Order Preference for Reduplicated Words with Differing Vowels

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Have you ever wondered why we say *fiddle-faddle* and not *faddle-fiddle*? Why is it *ping-pong* and *pitter-patter* rather than *pong-ping* and *patter-pitter*? Why *dribs and drabs* rather than vice versa? Why can't a kitchen be *span and spic*? Whence *riff-raff*, *mish-mash*, *flim-flam*, *chit-chat*, *tit for tat*, *knick-knack*, *zig-zag*, *sing-song*, *ding-dong*, *King Kong*, *criss-cross*, *shilly-shally*, *see-saw*, *hee-haw*, *flip-flop*, *hippity-hop*, *tick-tock*, *tic-tac-toe*, *eeny-meeny-miney-moe*, *bric-a-brac*, *clickey-clack*, *hickory-dickory-dock*, *kit and kaboodle,* and *bibbity-bobbity-boo*? The answer is that the vowels for which the tongue is high and in the front always come before the vowels for which the tongue is low and in the back. (Pinker, 1994:167)

1 Introduction

1.1 The phenomenon

Steven Pinker, in his book The Language Instinct, made the above observation concerning a preference, presumably by English speakers, for the order of reduplicated words that contain different vowels. He then revealed the rule that high front vowels *always* come before low back vowels. Any claim that is held to be true in all instances often does not prove to be the case upon further examination, and Pinker's assertion merited closer scrutiny. Additionally, a related question worth investigating is if such a preference only occurs in word pairs that contain high front and low back vowels. Do English speakers have a preferred order for reduplicated words that contain other vowels?

1.2 Theories that explain preference for the order of vowels in reduplicated words

1.2.1 Tsur's Theory Reuven Tsur, in his book What Makes Sound Patterns Expressive (1992), offers a two-part theory as to why front vowels are preferred before back ones in reduplications. The first part of his theory has to do with the formants of vowels. He explains:

> Vowels consist of specific combinations of overtones, called formants. A formant is a concentration of acoustic energy within a restricted frequency region. . . Three or four formants are usually seen in spectrograms of speech. (Tsur, 1992: 9)

He goes on to explain that the frequency of the first and second formants of back vowels are much closer together than in front vowels. This results in the back vowels being more cognitively demanding than the front vowels to process due to the fact that the human ear effectively fuses formants that are close together. This makes it more difficult to discriminate between them.

The second part of Tsur's theory is based on the idea that, "Our cognitive economy tends to relegate to the end of the phrase (or clause) anything that requires

relatively great processing effort (Tsur, 1992:25)." Tying these two ideas together, Tsur proposes that back vowels are more difficult to process due to the close proximity of their first two formants, which results in our preference for placing words with back vowels last in reduplicated phrases. This two-part theory would explain Pinker's claim that high front vowels are preferred before low back vowels.

1.2.2 Pinker's Theory

After making the claim that high front vowels are always preferred before low back vowels, Pinker goes on to offer a multi-part theory as to why this possibly occurs. He explains:

> Words that connote me-here-now tend to have higher and fronter vowels than verbs *(sic)* that connote distance from 'me' . . . Words that connote me-here-now tend to come before words that connote literal or metaphorical distance form 'me' . . .The syllogism seems to be: 'me' = high front vowel; me first; therefore high front vowel first (Pinker, 1994: 167).

Pinker's theory does not specify any specific front vowels. The concept of "me" is a central part of this theory, and the vowel in this word is [i] (or in some forms of English [ij]). It should be safe to assume that the vowel in "me", which is the most high of the front vowels, is at least one of the high front vowels that this theory discusses.

1.3 The questions

This study was designed to look more closely at some of the aspects of this claim concerning the order of reduplicated words. The main focus is an attempt to limit the deciding factors to one rather than the original two of height and backness. The questions investigated are:

(1) If semantic value is removed from these reduplicated words, will speakers still prefer high front vowels before low back vowels?
(2) If the backness variable is held the same, do English speakers have a preference for the order of vowels of different heights in reduplicated word pairs?
(3) Is height or backness more important in preference for the order of vowels in reduplicated pairs of words?

