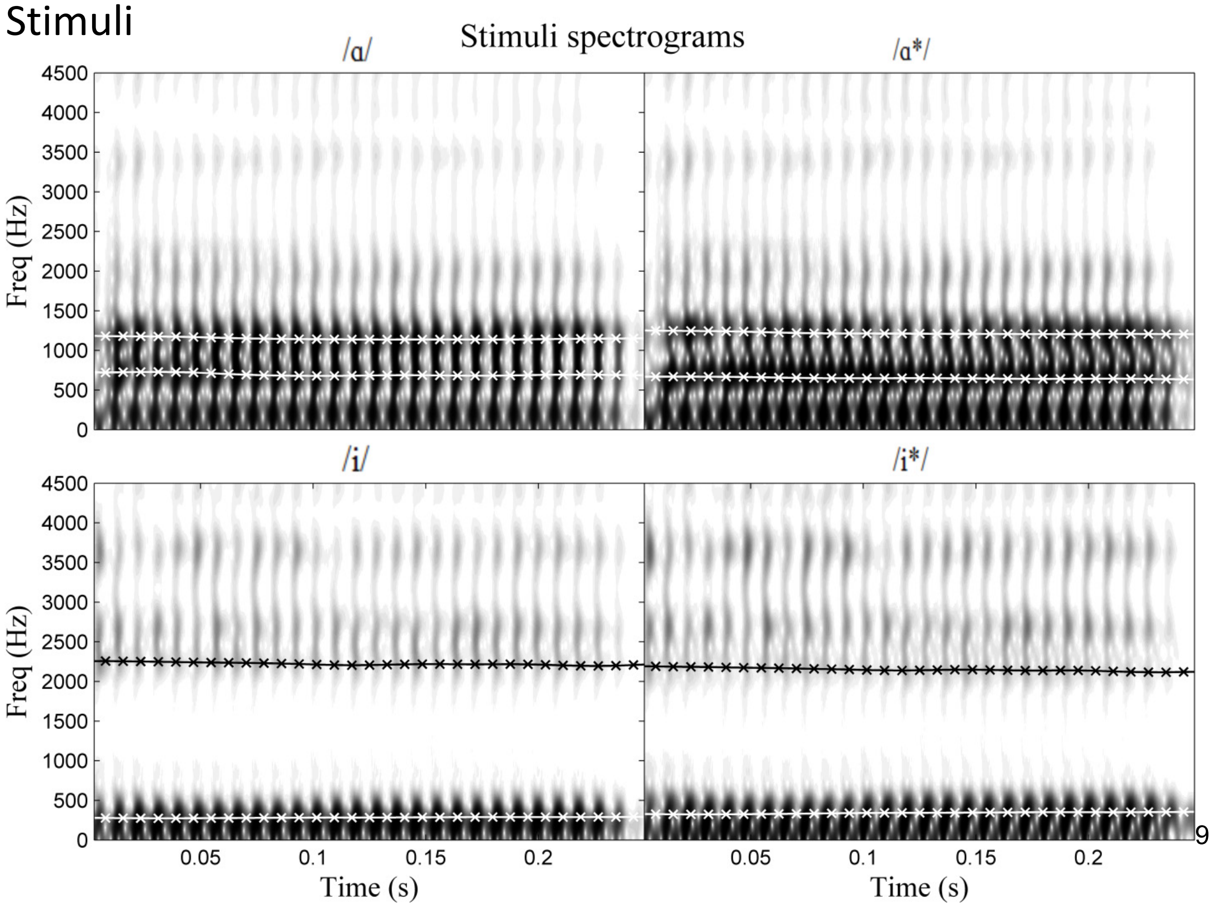
# Method

- Stimuli



# Hypotheses

**H1**. ***Subphonemic perceptual-motor integration:*** on concordant trials, responses made after centrally-shifted cues will be more central than those after unshifted cues. e.g. /ɑ/ responses after centralized /ɑ*/ cues will tend to be more central in F1,F2 space than after unshifted /ɑ/ cues.

**H2.** ***Carryover quasi-coarticulation:*** response vowels on discordant trials will be acoustically more like the cue vowel than responses on concordant trials. For example, /ɑ/ responses after /i/ cues will tend to be more like /i/ than /ɑ/ responses after /ɑ/ cues. Such effects are "quasi-coarticulatory" because they pattern like vowel-to-vowel coarticulation, but in this case the first vowel is not articulated.

**H3.** ***Temporal decay*:** carryover quasi-coarticulation and centralized-cue effects will be less extensive when there is a longer delay between cue and target stimuli. The effects on F1 and F2 in the 800 ms delay condition will be less extensive compared to the 100 ms delay condition.

# Discarded Trials

**Excluded trials by subject**

| **Exclusion reason** | **Subject**<br>**f1** | **f2** | **f3** | **f4** | **f5** | **f6** | **m1** | **m2** | **m3** | **m4** | **m5** | **m6** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **late response** | 35 | 32 | 30 | 12 | 26 | 30 | 36 | 34 | 33 | 18 | 22 | 26 | 334 |
| **early response** | 2 | 3 | 6 | 3 | 8 | 0 | 3 | 7 | 2 | 5 | 3 | 37 | 79 |
| **no response** | 1 | 3 | 0 | 0 | 3 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 11 |
| **too short** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| **wrong response** | 0 | 5 | 0 | 3 | 0 | 16 | 1 | 7 | 2 | 1 | 3 | 7 | 45 |
| **mixed response** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 4 | 0 | 2 | 8 |
| **other** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 4 |
| **LPC failure** | 2 | 5 | 0 | 0 | 2 | 2 | 2 | 7 | 0 | 0 | 0 | 0 | 20 |
| **F1 /A/ outlier** | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 5 |
| **F2 /A/ outlier** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 1 | 2 | 7 |
| **F1 /i/ outlier** | 0 | 1 | 0 | 0 | 1 | 0 | 4 | 5 | 0 | 0 | 2 | 3 | 16 |
| **F2 /i/ outlier** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 7 | 2 | 12 |
| **# of excluded trials** | 42 | 49 | 36 | 18 | 40 | 49 | 51 | 69 | 42 | 29 | 38 | 80 | 543 |
| **Total Trials** | 1167 | 1300 | 813 | 803 | 806 | 815 | 1328 | 1260 | 1321 | 836 | 875 | 814 | **12138** |
| **% of Total** | 3.6% | 3.8% | 4.4% | 2.2% | 5.0% | 6.0% | 3.8% | 5.5% | 3.2% | 3.5% | 4.3% | 9.8% | **4.5%** |

# Results

- Effects of shifted-cue (centralized) stimuli on same-phoneme responses

Analysis of variance in F1 and F2 due to shifted cue stimuli

| | | F1 | | F2 | |
|---|---|---|---|---|---|
| /ɑ/ | Shift | F(1,1450) = .18, p < .67 | | F(1,1450) = 12.49, p < .001 | * |
| | Shift x Subject | F(11,1450) = .46, p < .93 | | F(11,1450) = .87, p < .57 | |
| /i/ | Shift | F(1,1454) = 78.63, p < .001 | * | F(1,1454) = 8.26, p < .005 | * |
| | Shift x Subject | F(11,1454) = 3.91, p < .001 | * | F(11,1454) = 3.01, p < .001 | * |

