Recall for segmentation

Ansgar Endress

Contents

1 House keeping

In the analyses below, we use the following parameters:

Name	Value
ANALYZED.DATA.SETS	TRUE
ANALYZED.DATA.SETS	TRUE
FILTER.SINGLE.SYLLABLES	FALSE
FILTER.UNATTESTED.ITEMS	FALSE
PRINT.INDIVIDUAL.PDFS	TRUE
REMOVE.BAD.SUBJ	TRUE
REMOVE.INCOMPLETE.SUBJ	FALSE
RESEGMENT.RESPONSES	FALSE

Table 2: Languages used in the recall experiment.

L1	L2
pabiku	bikuti
tibudo	pigola
daropi	tudaro
golatu	budopa

2 Methods

2.1 Materials

We resynthesized the languages used in @Saffran-Science Experiment 2. The four words in each language are given in Table 2. Stimuli were synthesized using the us3 (male American English) voice of the mbrola @mbrola synthesizer, at with a constant F0 of 120 at a rate of 216 ms per syllable (108 ms per phoneme).

During familiarization, words were presented 45 times each. For each participant, we generated a random concatenation of 45 repetitions of the 4 words, with the constraint that a words could not occur in immediate reptition. Each randomization was then (i) synthesized into a continuous speech stream using mbrola and then converted to mp3 using ffmpeg (https://ffmpeg.org/) (ii) used to concatenate words that had been synthesized in isolation, separated by silences of 222 ms into a segmented speech stream, which was then converted to mp3. Streams were faded in and out for 5 s using sox (http://sox.sourceforge.net/). For continuous streams, this yielded a stream duration of 1 min 57 s; for segmented streams, the duration was 2 min 37.

2.2 Procedure

2.2.1 Familiarization

Participants were informed that they would be listening to an unknown language and that they should try to learn the words from that language. Following, the familiarization stream was presented twice, leading to a total familiarization duration of 3 min 53 for the continuous streams and 5 min 13 for the segmented streams. They could proceed to the next presentation of the stream by pressing a button.

For the online experiments, participants watched video with no clear objects during the familiarization (panning of the Carina nebula, obtained from https://esahubble.org/videos/heic0707g/). The video was combined with the speech stream using the the muxmovie utility.

Following the familiarization, the was a 30 s retention interval. Participants were instructed to count backwards from 99 in time with a metronome beat at 3s / beat. Performance was not monitored.

(Note to self: This was the case for both psyscope and testable.)

2.2.2 Recall test

Following the retention interval, participants completed the recall test. During the lab-based experiments, participants had 45 s to repeat back the words they remembered; their vocalizations were recorded using ffmpeg and saved in mp3 format. During the web-based experiments, participants had 60 s to type their answer into a comment field, during which they viewed a progress bar.

Table 3: Descriptives for the recognition test

data.set	mySegmentationCond	lang	N	M	SE	p.wilcox
all						
city	continuous	L1	11	0.386	0.074	0.168
city	continuous	L2	11	0.500	0.094	1.000
city	segmented	L1	11	0.932	0.051	0.003
city	segmented	L2	11	0.909	0.040	0.003
tstbl	continuous	L1	11	0.477	0.114	0.903
tstbl	continuous	L2	10	0.650	0.098	0.145
tstbl	segmented	L1	13	0.846	0.063	0.003
tstbl	segmented	L2	14	0.875	0.065	0.002
>= 50%						
city	continuous	L1	7	0.536	0.039	1.000
city	continuous	L2	7	0.679	0.077	0.089
city	segmented	L1	8	0.938	0.067	0.011
city	segmented	L2	7	0.893	0.055	0.019
tstbl	continuous	L1	9	0.583	0.108	0.429
tstbl	continuous	L2	10	0.650	0.098	0.145
tstbl	segmented	L1	13	0.846	0.063	0.003
tstbl	segmented	L2	14	0.875	0.065	0.002

2.2.3 Recognition test

Following the recall test, participant completed a recognition test during which we pitted words against part-words. The (correct) test words for Language 1 (and part-words for Language 2) were /pAbiku/ and /tibudO/; the (correct) test words for Language 2 (and part-words for Language 1) were /tudArO/ and /pigOlA/.These items were combined into 4 test pairs

3 Analysis

3.1 Recognition test

3.2 Recall test for the lab-based experiment

The substitution rules employed in the current experiment are shown in Table 4.

3.2.1 Substitution rules compensating for potential misperceptions

- O might be perceived as A (but probably not vice versa)
- Voiced and unvoiced consonants can be confused:
  - g and k
  - d and t
  - b and p
- b might be perceived as v

In some cases, these rules give you several possible matches. For example, in line 64, rapidala might be rOpidAlA or rOpidOlA

In such case, we apply the following criteria to decide which match to choose (in this order).

Table 4: Substitution rules

pattern	replacement
Before segmentation	
-	
2	tu
two	tu
([aeou])ck	\1k
ar([,\s+])	a\1
ar$	a
tyu	tu
ph	f
th	t
qu	k
ea	i
ou	u
aw	a
ai	a
i e	i
ee	i
oo	u
e	i
c	k
w	v
y	i
h	
After segmentation	
u	o
v	b
p	b
b	p
t	d
d	t
k	g
g	k
a	o

1. If one option provides more or longer existing chunks, choose it. For example, rOpidAlA has the chunk rOpi (pidA isn't possible in the stream), while rOpidOlA contains rOpi, so in this case the rule doesn't discrminate between the two :)
2. If one option requires fewer changes with respect to the original transcription, choose that.

I would apply the rules in this order, but I can see why you might want to use the opposite order as well.