2 Methodology

2.1 The data collection test

Subjects were given a test containing 56 pairs of one-syllable nonsense words. The paired words were the same except for the vowel. The subjects were read the words first in one order and then the other. The subjects were then asked to circle the pair that sounded "better" to them. The test paired 14 different combinations of vowels four different times. The vowels compared were:

a) front vowels [i, ɪ, ɛ, æ] to each other (twenty-four words)
b) back vowels [u, ʊ, ɔ, ɑ] to each other (twenty-four words)
c) high front [i] and low back [ɑ] (four words)
d) high back [u] and low front [æ] (four words)

For the pairs containing the same two vowels, twice the high vowel came first and twice the low. A coin was flipped to determine if the high vowel or the low vowel came first for the first two or three pairs. The remaining pair or pairs was ordered so that exactly two of the four pairs were high vowels before low and two were vice versa. Next, the order in which all 56 pairs of words occurred in the test was determined by a computer-generated list of random numbers. The actual words used in this test can be found in the appendix.

The vowels chosen for this test were four English monophthong front vowels and four monophthong back vowels. In an attempt to avoid the variable of monophthong versus diphthong, the vowels that are generally diphthongs in American English were not included. It should be noted, though, that two vowels originally classified as monophthong for this study, [i] and [u], are considered by many phoneticians to also be diphthongs in American English. The diphthongs are [ij] and [uw] respectively.

2.2 The test subjects

The test subjects were 25 native English speakers between the ages of 25 and 75. Sixteen of the subjects were between the ages of 25 and 35. None of the subjects had acquired a second language during childhood although most of them had studied at least one other language later in life. Twelve of the subjects had spent the majority of their lives in the Philadelphia area. One subject was from North Carolina. The remaining subjects currently live in the Washington D.C. area, but most of them have not spent the majority of their lives there.

3 Results

Tables (1) – (3) list a summary of the test results. The vowel pairs are listed in decreasing order of the subjects' preferences. Individual test subjects' responses to each pair of nonsense words can be found in the appendix.

Table 1
Front Vowels: Subjects' preference for word order in reduplications

Preference	Order
69%	[ɪ] [ɛ]
68%	[ɪ] [æ]
62%	[ɪ] [i]
58%	[i] [æ]
53%	[i] [ɛ]
53%	[æ] [ɛ]

Table 2
Back Vowels: Subjects' preference for word order in reduplications

Preference	Order
63%	[ɑ] [ɔ]
60%	[ʊ] [u]
54%	[ɔ] [ʊ]
53%	[ɔ] [u]
53%	[ɑ] [ʊ]
50%	[ɑ] [u] / [u] [ɑ]

Table 3
Front and Back Vowels: Subjects' preference for word order in reduplications

Preference	Order
64%	[u] [æ]
55%	[i] [ɑ]

4 Discussion

4.1 Comparisons of front vowels

Test subjects showed a preference for high [ɪ] before mid [ɛ] 69% of the time and [ɪ] before low [æ] 68% of the time. There were no other significant comparisons, although in most cases the trend was for the higher vowel to be preferred before the lower. Interestingly, the only exception was in the comparison of the two high front vowels. In this case, the trend was to prefer the lower [ɪ] before the higher [i].

4.2 Comparisons of back vowels

The test subjects did not show a really strong preference in any of these categories. There was a trend in many of the comparisons, though, to prefer the lower vowel before the higher. This is the reverse of the trend noticed in the front vowels.

4.3 Comparisons of front and back vowels

The subjects in this study did not adhere to Pinker's claim that high front vowels always come before low back vowels. When [i], the highest front vowel in English, was paired with the lowest back vowel [ɑ], subjects did not show a significant preference for their order.