# Results

Within-subject F1 and F2 comparisons between shifted-cue and unshifted-cue trials

| | F1 | | | | | |
|---|---|---|---|---|---|---|
| | Unshifted | | Shifted | | Shifted-Unshifted | |
| Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < |
| /ɑ/ | | | | | | |
| f5 | 867 | (65,49) | 854 | (74,49) | -13 | .37 |
| f6 | 946 | (57,48) | 934 | (55,50) | -12 | .31 |
| f3 | 851 | (33,50) | 840 | (47,50) | -10 | .22 |
| f4 | 995 | (40,49) | 990 | (33,50) | -6 | .45 |
| m3 | 741 | (28,82) | 738 | (34,81) | -3 | .51 |
| m5 | 586 | (40,54) | 583 | (42,53) | -3 | .73 |
| m1 | 672 | (48,80) | 672 | (44,79) | 0 | 1.00 |
| m2 | 667 | (89,76) | 670 | (93,77) | 2 | .89 |
| f1 | 961 | (54,70) | 964 | (51,72) | 3 | .77 |
| f2 | 790 | (94,79) | 796 | (88,79) | 6 | .68 |
| m6 | 572 | (51,48) | 581 | (45,49) | 9 | .37 |
| m4 | 786 | (60,51) | 796 | (54,49) | 10 | .37 |

| | F2 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Unshifted | | Shifted | | Shifted-Unshifted | | |
| Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < | |
| /ɑ/ | | | | | | | |
| f4 | 1686 | (57,49) | 1673 | (71,50) | -13 | .32 | |
| f3 | 1517 | (56,50) | 1519 | (51,50) | 3 | .82 | |
| f2 | 1393 | (66,79) | 1398 | (80,79) | 5 | .67 | |
| f6 | 1364 | (72,48) | 1370 | (66,50) | 6 | .66 | |
| m2 | 1244 | (36,76) | 1256 | (37,77) | 12 | .05 | * |
| m5 | 1122 | (45,54) | 1133 | (51,53) | 12 | .23 | |
| m3 | 1264 | (36,82) | 1276 | (36,81) | 13 | .04 | * |
| m6 | 1259 | (43,48) | 1273 | (39,49) | 14 | .10 | |
| m4 | 1271 | (52,51) | 1291 | (42,49) | 20 | .05 | * |
| f1 | 1375 | (100,70) | 1398 | (69,72) | 23 | .12 | |
| m1 | 1133 | (76,80) | 1158 | (66,79) | 25 | .04 | * |
| f5 | 1262 | (117,49) | 1294 | (143,49) | 32 | .24 | |

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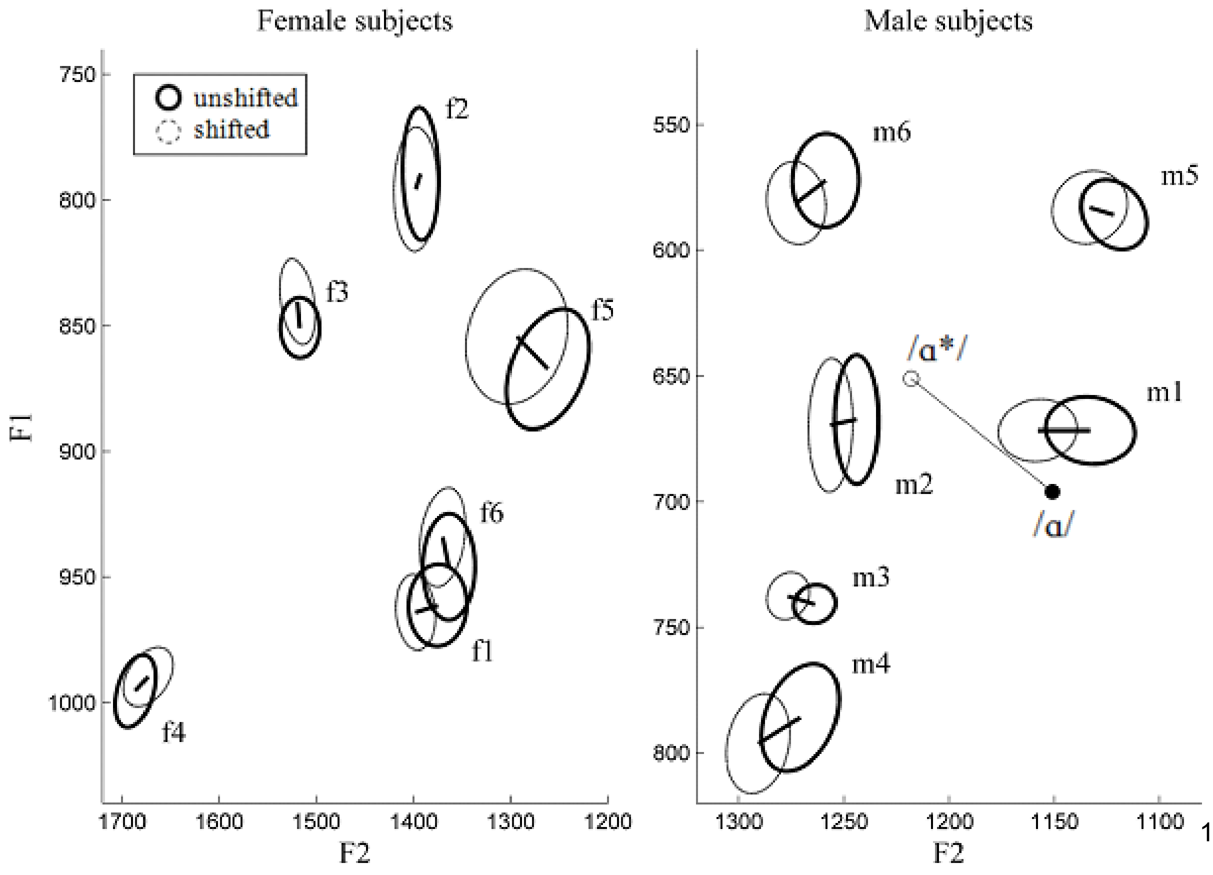
# Results