3.2.2 Identify closest matches (for testable)

Each recall response was analyzed in five steps. First, we applied pre-segmentation substitution rules to make the transcriptions more consistent (see Table 4). For example, *ea* (presumably as in *tea*) was replaced with *i*.

Second, responses were segmented into their underlying units. If a response contained a semicolon (;) or comma character (,), these were used to delineate units. For each of the resulting units, we verified if they contained additional spaces. If they did, these spaces were removed if further subdividing resulted in any

single-syllable response (operationalized as a string with a single vowel); otherwise, the units were further sub-divided based on the spaces. The rationale for this algorithm is that responses such as *bee coo tee,two da ra,bout too pa* were like to reflect the words *bikuti*, *tudaro* and *budopa*.

Finally, if the response did not contain any commata or semicolons, it was segmented based on its spaces (if any).

Third, we removed geminate consonants and applied another set of substitution rules that to take into account possible misperceptions (see 4)). For example, we treated the voiced and unvoiced variety of stop consonants as interchangeable. Specifically, for each "surface" form produced by the participants, we generated candidate "underlying" forms by recursively applying all substitutions rules and keeping track of the number of substitution rules that were applied to derive an underlying form from a surface form. For each unique candidate underlying form, we kept the shortest derivation.

Fourth, for each candidate underlying form, we identified the longest matching string in the familiarization stream. The algorithm first verified if a form was contained in a speech stream starting with an *A*, *B* or *C* syllable; if the underlying form contained unattested syllable, one syllable change was allowed with respect to the speech streams. If no matches were found, two substrings were created by clipping the first or the last syllable from the underlying form, and the search was repeated recursively for each of these substrings until a match was found. We then selected the longest match for all substrings.

Fifth, for each surface form, we selected the underlying form using the criteria (in this order) that, among the candidate underlying form of each surface form, the selected underlying form had (i) had the maximal number of attested syllables, (ii) the maximal length, and (iii) the shortest derivation.

3.3 Change columns to categorize transcriptions

We then computed various properties for each underlying form, given the "target" language the participant had been exposed to. Specifically, we calculated: (1) the number of syllables, (2) whether it was a word from the target language, (3) whether it was a concatentation of words from the target language, (4) whether it was a single word or a concatenation of words from the target language (i.e., the disjunction of (2) and (3)), (5) whether it was a part-words from the target language, (6) whether it was a *complete* concatenation of part-words from the target language (i.e., the number of syllables of the item had to be a multiple of three, without any unattested syllables), (7) whether it was a single part-word or a concatenation of part-words from the target language, (8) whether it was a "class-word" with the two initial syllables coming from one word and the final syllables from another word or vice versa (i.e., class-words had the form *A_iB_iC_j* or *A_iB_jC_j*, (9) whether it was high-TP chunk (i.e., a word or a word with the first or the last syllable missing, after removing any leading or trailing unattested syllables), (10) whether it was a low-TP chunk (i.e., a chunk of the form *C_iA_j*, after removing lead or trailing unattested syllables, (11) whether it had a "correct" initial syllable, (12) whether it had a "correct" final syllable, (13) whether it is part of the speech stream (i.e., the disjunction of being an attested syllable, being a word or a concatenation thereof, being a part-word or a concatenation thereof, being a high-TP chunk or a low-TP chunk), (14) whether it was a backward word from the target language (i.e., a word with the syllable order reversed), (15) whether it was a concatenation of backward words, (16) whether it was a backward word or a concatenation thereof (i.e., the disjunction of (14) and (15)), (17) whether it was a backward part-word, (18) whether it was a concatenation of backward part-words, (19) whether it was a backward word or a concatenation thereof (i.e., the disjunction of (17) and (18)), (19) whether it was high-*backward*-TP chunk (i.e., a backward word or a backward word with the first or the last syllable missing, after removing any leading or trailing unattested syllables), (20) whether it was a low-*backward*-TP chunk (i.e., a chunk of the form *A_iC_j*, after removing lead or trailing unattested syllables, (21) the average forward TP of the transitions in the form, (22) the *expected* forward TP of the form if form is attested in the speech stream (see below for the calculation), and (23) the average backward TP of the transitions in the form.

3.3.1 Expected TPs

For items that are *correctly* reproduced from the speech stream, the expected TPs depend on the starting position. For example, the expected TPs for items of at least 2 syllables starting on an initial syllable are c(1, 1, 1/3, 1, 1, 1/3, 1, 1, 1/3, ...); if the item starts on a word-medial syllable, these TPs are c(1, 1/3, 1, 1, 1/3, 1, 1, 1/3, 1, ...).

In contrast, the expected TPs for a random concatenation of syllables are the TPs in a random bigram. For an A or a B syllable, the random TP is 1×1 / 12, as there is only 1 (out of 12) non-zero TP continuations. For a C syllable, the random TP is $3 \times 1/3$ / 12, as there are 3 possible concatenations. On average, the random TP is thus $(1/12 + 1/12 + 1/12)/3 = 1/12 \approx .083$.

Table 5: Number of unattested items

data.set	streamType	N.total.M	N.total.min	N.total.max	N.unattested.M	N.unattested.min	N.unattested.max
city	continuous	4.21	1	9	2.50	0	5
city	segmented	4.21	2	13	1.86	0	10
testable	continuous	3.77	1	8	1.53	0	4
testable	segmented	3.52	1	10	1.48	0	5

As shown in Table 5, there was a considerable number of recall responses containing unattested syllables. The complete list of unattested items is in `segmentation_recall_unattested.xlsx`. Unattested items are items that are not word, part-words (or concatenations thereof), high- or low-TP chunks, or a single syllable. However, it is unclear if these unattested syllables reflect misperceptions not caught by our substitution rules, typos, memory failures or creative responses. This makes it difficult to analyze these responses. For example, the TPs from and to an unattested syllable are zero. However, if the unattested syllable reflects a misperception or a typo, the true TP would be positive, and our estimates would underestimate the participant's statistical learning ability.