A possible reason for why these results do not support Pinker's claim could be related to which high front vowel was used in this study. The study used [i] as it is the highest front vowel. The slightly lower front vowel [ɪ] happens to be the front vowel present in twenty-six of the twenty-nine reduplicated word phrases listed by Pinker. Only three contain [i]. It is possible that the phenomenon that Pinker is describing does not hold true for all high front vowels, but only for the specific high front vowel [ɪ].

In the other test comparison of front and back vowels, 64% of the time the test subjects had a significant preference for the order of the high back vowel [ʊ] before the low front vowel [æ]. If height and backness are the only factors that determine a preference, in this case it seems to be more important to be a high vowel than to be a front one. This may provide some insight into question (3), which seeks to determine which variable has more of an influence on preference.

4.4 Tsur's and Pinker's theories in light of these data

Tsur's theory is not supported by the results of the study. Test subjects showed a significant preference for placing the words with the back vowel [ʊ] before words with the front vowel [æ]. Additionally, if this were the only reason for a preference to occur, it would not explain why subjects in this study preferred the front vowel [ɪ] before both of the front vowels [ɛ] and [æ]. As only front vowels were involved in these comparisons, none was more cognitively demanding than the other due to closeness of their formants. This theory would predict that there would not be any preference in these cases.

Pinker's theory was also not supported by the results of this study as [i] was not significantly preferred before the back vowel [ɑ]. Additionally, as with Tsur's theory, Pinker's explanation does not give any insight into why a significant preference was found when the front vowel [ɪ] was compared with the front vowels [ɛ] and [æ].

5 Conclusion

The results of this study provide some insight into the initially proposed questions. It was hoped that the comparison of the highest front vowel [i] with the lowest back vowel [ɑ] would provide some insight into question (1) concerning the effect of semantic value on order preference. Pinker's claim predicted that there would be an order preference when these two vowels occurred in a reduplication. No significant preference was shown by the test subjects in regard to these two vowels. In retrospect, though, this cannot be attributed to the use of nonsense words in the study as no preference was shown for this vowel pair in actual English reduplications. In Pinker's examples, the only two that contained [i] (*see-saw* and *hee-haw*) preferred it before the vowel [ɔ]. The majority of the reduplicated word pairs listed by Pinker contained the vowels [ɪ] and [æ] or [ɪ] and [ɑ]. The vowels [ɪ] and [ɑ] were not paired in this study, but the two front vowels [ɪ] and [æ] were. In this latter case, subjects preferred [ɪ] before [æ] 68% of the time. This would suggest that the semantic value of these reduplicated words is not the reason fo the preference when these two vowels occurred in a reduplication.

In response to question (2), subjects had a preference for the high front vowel [ɪ] before both the mid front vowel [ɛ] and the low front vowel [æ]. No other significant preferences were found between other front vowels, and none were found between any of the back vowels. When the backness variable is held constant, the test subjects had a preference for the order of a few, but not all, of the vowels of different heights.

The pairing of the vowels [u] and [æ] in the study may provide some information concerning question (3) that asks if height or backness is more important for order preference. In reduplicated words containing high, back [u] and not high, front [æ], subjects preferred the high, back [u] before the front [æ] 64% of the time. This suggests that when front and back vowels are paired, the height of the vowels may be more instrumental than backness in determining a preference for their order in reduplications.

The study results in addition to the examples listed by Pinker suggest that English speakers prefer the vowel [ɪ] before the vowels [ɛ], [æ], and [ɑ] in reduplicated words. Pinker's claim, though, predicts that there should also be a preference for the higher front vowel [i] to come first in such word pairs. This was not seen in the results of the study. As diphthongs were not included in this study, [i] was the only traditional long vowel that was examined. Additionally, if [i] is reclassified as the diphthong [ij] as some phoneticians feel that it should be for American English, this would mean that this vowel was longer than most of the others examined. It is possible that this preference phenomenon only occurs when short vowels are compared.