/ɑ/ Responses



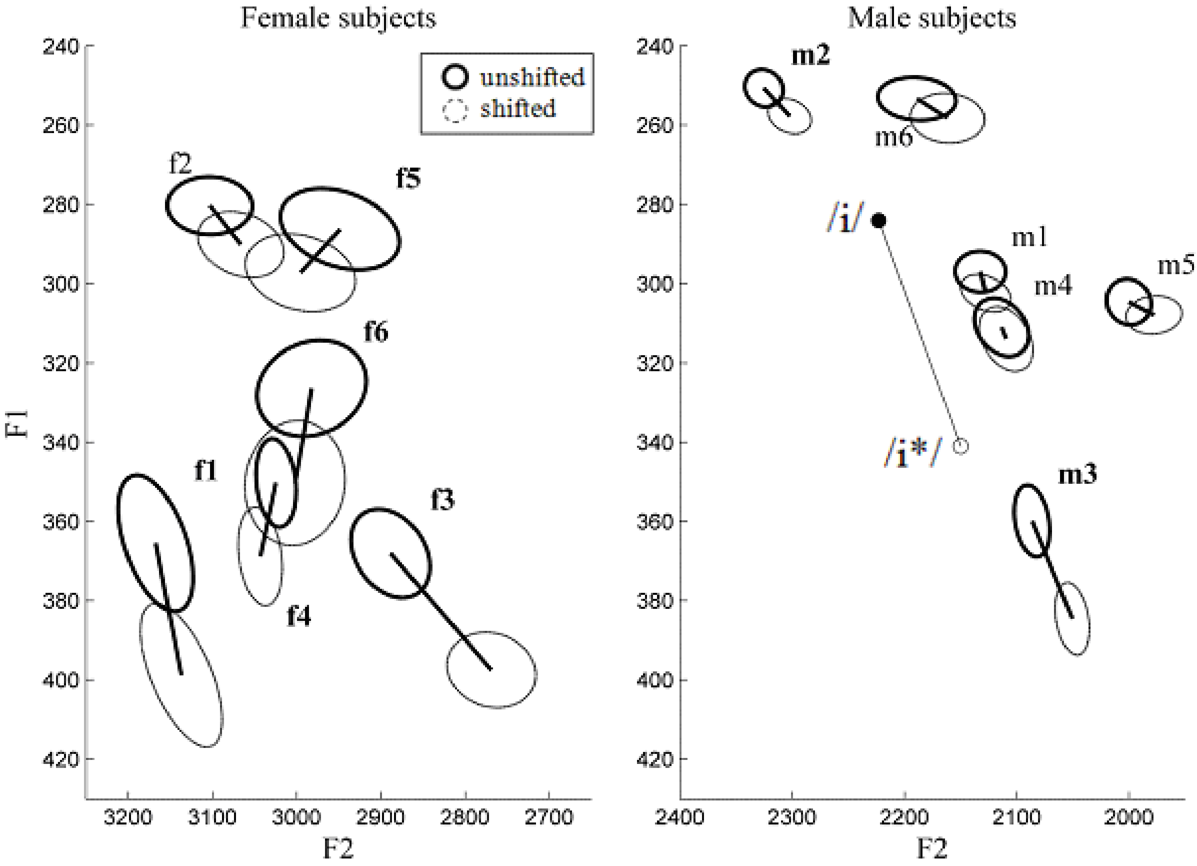
# Results

Within-subject F1 and F2 comparisons between shifted-cue and unshifted-cue trials

| | F1 | | | | | | | | F2 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unshifted | | Shifted | | Shifted-Unshifted | | | | Unshifted | | Shifted | | Shifted-Unshifted | | |
| Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < | | Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < | |
| /i/ | | | | | | | | /i/ | | | | | | | |
| m4 | 311 | (21,52) | 314 | (23,52) | 3 | .51 | | f3 | 2889 | (130,50) | 2769 | (145,49) | -120 | .01 | * |
| m5 | 305 | (17,54) | 308 | (14,54) | 3 | .28 | | f2 | 3103 | (179,79) | 3066 | (182,80) | -37 | .21 | |
| m1 | 297 | (19,82) | 302 | (17,81) | 5 | .06 | + | m3 | 2086 | (56,79) | 2051 | (54,80) | -36 | .01 | * |
| m6 | 253 | (15,48) | 258 | (17,48) | 5 | .15 | | f1 | 3167 | (150,72) | 3137 | (162,71) | -30 | .26 | |
| m2 | 251 | (17,76) | 258 | (16,77) | 7 | .02 | * | m6 | 2189 | (94,48) | 2162 | (90,48) | -27 | .16 | |
| f2 | 280 | (26,79) | 290 | (30,80) | 10 | .04 | * | m2 | 2325 | (59,76) | 2302 | (67,77) | -23 | .04 | * |
| f5 | 286 | (27,46) | 297 | (27,49) | 11 | .06 | + | m5 | 2000 | (57,54) | 1978 | (73,54) | -22 | .09 | + |
| f4 | 350 | (31,49) | 369 | (35,50) | 19 | .02 | * | m1 | 2132 | (82,82) | 2128 | (81,81) | -5 | .72 | |
| f6 | 326 | (34,50) | 350 | (44,50) | 24 | .01 | * | m4 | 2114 | (68,52) | 2110 | (67,52) | -4 | .77 | |
| m3 | 360 | (32,79) | 385 | (33,80) | 25 | .01 | * | f4 | 3025 | (65,49) | 3043 | (73,50) | 18 | .20 | |
| f3 | 368 | (31,50) | 397 | (26,49) | 29 | .01 | * | f6 | 2982 | (180,50) | 3002 | (165,50) | 20 | .58 | |
| f1 | 366 | (58,72) | 399 | (61,71) | 33 | .01 | * | f5 | 2949 | (187,46) | 2995 | (179,49) | 47 | .23 | |

# Results

/i/ Responses



# Results

**H1**. ***Subphonemic perceptual-motor integration:*** on concordant trials, responses made after centrally-shifted cues will be more central than those after unshifted cues. e.g. /ɑ/ responses after centralized /ɑ*/ cues will tend to be more central in F1,F2 space than after unshifted /ɑ/ cues.

**-- Confirmed**

- indicates that subphonemic details of the cue stimuli were perceived and integrated into motor plans.
- evidence for motor theory of speech perception – mirror circuitry

# Results

- Effects of cue-target concordance

(w/o shifted cue trials)