We thus decided to restrict ourselves to responses that can be clearly interpreted and removed all items containing unattested syllables. Here, `FILTER.UNATTESTED.ITEMS` was set to FALSE, while `FILTER.SINGLE.SYLLABLES` was set to FALSE.

We also decided to remove single syllable responses, as it is not clear if participants volunteered such responses because they thought that individual syllables reflected the underlying units in the speech streams or because they misunderstood what they were ask to do.

3.4 Demographics and missing subjects

The final demographic information is given in Table 6.

3.5 Save categorized data

3.6 Measures for productions in the recall phase

We will use the following measures to analyze the participants' productions in the recall phase. Some analyses below rely on within-participant averages [A], within-participant sums [S] or other measures [O].

- General measures
  - [S] Number of items produced. To be compared across segmentation conditions, and against zero.
  - [A] Average length of items produced. To be compared across segmentation conditions.
  - [S,A] Number and proportion (among productions) of words (and concatenations thereof)
  - [S,A] Number and proportion (among productions) of part-words (and concatenations thereof)

Table 6: Demographics of the final sample. Note that the City participants completed both segmentation conditions.

data.set	streamType	lang	N	Females	Males	Age.m	Age.range
city							
city	continuous	both	14	14	0	17.9	0-22
city	segmented	both	14	14	0	17.9	0-22
tstbl							
tstbl	continuous	L1	8	2	6	37.8	22-71
tstbl	continuous	L2	9	4	5	32.9	18-56
tstbl	segmented	L1	11	3	8	25.7	18-38
tstbl	segmented	L2	14	4	10	39.0	20-62

  - [O] Performance in the two alternative forced-choice test. To be compared across segmentation conditions.
- TP-based analyses (raw TPs)
  - [A] Average forward TP in items
    - Compare across segmentation conditions
    - Compare to expected TPs for a random string. The expected TPs for a random concatenation are the TPs in a random bigram. For an A or a B syllable, the random TP is $1 \times 1 / 12$, as there is only 1 (out of 12) non-zero TP continuations. For a C syllable, the random TP is $3 \times 1/3 / 12$, as there are 3 possible concatenations. On average, the random TP is thus $(1/12 + 1/12 + 1/12)/3 = 1/12 \approx .083$.
    - Calculate difference *expected* TPs for correctly reproduced items, given the item's initial position. The expected TPs for items of at least 2 syllables starting on an initial syllable are c(1, 1/3, 1, 1, 1/3, 1, 1, 1/3, ...). The difference between the actual and the expected TP needs to be compared to zero, as the expected TP differs across items.
  - [A] Average backward TP in items
- TP-based analyses (chunks). In addition to th raw TPs above, we also counted high- and low-TP *chunks*. As mentioned above, high-TP chunks are words or words with the first or the last syllable missing, after removing any leading or trailing unattested syllables, while low-TP chunks are chunks of the form C_iA_j, after removing lead or trailing unattested syllables.
  - [S,A] Number and proportion of high TP-chunks.
  - [S,A] Number and proportion of low TP-chunks.
  - [0] Proportion of high-TP chunks among high and low-TP chunks.
- Positional analyses
  - [A] Proportion of items with syllables in correct postions
    a. Items with correct initial syllables. Chance level: 4/12
    b. Items with correct final syllables. Chance level: 4/12
    c. Disjunction of *a* and *b*. Chance level: $2 \times 4/12 - 4/12 \times 4/12 = 5/9$

4 Results

In the analyses below, we removed all items that contained syllables not attested in the speech stream as it is unclear how these items should be analyzed. As a result, we also removed participants who did not produce any items that contained attested syllables only.

4.1 Make overall averages

Table 7: Analyses performed for the vocalizations

colName	meaning
n.items	Number of recalled items
n.syll	Mean number of syllables of the recalled items
n.words	Number of recalled words
p.words	Proportion (among recalled items) of words
n.words.or.multiple	Number of recalled words or concatenation of words
p.words.or.multiple	Proportion (among recalled items) of words or concatenation of words
n.part.words	Number of recalled part-words
p.part.words	Proportion (among recalled items) of part-words
n.part.words.or.multiple	Number of recalled part-words or concatenation of part-words
p.part.words.or.multiple	Proportion (among recalled items) of part-words or concatenation of part-words
p.words.part.words	Proportion of words among (recalled) words and part-words. This is used for comparison to the recognition test.
p.words.part.words.or.multiple	Proportion of words among (recalled) words and part-words or concatenation thereof. This is used for comparison to the recognition test.
n.high.tp.chunk	Number of high TP chunks. High TP chunks are defined as two-syllabic chunk from a word
p.high.tp.chunk	Proprtion (among recalled items) of high TP chunks. High TP chunks are defined as two-syllabic chunk from a word
n.low.tp.chunk	Number of low TP chunks. Low TP chunks are defined as two-syllabic word transitions
p.low.tp.chunk	Proportion (among recalled items) of low TP chunks. Low TP chunks are defined as two-syllabic word transitions
p.high.tp.chunk.low.tp.chunk	Proportion of high-TP chunks among high and low-TP chunks. High TP Chunks are defined as two-syllabic chunks from words; low TP chunks are two-syllabic word transitions
average_fw_tp	Average (across recalled items) of average forward TPs among transitions in a given item.
average_fw_tp_d_actual_expected	Average (across recalled items) of the difference between the average ACTUAL forward TPs among transitions in a given item and the EXPECTED forward TP in that item, based on the items first element. See calculate.expected.tps.for.chunks for the calculations
average_bw_tp	Average (across recalled items) of average backward TPs among transitions in a given item.
p.correct.initial.syll	Proportion (among recalled items) that have a correct initial syllable.
p.correct.final.syll	Proportion (among recalled items) that have a correct final syllable.
p.correct.initial.or.final.syll	Proportion (among recalled items) that have a correct initial or final syllable.