Neither of the two theories of vowel order preference discussed lends any insight into why English speakers would have a preference for the high front vowel [ɪ] before the non-high front vowels [ɛ] and [æ], and the low back vowel [ɑ]; and have a preference for the high back vowel [ʊ] before the low front vowel [æ]; but not have a preference for the highest front vowel [i] before the low back vowel [ɑ] or before any of the front vowels. For the most part, this study only compared monophthong front vowels to each other and monophthong back vowels to each other. Possibly a study that pairs all of the front and back vowels, including the diphthongs, would provide important pieces to the puzzle and would lead to a claim that could predict all cases where an English speaker vowel order preference would occur. This claim could then in turn be used to evaluate the validity of theories that propose to explain why such a phenomenon would occur.

This study has demonstrated that Pinker's claim that high front vowels are always preferred before low back vowels is not correct. It further suggests that semantic value is not the determining factor for vowel order preference, that height may be a more significant factor than backness, and that a preference seems to exist when various front vowels are compared.

References

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Ladefoged, Peter. 1993. *A Course in Phonetics*. Fort Worth, TX: Harcourt Brace College Publishers.
Pinker, Steven. 1994. *The Language Instinct*. New York: HarperPerennial.
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Appendix: Study Data

Figures 1 – 14 follow this page and contain the data from the study. The nonsense words used in the test are listed along with where those pairs occurred in the test. The responses of all twenty-five subjects to each of the word pairs are recorded. Subjects are identified both by number and by their initials.

Fig. 1	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGHEST FRONT [i] - LOW BACK [ɑ]																											
# 10 peeg pog	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	0	0	0	1	1	0	0	0	1	0	15	60%
pog peeg	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	1	0	0	1	1	1	0	1	10	40%
# 33 fleem flom	1	0	1	1	1	1	0	1	1	1	0	0	0	1	1	0	1	1	1	0	0	0	1	0	1	15	60%
flom fleem	0	1	0	0	0	0	1	0	0	0	1	1	1	0	0	1	0	0	0	1	1	1	0	1	0	10	40%
# 42 deez doz	1	1	1	0	1	0	1	1	1	1	0	1	0	1	1	0	0	0	1	0	0	0	1	0	0	13	52%
doz deez	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	1	1	0	1	1	1	0	1	1	12	48%
# 44 sweef swof	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	12	48%
swof sweef	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	0	1	13	52%

	AVERAGE	P-VALUE
[i] - [ɑ]	55%	0.76959
[ɑ] - [i]	45%	

Fig. 2	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
LOW FRONT [æ] - HIGH BACK [u]																											
# 13 tav tuve	0	0	0	1	0	1	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	8	32%
tuve tav	1	1	1	0	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	1	1	0	1	1	0	17	68%
# 28 fap fupe	0	1	0	0	0	1	1	1	0	0	0	1	1	1	1	1	0	1	0	0	0	1	1	0	0	12	48%
fupe fap	1	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	1	0	1	1	1	0	0	1	1	13	52%
#37 jat jute	1	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	8	32%
jute jat	0	1	1	1	1	1	0	0	0	1	1	1	0	1	1	1	0	1	0	0	1	1	1	1	1	17	68%
# 43 baf bufe	1	0	0	0	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	8	32%
bufe baf	0	1	1	1	1	1	0	0	0	1	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	17	68%

	AVERAGE	P-VALUE
[æ] - [u]	36%	0.00563
[u] - [æ]	64%	

Fig. 3	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGHEST FRONT [i] - HIGH FRONT [I]																											
# 6 feem fim	0	1	1	1	0	0	0	0	0	0	1	1	0	1	1	0	0	1	0	0	0	0	0	0	1	9	36%
fim feem	1	0	0	0	1	1	1	1	1	1	0	0	1	0	0	1	1	0	1	1	1	1	1	1	0	16	64%
# 9 reen rin	0	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	1	10	40%
rin reen	1	0	0	1	0	0	0	1	1	1	0	1	1	1	1	1	1	0	0	1	1	0	1	1	0	15	60%
# 30 geep gip	1	0	1	0	1	1	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	1	0	1	0	10	40%
gip geep	0	1	0	1	0	0	1	1	0	1	0	1	1	0	1	0	1	1	1	1	1	0	1	0	1	15	60%
# 55 zeed zid	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	1	1	0	9	36%
zid zeed	1	1	0	1	0	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	0	0	1	16	64%