Analysis of variance due to cue-target concordance

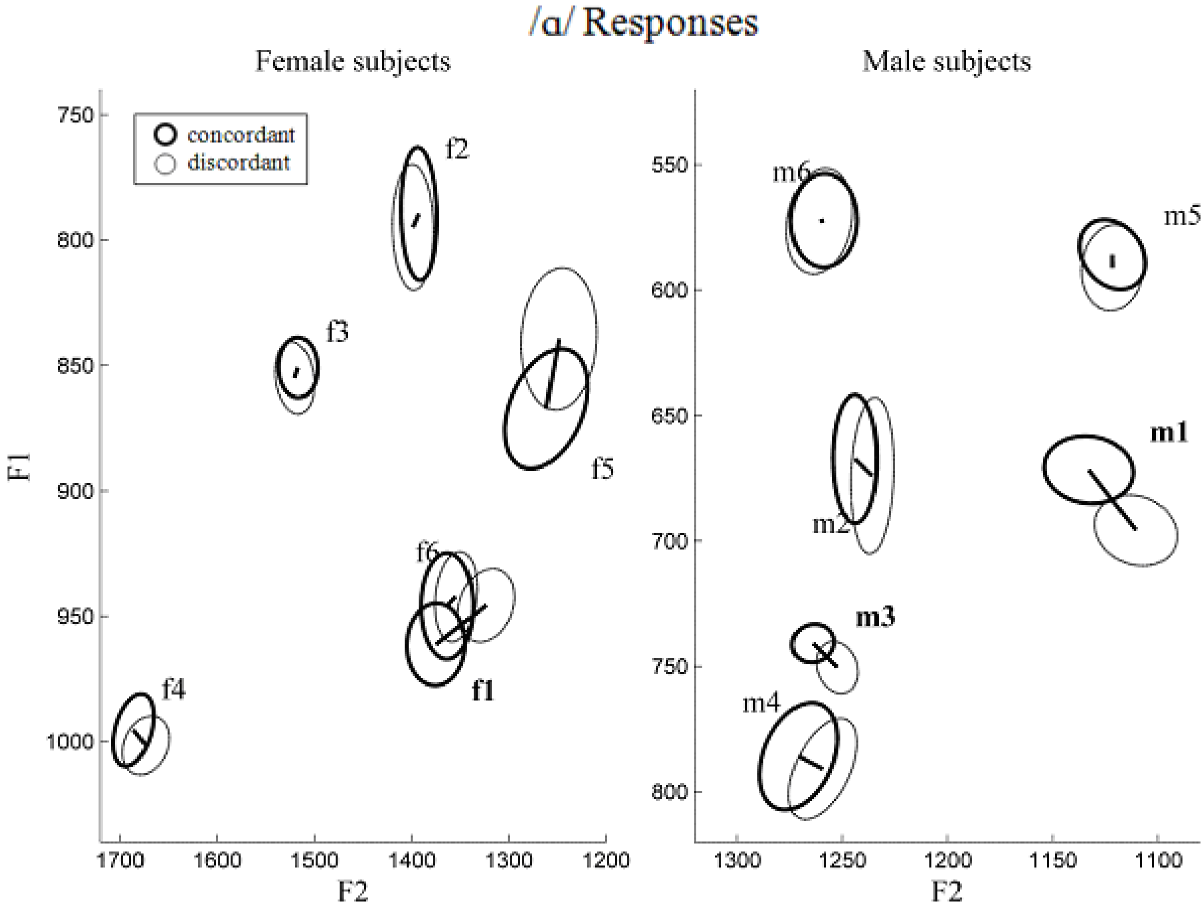
| | | F1 | | F2 | |
|---|---|---|---|---|---|
| /ɑ/ | Concordance | F(1,1429) = 0.24, p < .63 | | F(1,1429) = 9.18, p < .003 | * |
| | Concordance x Subject | F(11,1429) = 1.39, p < .18 | | F(11,1429) = 1.82, p < .05 | * |
| /i/ | Concordance | F(1,1429) = 8.57, p < .004 | * | F(1,1429) = .94, p < .34 | |
| | Concordance x Subject | F(11,1429) = 2.24, p < .01 | * | F(11,1429) = 1.61, p < .10 | + |

# Results

Within-subject formant comparisons between concordant and discordant trials

| | F1 | | | | | | | | F2 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concordant | | Discordant | | Discordant-Concordant | | | | Concordant | | Discordant | | Discordant-Concordant | | |
| Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < | | Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < | |
| /ɑ/ | | | | | | | | /ɑ/ | | | | | | | |
| f5 | 867 | (65,49) | 839 | (78,50) | -28 | 0.06 | + | f1 | 1375 | (100,70) | 1323 | (96,69) | -52 | 0.01 | * |
| f1 | 961 | (54,70) | 946 | (48,69) | -16 | 0.08 | + | m1 | 1133 | (76,80) | 1111 | (70,80) | -22 | 0.05 | * |
| f6 | 946 | (57,48) | 942 | (48,46) | -4 | 0.74 | | f4 | 1686 | (57,49) | 1673 | (66,49) | -13 | 0.31 | |
| m6 | 572 | (51,48) | 573 | (54,44) | 0 | 0.98 | | f5 | 1262 | (117,49) | 1249 | (108,50) | -13 | 0.56 | |
| f3 | 851 | (33,50) | 855 | (39,48) | 4 | 0.58 | | m4 | 1271 | (52,51) | 1259 | (45,50) | -12 | 0.23 | |
| f2 | 790 | (94,79) | 795 | (89,79) | 5 | 0.71 | | m3 | 1264 | (36,82) | 1252 | (36,81) | -11 | 0.04 | * |
| m4 | 786 | (60,51) | 791 | (56,50) | 5 | 0.67 | | f6 | 1364 | (72,48) | 1354 | (58,46) | -9 | 0.50 | |
| m5 | 586 | (40,54) | 591 | (47,49) | 5 | 0.55 | | m2 | 1244 | (36,76) | 1236 | (34,72) | -8 | 0.16 | |
| f4 | 995 | (40,49) | 1002 | (32,49) | 6 | 0.40 | | m5 | 1122 | (45,54) | 1122 | (41,49) | -0 | 1.00 | |
| m2 | 667 | (89,76) | 674 | (105,72) | 7 | 0.69 | | m6 | 1259 | (43,48) | 1261 | (40,44) | 2 | 0.80 | |
| m3 | 741 | (28,82) | 750 | (37,81) | 10 | 0.07 | + | f3 | 1517 | (56,50) | 1520 | (55,48) | 4 | 0.75 | |
| m1 | 672 | (48,80) | 696 | (50,80) | 24 | 0.01 | * | f2 | 1393 | (66,79) | 1399 | (76,79) | 6 | 0.59 | |