After computing these counts and averages, we asked which counts were significantly different from zero in a one-tailed Wilcoxon test, either for the continuous or the segmented condition. These counts were n.items, n.syll, n.words, n.words.or.multiple, n.high.tp.chunk, n.low.tp.chunk. (Note: These counts are currently restricted to the testable data set.)

As shown in Table 8, participants produced on average 1, 2, 1, 0, 1, 4, 2, 0, 1, 2, 2, 3, 2, 3, 2, 0, 4, 1, 1, 0, 2, 1, 0, 0, 2, 3, 1, 0, 0, 0, 3, 1, 2, 0, 1, 1, 1, 4, 1 words in the segmented condition, and 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 in the continuous condition.

Table 8: All averages. The *p* value has been calculated from a paired Wilcoxon test across the familiarization conditions.

	city.segmented	city.continuous	city.$p_{Wilcoxon}$	testable.segmented	testable.continuous	testable.$p_{Wilcoxon}$
data.set	city	city	city	testable	testable	testable
streamType	segmented	continuous	$p_{Wilcoxon}$	segmented	continuous	$p_{Wilcoxon}$
correct_segm	0.910714	0.607143	0.000288	0.880000	0.661765	0.005308
n.items	4.214	4.214	0.888	3.520	3.765	0.656
n.syll	2.80000	3.53006	0.01440	2.66267	2.16232	0.00569
n.words	1.71e+00	2.14e-01	2.62e-04	1.24e+00	0.00e+00	2.89e-05
p.words	4.85e-01	3.12e-02	1.72e-04	4.07e-01	0.00e+00	3.14e-05
n.words.or.multiple	1.71e+00	2.86e-01	5.08e-04	1.24e+00	0.00e+00	2.89e-05
p.words.or.multiple	4.85e-01	4.90e-02	3.87e-04	4.07e-01	0.00e+00	3.14e-05
n.part.words	0.0000	0.3571	0.0376	0.0000	0.0000	NA
p.part.words	0.0000	0.0704	0.0379	0.0000	0.0000	NA
n.part.words.or.multiple	0.00000	0.64286	0.00774	0.00000	0.05882	0.24435
p.part.words.or.multiple	0.00000	0.12698	0.00788	0.00000	0.01961	0.24435
p.words.part.words	1.00000	0.41667	0.00241	1.00000	NA	NA
p.words.part.words.or.multiple	1.000000	0.321429	0.000264	1.000000	0.000000	NA
n.high.tp.chunk	2.14286	0.71429	0.00578	1.48000	0.64706	0.02490
p.high.tp.chunk	0.56053	0.09702	0.00089	0.44400	0.16737	0.00695
n.low.tp.chunk	0.00000	0.07143	0.35311	0.00000	0.41176	0.00167
p.low.tp.chunk	0.00000	0.00893	0.35311	0.00000	0.11821	0.00170
p.high.tp.chunk.low.tp.chunk	1.000000	0.750000	0.112351	1.000000	0.530303	0.000487
average_fw_tp	0.6344	0.3008	0.0135	0.5845	0.3358	0.0353
average_fw_tp_d_actual_expected	-0.328	-0.515	0.136	-0.367	-0.442	0.376
average_bw_tp	0.6344	0.3008	0.0135	0.5845	0.3358	0.0353
p.correct.initial.syll	0.78855	0.31845	0.00191	0.73333	0.38761	0.00151
p.correct.final.syll	0.7599	0.4595	0.0589	0.7427	0.5238	0.0540
p.correct.initial.or.final.syll	0.9083	0.5139	0.0115	0.9047	0.7104	0.0210

4.2 General measures

We first calculate the number of items produced as well their average, and compare them against the zero as well as across segmentation conditions. As shown in Table 4.5 and Figure 1, participants produced positive number of items. Neither the number of items produced nor their number of syllables differed across the segmentation conditions.

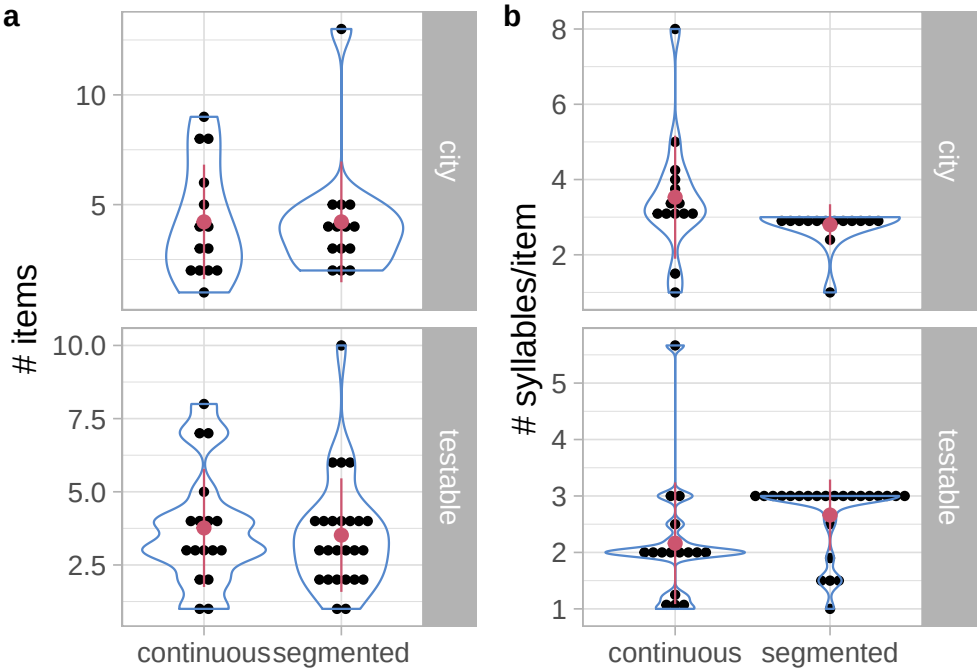

Figure 1: Number of items produced as well as their numbers of syllables.