	AVERAGE	P-VALUE
[i] - [I]	38%	0.10499
[I] - [i]	62%	

Fig. 4	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGHEST FRONT [i] - MID FRONT [ɛ]																											
# 2 steeb steb	1	1	1	0	1	0	1	1	1	1	0	0	1	0	1	1	0	1	1	0	0	1	0	1	0	15	60%
steb steeb	0	0	0	1	0	1	0	0	0	0	1	1	0	1	0	0	1	0	0	1	1	0	1	0	1	10	40%
# 3 pleem plem	1	1	1	0	1	1	0	1	0	1	0	0	1	1	1	1	0	0	1	0	0	1	0	0	1	14	56%
plem pleem	0	0	0	1	0	0	1	0	1	0	1	1	0	0	0	0	1	1	0	1	1	0	1	1	0	11	44%
# 21 teeg teg	0	0	1	1	1	0	0	1	0	1	0	0	0	1	0	1	0	1	1	0	0	1	1	0	1	12	48%
teg teeg	1	1	0	0	0	1	1	0	1	0	1	1	1	0	1	0	1	0	0	1	1	0	0	1	0	13	52%
# 41 jeek jek	0	1	1	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	12	48%
jek jeek	1	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	13	52%

	AVERAGE	P-VALUE
[i] - [ɛ]	53%	0.90105
[ɛ] - [i]	47%	

Fig. 5	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGHEST FRONT[i]-LOW FRONT [æ]																											
# 4 skeef skaf	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0	12	48%
skaf skeef	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	1	1	1	1	1	1	0	1	1	1	13	52%
# 14 kleeg klag	1	1	1	0	1	1	0	1	0	0	1	0	0	0	1	1	1	1	1	1	1	0	1	0	0	15	60%
klag kleeg	0	0	0	1	0	0	1	0	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	1	1	10	40%
# 20 weeb wab	1	1	1	0	1	1	1	1	1	0	1	0	0	0	1	1	1	1	1	0	0	1	1	0	1	17	68%
wab weeb	0	0	0	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	1	1	0	0	1	0	8	32%
# 29 treeb trab	1	1	1	1	1	0	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0	1	0	1	0	14	56%
trab treeb	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	1	1	1	1	0	1	0	1	11	44%

	AVERAGE	P-VALUE
[i] - [æ]	58%	0.23588
[æ] - [i]	42%	

Fig. 6	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15 MS)	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGH FRONT [I] - MID FRONT [ɛ]																											
# 8 yig yeg	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1	0	0	1	19	76%
yeg yig	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	1	0	6	24%
# 22 wim wem	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	14	56%
wem wim	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	11	44%
# 49 mif mef	1	0	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	0	1	19	76%
mef mif	0	1	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	6	24%
# 50 plik plek	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	1	0	17	68%
plek plik	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	8	32%

	AVERAGE	P-VALUE
[I] - [ɛ]	69%	0.0000058
[ɛ] - [I]	31%	

Fig. 7	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGH FRONT [I] - LOW FRONT [æ]																											
# 5 zish zash	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	13	54%
zash zish	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	11	46%
# 19 gich gach	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	0	1	1	0	1	0	1	1	1	1	19	76%
gach gich	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	1	0	1	0	0	0	0	6	24%
# 34 jid jad	1	0	1	1	1	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	1	0	0	14	56%
jad jid	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	0	0	1	1	11	44%
# 52 brip brap	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	1	0	1	1	1	1	1	21	84%
brap brip	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	4	16%