# Results

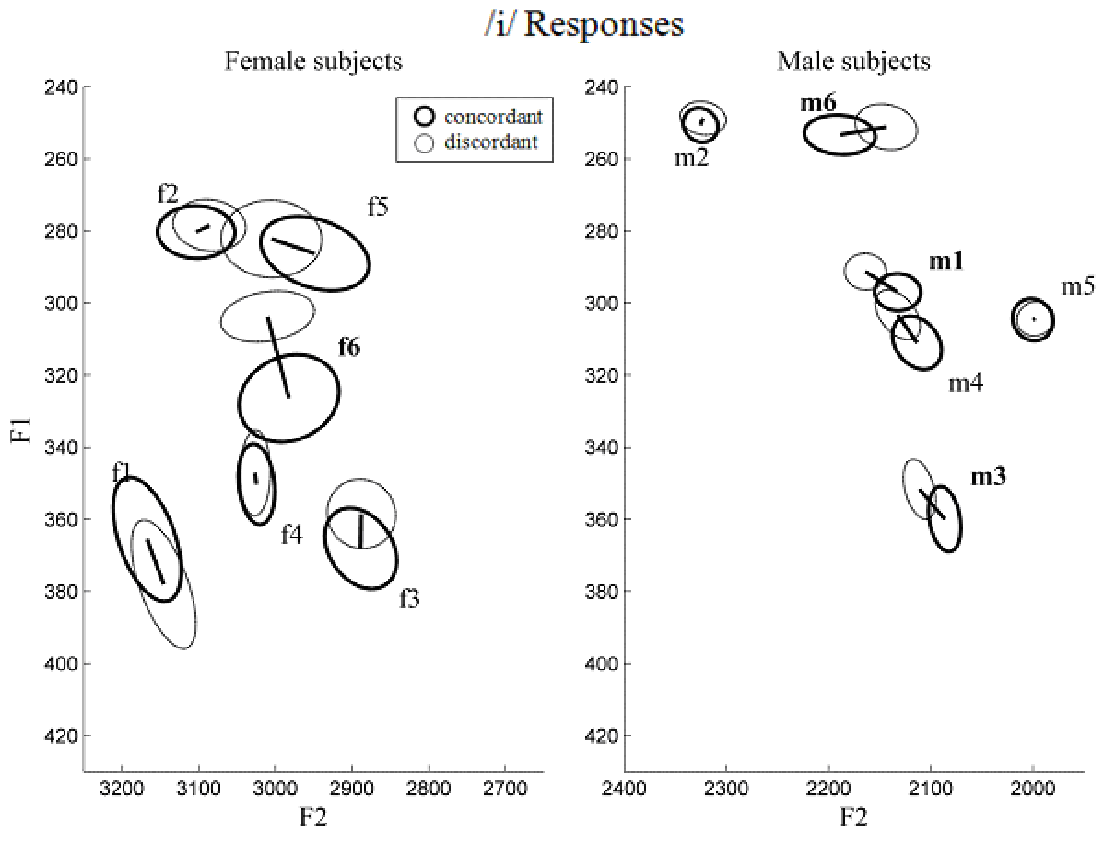


# Results

Within-subject formant comparisons between concordant and discordant trials

| | F1 | | | | | | | | F2 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concordant | | Discordant | | Discordant-Concordant | | | | Concordant | | Discordant | | Discordant-Concordant | | |
| Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < | | Subj. | Hz | (σ,N) | Hz | (σ,N) | Δ | p < | |
| /i/ | | | | | | | | /i/ | | | | | | | |
| f6 | 326 | (34,50) | 304 | (19,49) | -23 | 0.01 | * | m6 | 2189 | (94,48) | 2144 | (81,47) | -45 | 0.01 | * |
| f3 | 368 | (31,50) | 358 | (26,49) | -10 | 0.11 | + | f1 | 3167 | (150,72) | 3146 | (137,68) | -22 | 0.37 | |
| m3 | 360 | (32,79) | 352 | (30,80) | -8 | 0.10 | + | f2 | 3103 | (179,79) | 3086 | (165,76) | -17 | 0.53 | |
| m4 | 311 | (21,52) | 303 | (19,51) | -8 | 0.06 | + | m5 | 2000 | (57,54) | 1998 | (52,53) | -3 | 0.81 | |
| m1 | 297 | (19,82) | 291 | (18,80) | -6 | 0.06 | + | m2 | 2325 | (59,76) | 2323 | (77,74) | -2 | 0.83 | |
| f5 | 286 | (27,46) | 282 | (29,48) | -4 | 0.49 | | f3 | 2889 | (130,50) | 2888 | (123,49) | -1 | 0.98 | |
| f4 | 350 | (31,49) | 347 | (33,49) | -3 | 0.64 | | f4 | 3025 | (65,49) | 3026 | (54,49) | 2 | 0.89 | |
| f2 | 280 | (26,79) | 278 | (25,76) | -2 | 0.65 | | m4 | 2114 | (68,52) | 2132 | (62,51) | 19 | 0.15 | |
| m2 | 251 | (17,76) | 249 | (16,74) | -2 | 0.48 | | m3 | 2086 | (56,79) | 2111 | (57,80) | 25 | 0.01 | * |
| m6 | 253 | (15,48) | 251 | (17,47) | -2 | 0.51 | | f6 | 2982 | (180,50) | 3010 | (168,49) | 28 | 0.42 | |
| m5 | 305 | (17,54) | 304 | (14,53) | -0 | 0.94 | | m1 | 2132 | (82,82) | 2164 | (73,80) | 31 | 0.01 | * |
| f1 | 366 | (58,72) | 378 | (58,68) | 12 | 0.21 | | f5 | 2949 | (187,46) | 3005 | (178,48) | 57 | 0.14 | |

# Results



Confidence regions for /i/ response mean formant vectors from concordant and discordant trials. Bold ellipses show 95% confidence regions for concordant trials, thin ellipses discordant trials. Subjects for whom there were significant bivariate differences between the mean vectors are labeled in bold.

# Results

**H2.** ***Carryover quasi-coarticulation:*** response vowels on discordant trials will be acoustically more like the cue vowel than responses on concordant trials. For example, /ɑ/ responses after /i/ cues will tend to be more like /i/ than /ɑ/ responses after /ɑ/ cues. Such effects are "quasi-coarticulatory" because they pattern like vowel-to-vowel coarticulation, but in this case the first vowel is not articulated.

**-- Not confirmed for most subjects/vowel-formants**

**H2'.** ***Carryover quasi-dissimilation:*** response vowels on discordant trials will be acoustically ***<u>less</u>*** like the cue vowel than responses on concordant trials.

**-- Partly confirmed: observed in 6 subjects**

- Suggests that there exists a mechanism in speech that makes contemporaneously-planned vowel gestures less similar.

# Results

ANOVA of delay and concordance effects on formants

| | | F1 | F2 | |
|---|---|---|---|---|
| /ɑ/ | Delay | F(1,1426) = 0.64, p < .43 | F(1,1426) = 2.07, p < .15 | |
| | Delay x Concordance | F(1,1426) = 0.47, p < .49 | F(1,1426) = 0.01, p < .99 | |
| /i/ | Delay | F(1,1430) = 1.68, p < .20 | F(1,1430) = 5.22, p < .03 | * |
| | Delay x Concordance | F(1,1430) = 0.31, p < .58 | F(1,1430) = 0.01, p < .92 | |