4.3 Word vs. part-word analysis

We next calculate the number and proportion of among (productions) of words and part-words respectively; we also accept concatenations of words and part-words. The proportions will be compared across stream types as well as to zero.

Finally, we calculate the proportion of words among the word and part-word productions. This proportion will be compared across segmentation types, as well as to the chance level of 50%.

As shown in Table 4.5 and in Figure 2, participants produced a positive number of words only in the segmented condition, but not in the continuous condition. In contrast, they produced a positive number of part-words only in the continuous condition, but not in the segmented condition. Accordingly, the proportion of words among words and part-words was significantly greater than 50% in the segmented condition, but numerically (though not significantly) smaller than 50% in the continuous condition. The latter result is consistent with participants randomly picking a syllable to start their vocalizations; if so, part-words should be 2 times as likely as words.

4.4 TP-based analyses

We first computed the average forward TPs in the produced items, and separately for each segmentation condition, compared it to both the expected TPs for random strings and the expected TPs given the starting syllable.

- The expected TPs for items of at least 2 syllables starting on an initial syllable are c(1, 1/3, 1, 1, 1/3, 1, 1, 1/3, ...). The difference between the actual and the expected TP needs to be compared to zero, as the expected TP differs across items.
- The expected TPs for a random concatenation are the TPs in a random bigram. For an A or a B syllable, the random TP is 1 × 1 / 12, as there is only 1 (out of 12) non-zero TP continuations. For a

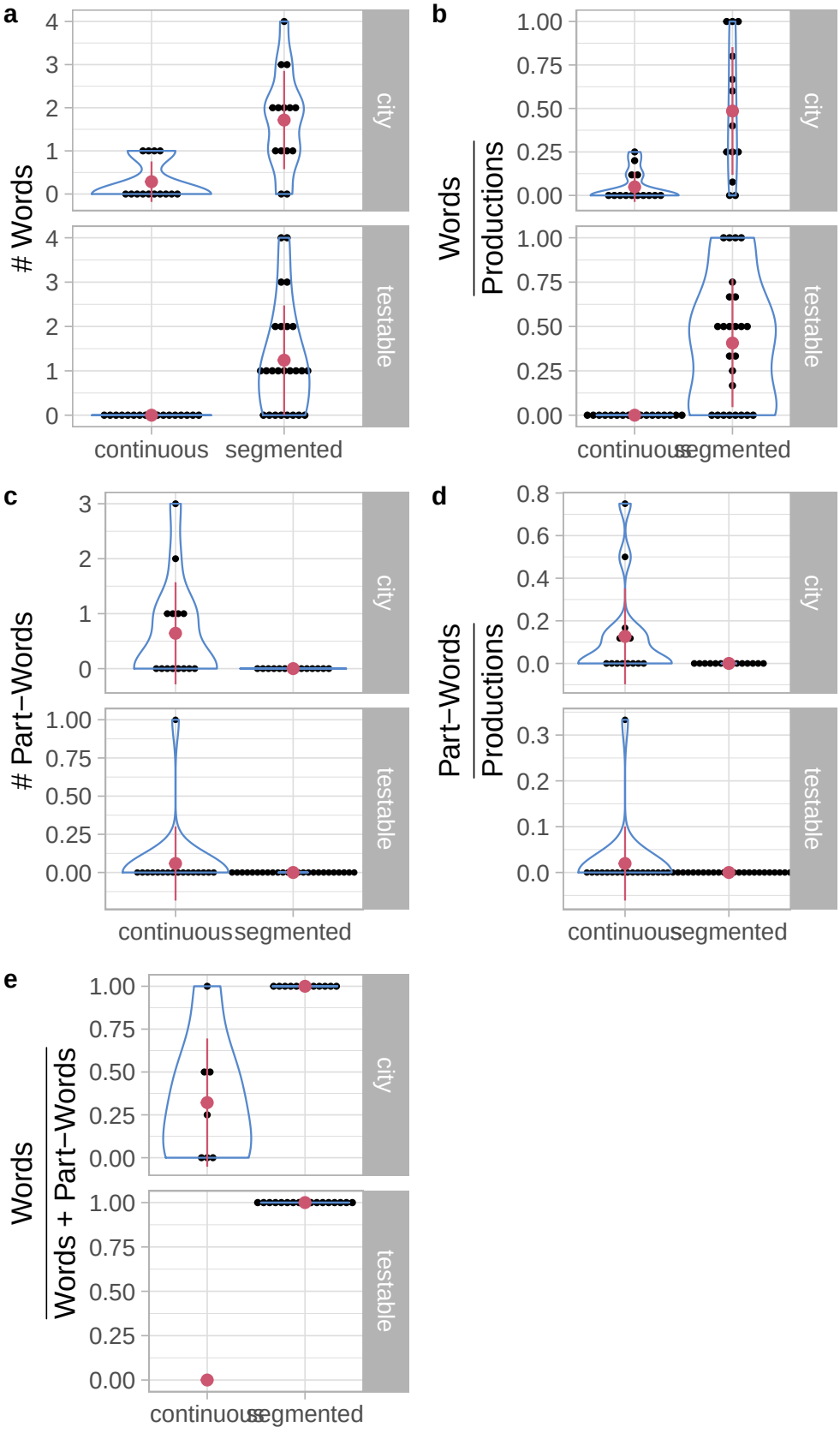

Figure 2: Plot of various comparisons between words and part-words.