	AVERAGE	P-VALUE
[I] - [æ]	68%	0.000000938
[æ] - [I]	32%	

Fig. 8	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
MID FRONT [ɛ] - LOW FRONT [æ]																											
# 12 cheb chab	0	0	1	1	1	1	1	1	0	0	1	0	0	1	0	1	0	1	0	0	0	1	0	0	0	11	44%
chab cheb	1	1	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	1	1	1	0	1	1	1	14	56%
# 17 zel zal	0	0	0	0	1	1	1	1	0	1	0	0	1	1	0	0	0	1	0	0	0	1	1	0	1	11	44%
zal zel	1	1	1	1	0	0	0	0	1	0	1	1	0	0	1	1	1	0	1	1	1	0	0	1	0	14	56%
# 35 prev prav	1	1	1	1	1	0	0	0	1	0	1	0	0	1	1	1	1	0	0	0	0	0	1	0	0	12	48%
prav prev	0	0	0	0	0	1	1	1	0	1	0	1	1	0	0	0	0	1	1	1	1	1	0	1	1	13	52%
# 36 tef taf	1	0	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	13	52%
taf tef	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	12	48%

	AVERAGE	P-VALUE
[ɛ] - [æ]	47%	0.98008
[æ] - [ɛ]	53%	

Fig. 9	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGHEST BACK [u] - HIGH BACK [U]																											
# 16 muke mook	0	1	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	8	32%
mook muke	1	0	0	0	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	0	1	0	17	68%
# 27 zune zoon	0	0	1	1	1	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	1	1	1	0	10	40%
zoon zune	1	1	0	0	0	1	1	1	1	1	0	1	1	0	1	0	0	1	1	1	1	0	0	0	1	15	60%
# 32 rupe roop	0	1	1	1	0	0	0	0	1	1	1	1	0	1	1	0	0	0	1	0	0	0	1	0	0	11	44%
roop rupe	1	0	0	0	1	1	1	1	0	0	0	0	1	0	0	1	1	1	0	1	1	1	0	1	1	14	56%
# 54 fube foob	1	1	0	0	1	1	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	1	1	0	11	44%
foob fube	0	0	1	1	0	0	1	0	0	1	0	1	1	1	0	0	1	1	1	1	1	1	0	0	1	14	56%

	AVERAGE	P-VALUE
[u] - [U]	40%	0.19468
[U] - [u]	60%	

Fig. 10	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGHEST BACK [u] - MID BACK [ɔ]																											
# 15 strupe strawp	1	0	1	1	0	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	9	36%
strawp strupe	0	1	0	0	1	0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	16	64%
# 25 hube hawb	1	1	0	1	1	0	0	1	1	1	1	1	1	1	0	1	0	0	0	1	0	0	1	0	0	14	56%
hawb hube	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	1	1	1	0	1	1	0	1	1	11	44%
# 26 chufe chawf	1	0	0	1	1	0	0	1	0	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	9	36%
chawf chufe	0	1	1	0	0	1	1	0	1	1	1	0	0	0	0	1	1	1	1	0	1	1	1	1	1	16	64%
# 47 glune glawn	1	1	1	1	0	1	0	0	0	1	1	0	1	1	0	0	0	1	1	0	0	1	1	1	1	15	60%
glawn glune	0	0	0	0	1	0	1	1	1	0	0	1	0	0	1	1	1	0	0	1	1	0	0	0	0	10	40%

	AVERAGE	P-VALUE
[u] - [ɔ]	47%	0.15951
[ɔ] - [u]	53%	

Fig. 11	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGHEST BACK [u] - LOW BACK [ɑ]																											
# 11 shufe shof	1	0	1	1	1	1	0	1	0	0	1	0	1	1	0	0	0	0	0	1	0	1	0	0	1	12	48%
shof shufe	0	1	0	0	0	0	1	0	1	1	0	1	0	0	1	1	1	1	1	0	1	0	1	1	0	13	52%
# 40 zute zot	1	0	1	1	1	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	10	40%
zot zute	0	1	0	0	0	1	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	15	60%
# 53 duve dov	0	0	1	1	1	1	0	0	1	1	0	0	1	1	1	0	0	1	0	0	1	1	1	1	0	14	56%
dov duve	1	1	0	0	0	0	1	1	0	0	1	1	0	0	0	1	1	0	1	1	0	0	0	0	1	11	44%
# 56 puze poz	1	0	1	1	1	1	0	0	1	1	0	0	0	1	0	0	0	1	0	1	0	1	1	1	1	14	56%
poz puze	0	1	0	0	0	0	1	1	0	0	1	1	1	0	1	1	1	0	1	0	1	0	0	0	0	11	44%