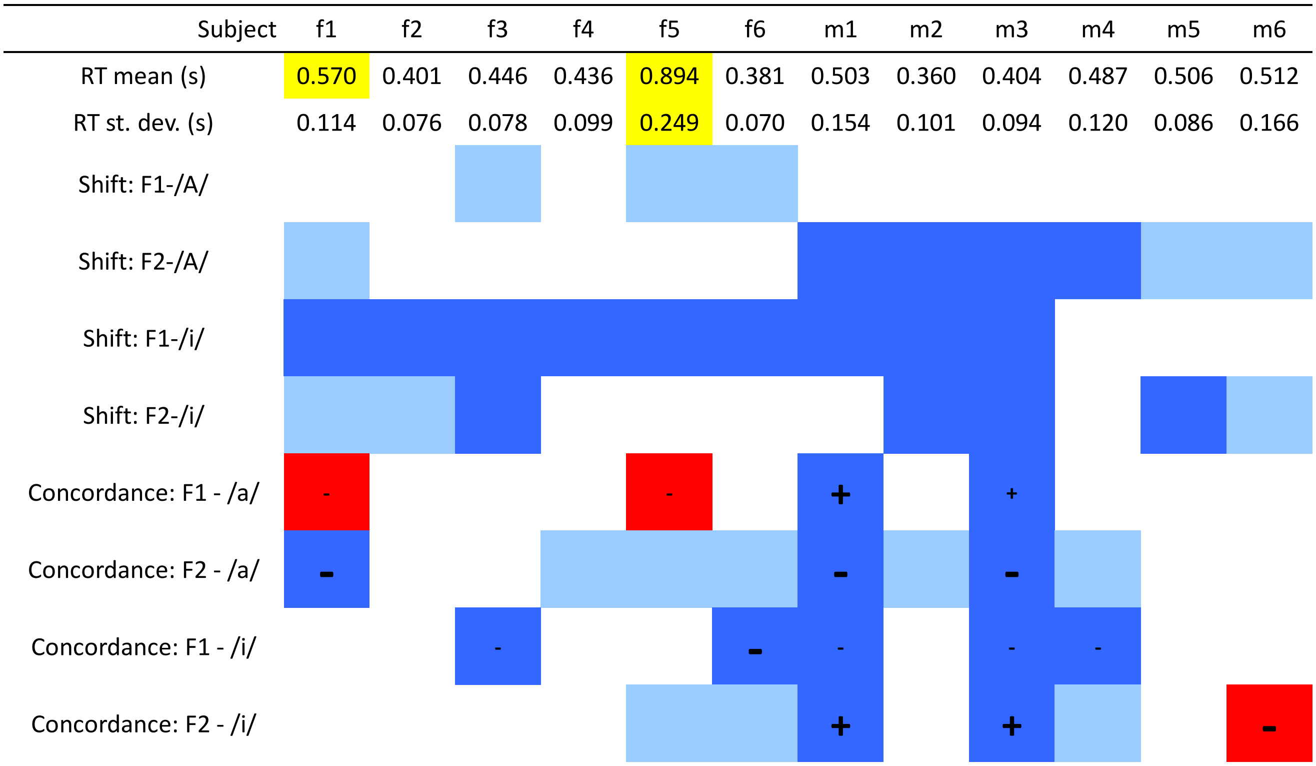
**H3.** ***Temporal decay*****:** carryover quasi-coarticulation (or dissimilation) will be less extensive when there is a longer delay between cue and target stimuli. The effects on F1 and F2 in the 800 ms delay condition will be less extensive compared to the 100 ms delay condition.

**-- Not confirmed**

# Results

- Overview

Response time statistics and experimental effects

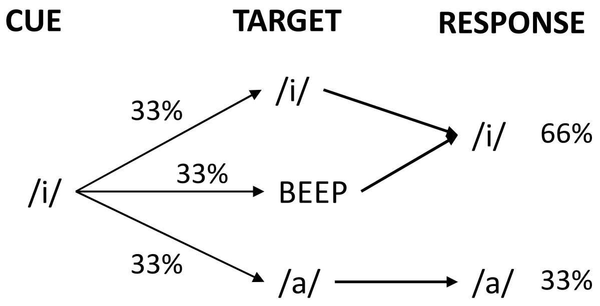


| Subject | f1 | f2 | f3 | f4 | f5 | f6 | m1 | m2 | m3 | m4 | m5 | m6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RT mean (s) | 0.570 | 0.401 | 0.446 | 0.436 | 0.894 | 0.381 | 0.503 | 0.360 | 0.404 | 0.487 | 0.506 | 0.512 |
| RT st. dev. (s) | 0.114 | 0.076 | 0.078 | 0.099 | 0.249 | 0.070 | 0.154 | 0.101 | 0.094 | 0.120 | 0.086 | 0.166 |
| Shift: F1-/A/ | | | ▨ | | ▨ | ▨ | | | | | | |
| Shift: F2-/A/ | ▨ | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | ▨ | ▨ |
| Shift: F1-/i/ | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | |
| Shift: F2-/i/ | ▨ | ▨ | 🟦 | | | | | 🟦 | 🟦 | | 🟦 | ▨ |
| Concordance: F1 - /a/ | 🟥 - | | | | 🟥 - | | 🟦 + | | 🟦 + | | | |
| Concordance: F2 - /a/ | 🟦 - | | | ▨ | ▨ | ▨ | 🟦 - | ▨ | 🟦 - | ▨ | | |
| Concordance: F1 - /i/ | | | 🟦 - | | | 🟦 - | 🟦 - | | 🟦 - | 🟦 - | | |
| Concordance: F2 - /i/ | | | | | ▨ | ▨ | 🟦 + | | 🟦 + | ▨ | | 🟥 - |

+/- : significant raising/lowering of formant (large symbols, p<.05), or marginally-significant (small symbols p<.15). red cells: assimilatory effects; dark blue cells: dissimilation (concordance trials) or centralization (shift trials); light-blue cells: > 10 Hz, non-significant dissimilatory or centralizing effect.

# Analysis

- cue vowel planning
  - o response bias due to asymmetry in experimental design:



o assumptions:

-- subjects attentive and motivated

-- subject expectations approximate the theoretical ones

-- cue and non-cue responses are preplanned to extents that reflect subject expectations

o assumption violations:

-- f5 extremely slow RT and large RT variability

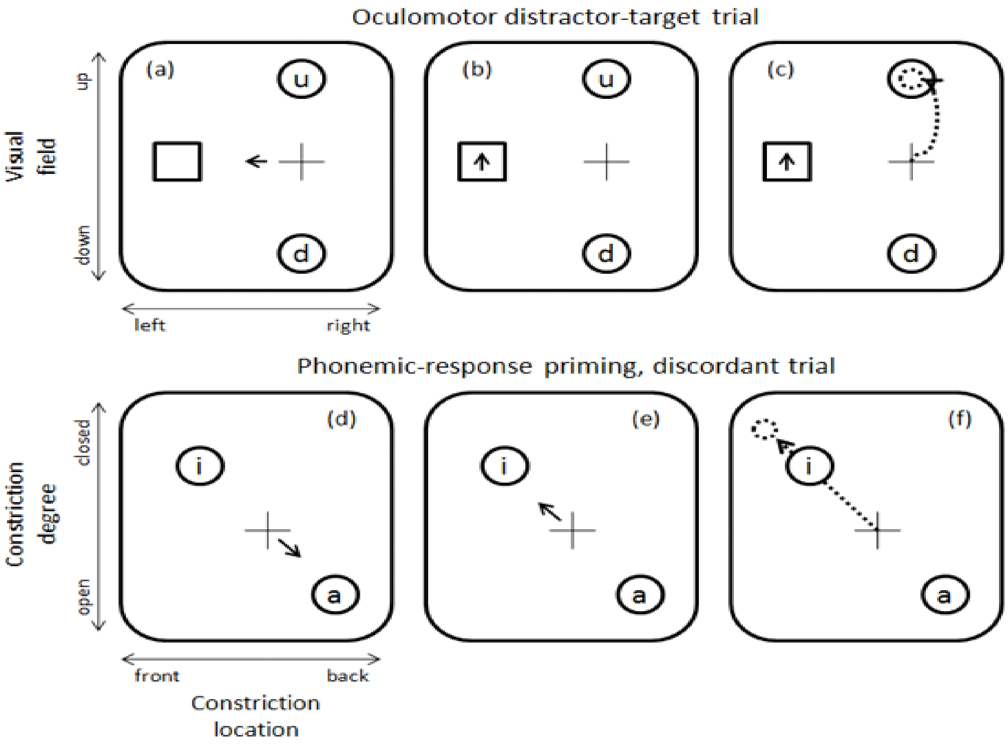
-- m6 anomalously high number of early responses

-- f1 relatively slow RT

o otherwise assumptions appear valid

# Analysis

- Selective inhibition in oculomotor and manual movement planning
  - Saccade trajectory deviations away from distractors (Sheliga et. al. 1994; Walker & Doyle 2001; Van der Stigchel & Theeuwes 2005).
  - Reaching trajectory deviations (Ghez et. al. 1997).
  - Premotor theory of attention (Rizzolatti 1983).