C syllable, the random TP is $3 \times 1/3$ / 12, as there are 3 possible concatenations. On average, the random TP is thus $(1/12 + 1/12 + 1/12)/3 = 1/12 \approx .083$.

We compared these measures across segmentation conditions.

As shown in Table 4.5 and Figure 3, forward and backward TPs were significantly greater than expected for a random string in both the continuous and the segmented condition, with greater TPs in the segmented conditions. However, they were significantly *lower* than the TPs expected if items recalled faithfully, given their starting position.

As shown in Figure 4, participants produced a positive number of high-TP chunks in both the segmented and the continuous condition, with a significantly greater number in the segmented condition. In contrast, they produced a positive number of low-TP chunks only in the continuous condition. Accordingly, the proportion of high-TP chunks among high- and low-TP chunks exceeded 50% only in the segmented condition.

4.5 Positional analyses

Finally, we analyze the productions in terms of correct initial final positions. As there are four initial and final positions, respectively, 4/12 of the productions should have "correct" initial positions, 4/12 should have correct final positions, while $2 \times 4/12 - (4/12)^2 = 5/9$ should have either correct initial or final positions.

As shown in Table 4.5 and Figure 5, participants produced items with correct initial or final positions at great than chance level only in the segmented condition, but not the continuous condition.

\begin{table}

\caption{Various analyses pertaining to the productions as well as test against their chances levels. Number of items produced, their numbers of syllables, number of words, number of part-words (chance level: 0), proportion of words among productions, proportion of part-words among productions, proportion of words among words and part-words (chance level 50%), average forward TPs (chance level: 1/12), difference between positionally expected and actual TPs, average backward TPS. CHUNKS }

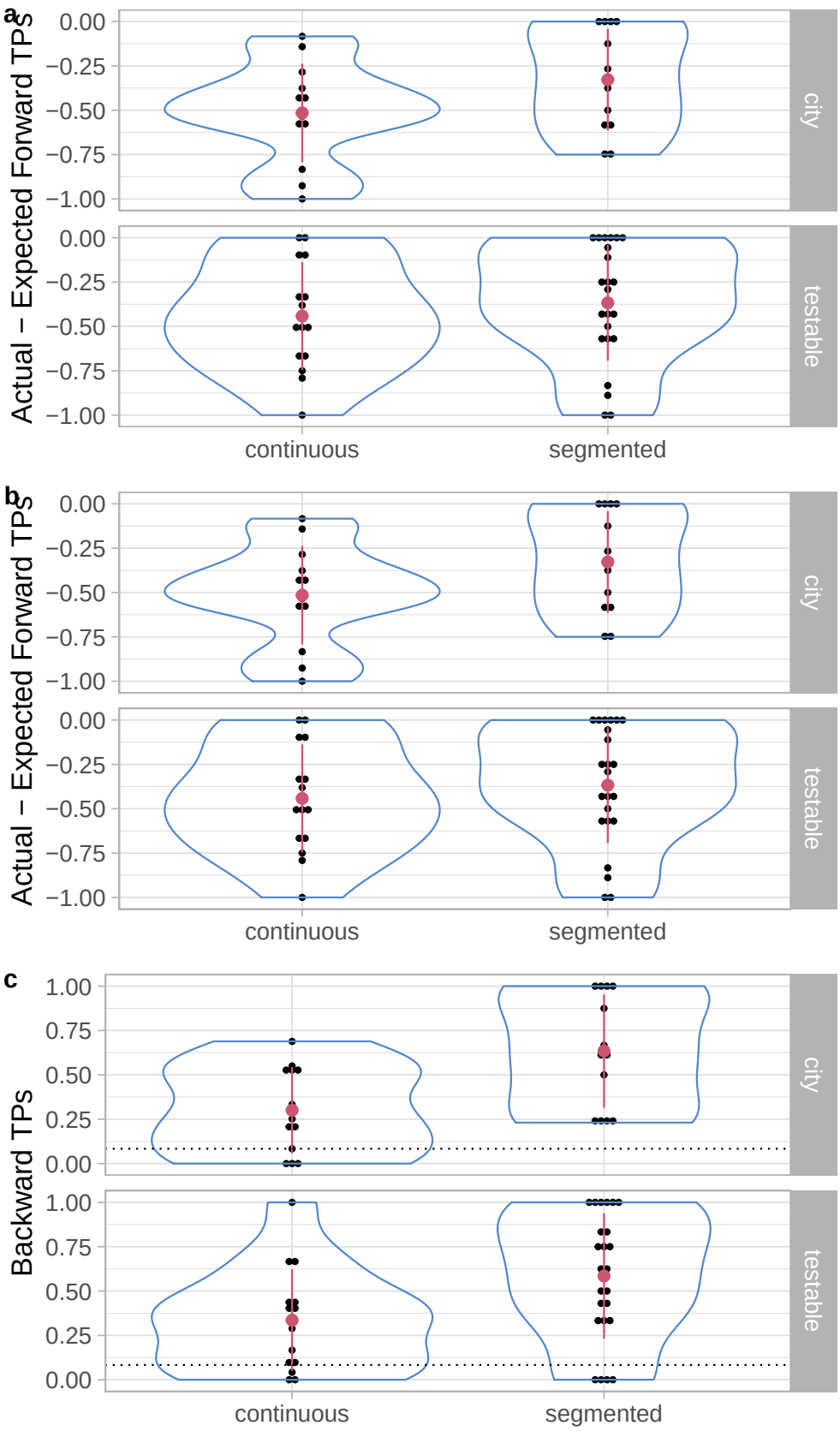

Figure 3: Plot of TP comparisons.