	AVERAGE	P-VALUE
[u] - [ɑ]	50%	0.84013
[ɑ] - [u]	50%	

Fig. 12	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGH BACK [U] - MID BACK [ɔ]																											
# 1 shoog shawg	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	7	28%
shawg shoog	1	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	18	72%
# 7 ploot plawt	1	1	0	0	0	1	0	0	1	1	1	0	0	1	0	0	0	1	1	0	0	1	0	0	0	10	40%
plawt ploot	0	0	1	1	1	0	1	1	0	0	0	1	1	0	1	1	1	0	0	1	1	0	1	1	1	15	60%
# 48 chood chawd	1	0	1	0	1	1	0	0	0	1	1	1	1	0	1	1	1	0	0	0	0	1	1	1	0	14	56%
chawd chood	0	1	0	1	0	0	1	1	1	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	1	11	44%
# 51 drook drawk	1	1	1	0	0	1	0	0	1	1	1	1	0	1	1	0	0	1	0	1	0	1	1	0	1	15	60%
drawk drook	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	10	40%

	AVERAGE	P-VALUE
[U] - [ɔ]	46%	0.04249
[ɔ] - [U]	54%	

Fig. 13	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
HIGH BACK [U] - LOW BACK [ɑ]																											
# 23 frooz froz	1	0	1	1	0	1	1	0	1	1	1	0	0	0	0	1	0	1	0	0	0	1	1	0	0	12	48%
froz frooz	0	1	0	0	1	0	0	1	0	0	0	1	1	1	1	0	1	0	1	1	1	0	0	1	1	13	52%
# 24 yood yod	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	9	36%
yod yood	1	0	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	16	64%
# 38 bloog blog	1	1	1	1	1	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	1	1	0	12	48%
blog bloog	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1	0	0	1	13	52%
# 45 woop wop	1	1	1	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	1	0	1	0	14	56%
wop woop	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	1	1	1	1	0	1	0	1	11	44%

	AVERAGE	P-VALUE
[U] - [ɑ]	47%	0.69353
[ɑ] - [U]	53%	

Fig. 14	1) TD	2) EL	3) EB	4) KT	5) LA	6) DIP	7) RS	8) DS	9) ES	10) LL	11) CHS	12) LH	13) KW	14) CLS	15) MS	16) EDS	17) BS	18) SM	19) ROS	20) RM	21) KM	22) DPJ	23) JW	24) MC	25) DP	TOTAL	AVERAGE
MID BACK [ɔ] - LOW BACK [ɑ]																											
# 18 mawf mof	0	0	1	0	1	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	6	24%
mof mawf	1	1	0	1	0	0	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1	19	76%
# 31 brawb brob	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	0	1	0	0	1	9	36%
brob brawb	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	0	1	1	0	16	64%
# 39 zawsh zosh	0	0	1	0	1	1	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0	0	1	1	11	44%
zosh zawsh	1	1	0	1	0	0	1	1	0	0	0	1	1	1	0	1	0	1	0	1	1	1	1	0	0	14	56%
# 46 fawk fok	0	0	1	1	1	1	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	1	1	1	11	44%
fok fawk	1	1	0	0	0	0	1	1	0	0	1	1	1	0	1	0	1	1	1	1	1	1	0	0	0	14	56%

	AVERAGE	P-VALUE
[ɔ] - [ɑ]	37%	0.00735
[ɑ] - [ɔ]	63%	