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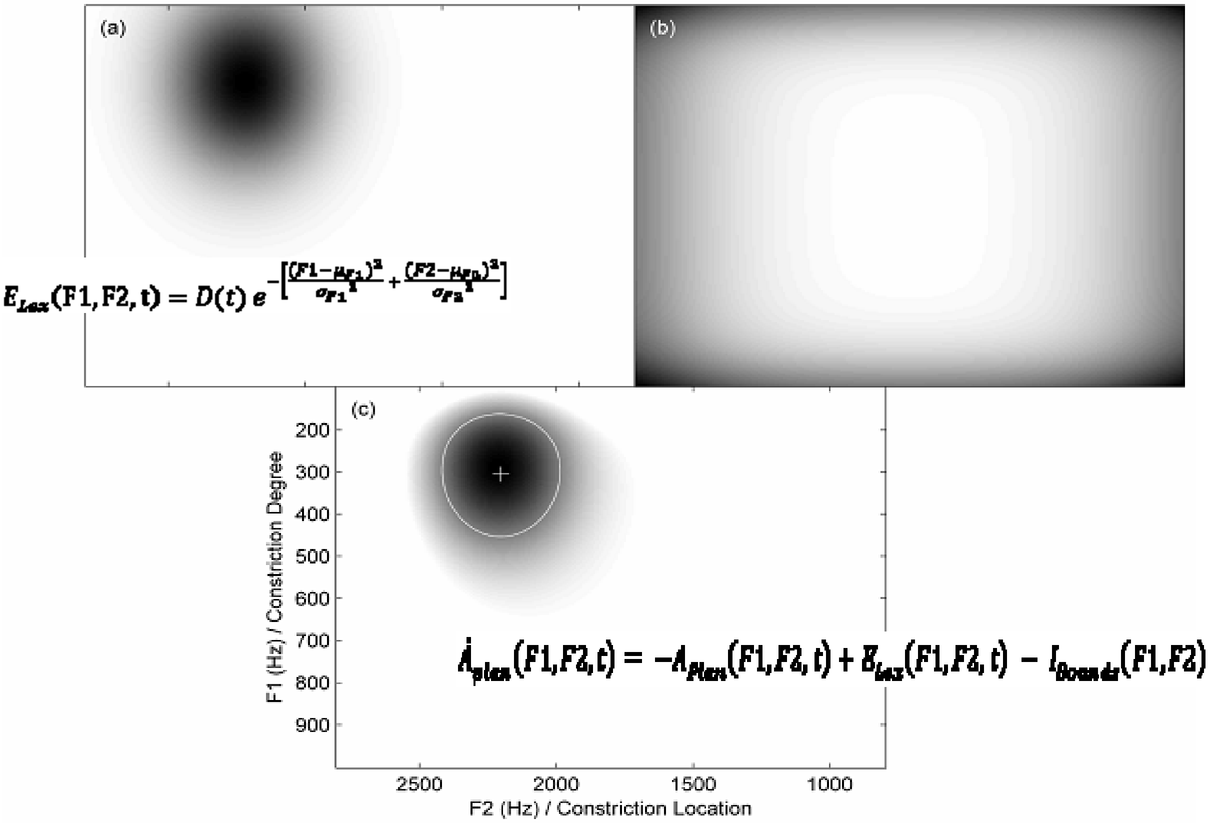
# Analysis

- *Selective inhibition* in oculomotor and manual movement planning
  - Selective inhibition of motor plans associated with saccade or reach to distractor (Houghton & Tipper 1994; Tipper and Houghton 1996; Tipper, Howard, and Houghton 1999): in order to saccade or reach to a target, movement plans for competing targets must be selectively inhibited.
  - more active competing plans require stronger selective inhibition
  - movement targets are encoded by activity in overlapping populations of neurons
  - inhibition of population encoding a competing response can affect the target response population, shifting the target away from the distractor.
- Dynamic field model of movement planning (Erlhagen & Schöner 2002).
- *Intergestural inhibition*: selective inhibition between co-planned gestures.

- Dynamical field model of vowel planning

$$I_{Bounds}(F1,F2) = \sum_{i=1}^{2}\left[\frac{1}{1-e^{\left[\frac{F1-B_{F1i}}{R_{F1i}}\right]}}\right] + \sum_{i=1}^{2}\left[\frac{1}{1+e^{\left[\frac{F2-B_{F2i}}{R_{F2i}}\right]}}\right]$$



$$E_{Lex}(F1,F2,t) = D(t)\, e^{-\left[\frac{(F1-\mu_{F1})^2}{\sigma_{F1}^2}+\frac{(F2-\mu_{F2})^2}{\sigma_{F2}^2}\right]}$$

$$\dot{A}_{Plan}(F1,F2,t) = -A_{Plan}(F1,F2,t) + E_{Lex}(F1,F2,t) - I_{Bounds}(F1,F2)$$

Activation field and components for production of /i/. Lexical excitation (a), boundary-constraint inhibition (b), and integrated planning activity with 50% threshold and vowel target (c) are shown.