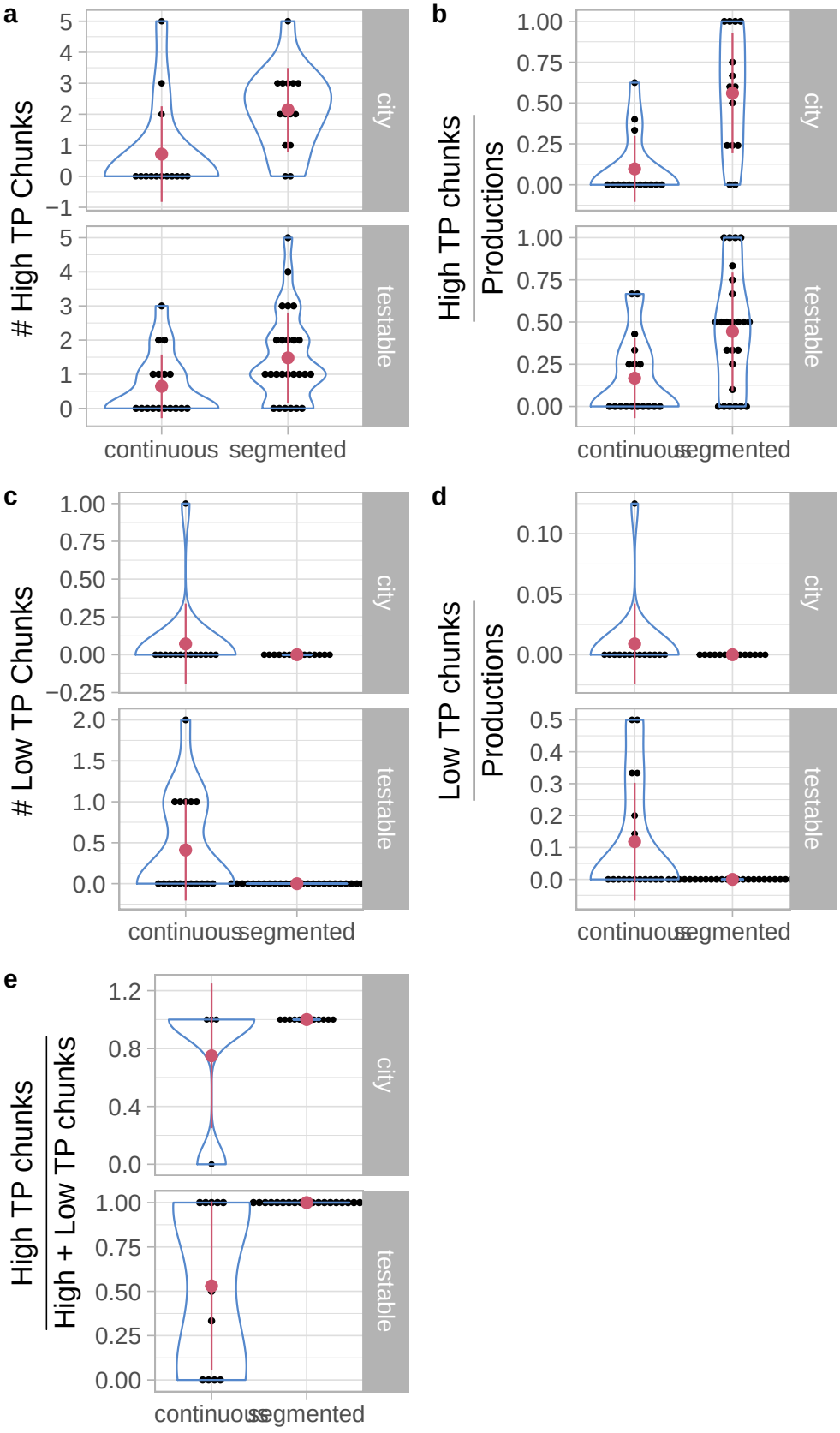

Figure 4: Plot of High and Low TP chunks.