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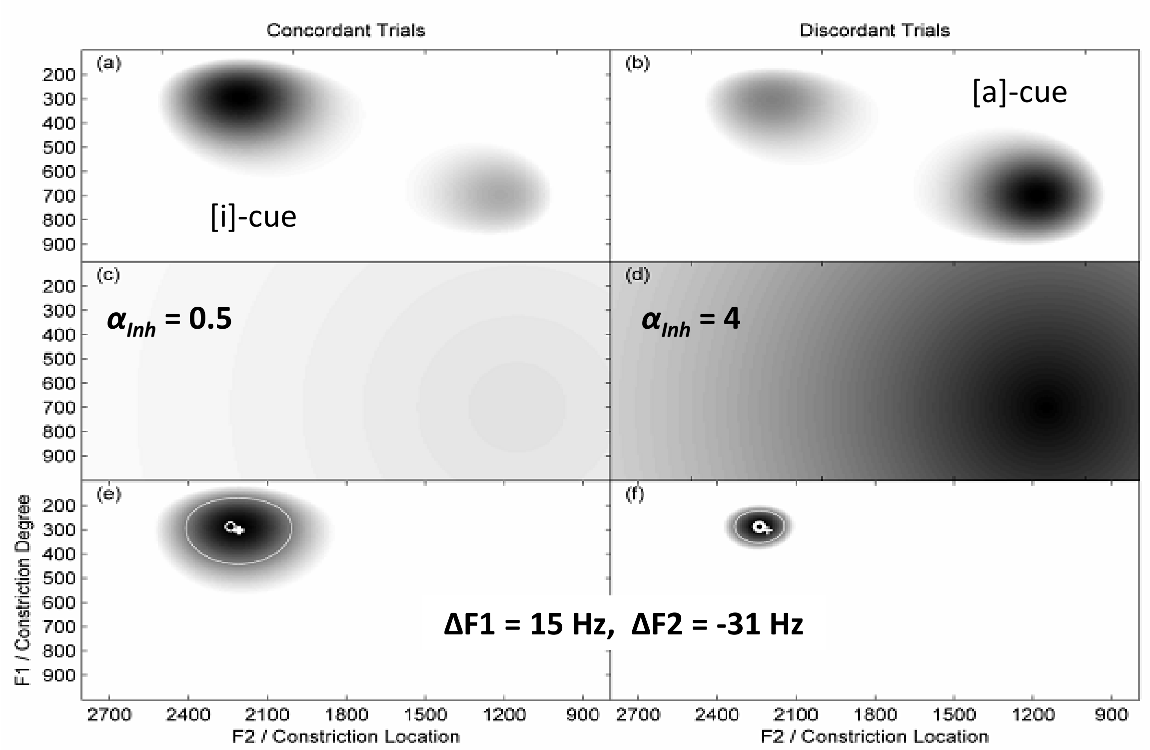
- Dynamical field model of vowel response-planning: [i]-target



[a]-cue

[i]-cue

$\alpha_{Inh}$ = 0.5

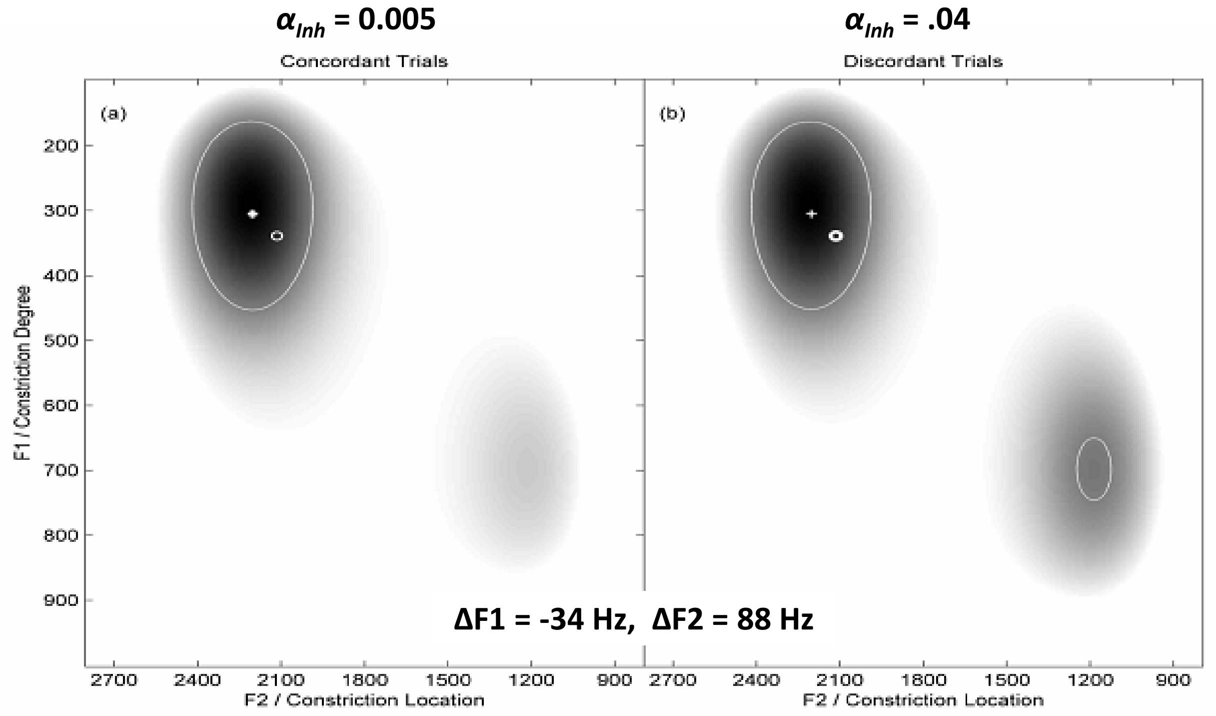
$\alpha_{Inh}$ = 4

ΔF1 = 15 Hz, ΔF2 = -31 Hz

$$I_{Intergestural}(F1,F2,t) = \alpha_{Inh} D(t)\, e^{-\left[\frac{(F1-\mu_{F1,cue})^2}{\sigma_{F1}^2}+\frac{(F2-\mu_{F2,cue})^2}{\sigma_{F2}^2}\right]}$$

Activation fields at different stages of concordant and discordant trials. (a,b) post-cue activation on concordant and discordant trials. (c,d) intergestural inhibition. (e,f) response activation fields. White lines show 50% activation contours used to determine concordant targets (+) and discordant targets (o).

- Dynamical field model of vowel planning



$$I_{intergestural}(F1,F2,t) = \alpha_{Inh} D(t)\, e^{-\left[\frac{(F1-\mu_{F1,prime})^2}{\sigma_{F1}^2} + \frac{(F2-\mu_{F2,prime})^2}{\sigma_{F2}^2}\right]}$$

Response activation fields in concordant and discordant trials with relatively low levels of intergestural inhibition. White lines show 50% activation contours used to determine concordant targets (+) and discordant targets (o)

# Analysis

- Dynamical field model of vowel planning in the vowel response-priming task:
  - balance of intergestural inhibition and target planning activity influences whether dissimilation or assimilation (coarticulation) occurs.
  - subphonemic priming can be modeled with a mapping from perceptual to motor space.
- Applying the model to speech:
  - the mechanism responsible for dissimilatory effects observed in the vowel response-priming task (intergestural inhibition), is also operative in normal speech to some extent—perhaps responsible for deactivating planning of preceding gestures.
  - but, assimilatory effects of physical constraints and gestural overlap between vowels presumably obscure the dissimilatory effects of intergestural inhibition.
  - language/speaker/lexical/gesture/utterance-specific modulation of strength of intergestural inhibition
  - diachrony: V-to-V coarticulation has been proposed to be responsible for the development of vowel harmony (Ohala 1993). intergestural inhibition counteracts this phonologization.

# Conclusion

- maybe intergestural inhibition is operative between all intentional speech gestures *to some extent*.

- intergestural inhibition is a cognitive mechanism that is responsible for the preservation of contrast, or faithfulness to lexical representations.

- some remaining questions:
  - to what extent is intergestural inhibition is learned/innate?
  - to what extent can intergestural inhibition be modulated by gesture-/speaker-/lexical-/language-specific factors?

- FUTURE DIRECTIONS:
  - vowel response-priming design with stimuli: /i/, /e/, /u/
  - Mandarin tone response-priming (with native speakers and tonally-naïve English speakers): high (55), mid-rising (35), falling (51).

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