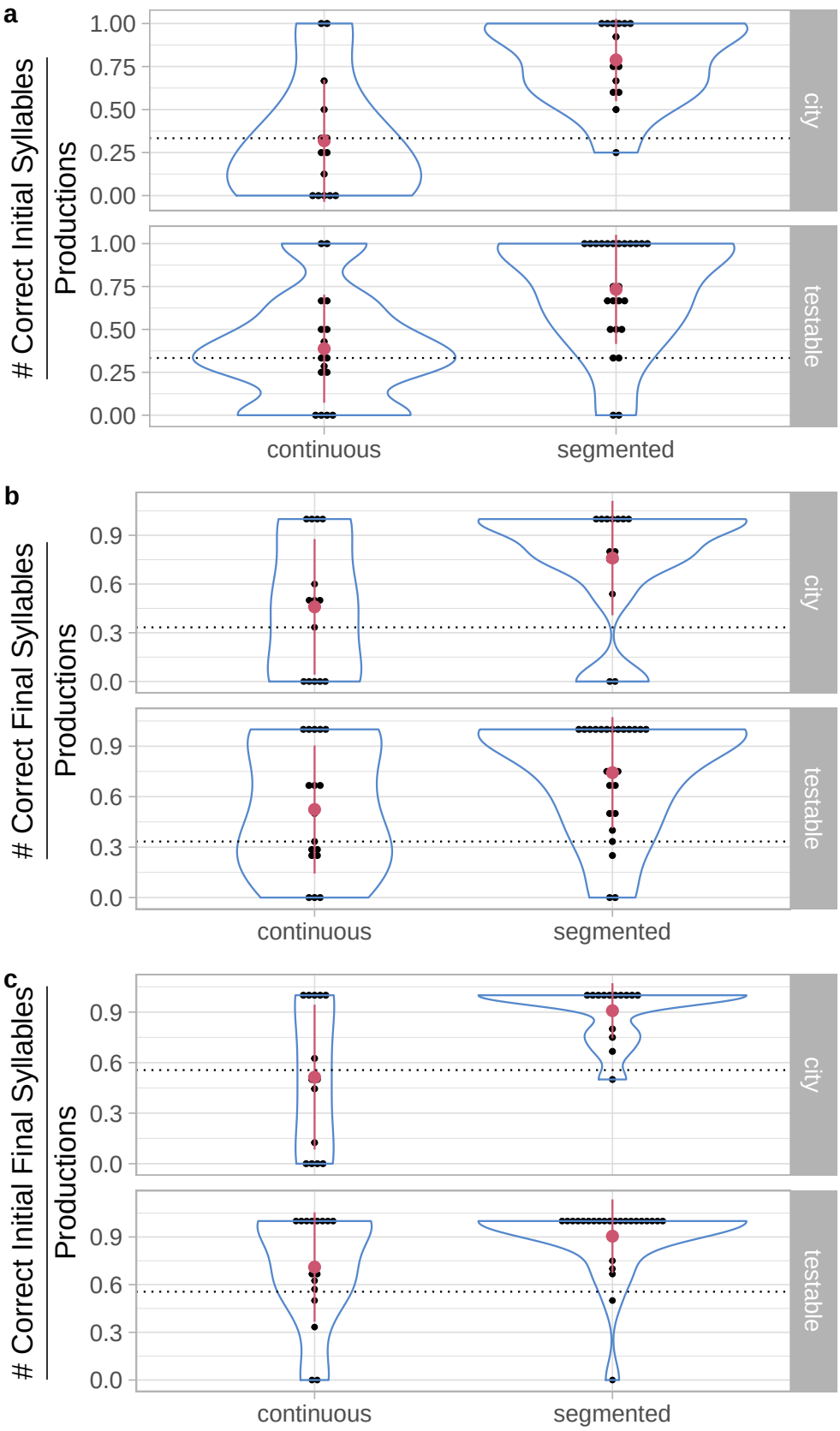

Figure 5: Plot of chunks with correct initial or final positions.

Continuous	Segmented	$p_{contvs.segm}$
Number of items		
M= 3.97, SE= 0.415, p= 1.14e-06	M= 3.77, SE= 0.366, p= 4.58e-08	0.800
Number of syllables/item		
M= 2.78, SE= 0.274, p= 1.15e-06	M= 2.71, SE= 0.0966, p= 1.03e-08	0.667
Number of words		
M= 0.129, SE= 0.0622, p= 0.0719	M= 1.41, SE= 0.196, p= 1.92e-06	0.000
Proportion of words among vocalizations		
M= 0.129, SE= 0.0622, p= 0.0719	M= 1.41, SE= 0.196, p= 1.92e-06	0.000
Number of part-words		
M= 0.323, SE= 0.128, p= 0.0179	M= 0, SE= 0, p= NaN	0.002
Proportion of part-words among vocalizations		
M= 0.323, SE= 0.128, p= 0.0179	M= 0, SE= 0, p= NaN	0.002
Proportion of part-words among words and part-words		
M= 0.281, SE= 0.138, p= 0.182	M= 1, SE= 0, p= 7.75e-08	0.000
Forward TPs		
M= 0.32, SE= 0.0506, p= 0.000215	M= 0.602, SE= 0.0563, p= 2.49e-07	0.001
Actual vs. Expected Forward TPs		
M= -0.476, SE= 0.0557, p= 8.77e-06	M= -0.353, SE= 0.0517, p= 5.88e-06	0.083
Backward TPs		
M= 0.32, SE= 0.0506, p= 0.000215	M= 0.602, SE= 0.0563, p= 2.49e-07	0.001
Number of High TP chunks		
M= 0.677, SE= 0.223, p= 0.00545	M= 1.72, SE= 0.22, p= 9.56e-07	0.000
Proportion of High TP chunks among productions		
M= 0.136, SE= 0.0403, p= 0.00573	M= 0.486, SE= 0.0577, p= 1.11e-06	0.000
Number of Low TP chunks		
M= 0.258, SE= 0.0939, p= 0.0147	M= 0, SE= 0, p= NaN	0.002
Number of Low TP chunks among productions		
M= 0.0689, SE= 0.0269, p= 0.022	M= 0, SE= 0, p= NaN	0.002
Proportion of High TP chunks among High and Low TP chunks		
M= 0.589, SE= 0.127, p= 0.446	M= 1, SE= 0, p= 2.75e-08	0.000
Proportion of items with correct initial syllables		
M= 0.356, SE= 0.0602, p= 1	M= 0.753, SE= 0.0471, p= 5.07e-07	0.000
Proportion of items with correct final syllables		
M= 0.495, SE= 0.0716, p= 0.0573	M= 0.749, SE= 0.0542, p= 8.03e-07	0.006
Proportion of items with correct initial or final syllables		
M= 0.622, SE= 0.0715, p= 0.482	M= 0.906, SE= 0.0336, p= 2.76e-07	0.001

\end{table}