CHAPTER 7

MEAN VOICING DURATION

7.1 INTRODUCTION TO CHAPTER 7

While the last two chapters dealt with token durations and frequency of devoicing, this chapter focuses on the second research question of this thesis; specifically, what variables affected the mean voicing durations (**MVDs**) of the vowels that were voiced. This will be determined as before by the use of ANOVA to test for effects of the variables in the study on the duration of f_o activity associated with the vowels of each production that were voiced.

The organization of this chapter is as follows. §7.2 presents the descriptive statistics of the data sets for the voiced vowel fo durations, as was done in §5.3 for the token duration data sets. §7.3 discusses the design of the ANOVA models used to test for effects of the variables on the duration of voicing activity for vowels that were voiced. (See §§4.2 and 4.3 for discussion of the variables and §4.5.3 for discussion of voicing criterion and measurement methodology.) §7.4 will present the results of those tests, with §7.5 summarizing the chapter.

7.2 DESCRIPTIVE STATISTICS OF THE DATA SETS

As with the data in the 3 mean token duration sets, it is necessary to check the data sets consisting of the voicing durations of the vowels that were voiced to see if they satisfy the base requirements for comparisons using ANOVA. Again, as in Chapter 5, checks for normalcy and homogeneity of variance were made. Again, following Milton (1992) in accounting for outlying data points (outliers) rather than excluding them, all data from these sets were utilized. The justification for including them was that, as can be seen in the following figure, the distribution of data within the data set for each SR did not contain any data points that seemed excessively large; i.e. there are no voiced vowels that sounded unnaturally long (cf. the production of *tsutchi* at 867 ms in the slow data set in Figure 5.1).

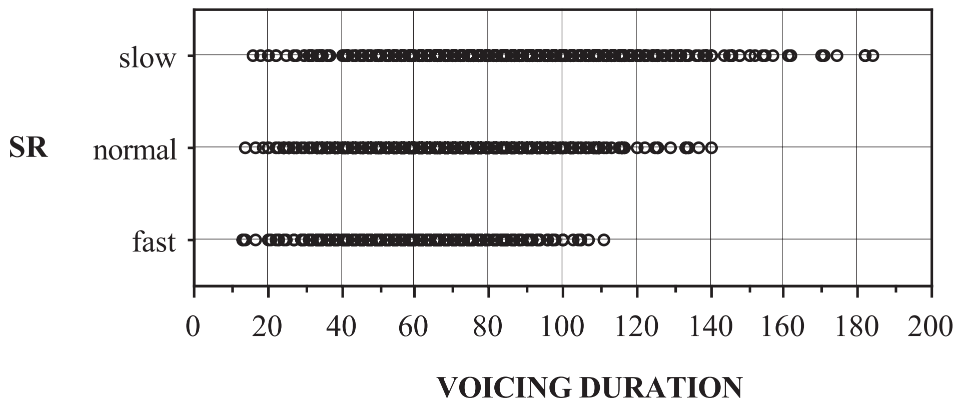

Figure 7.1 Distribution plot of VOICING DURATION VS. SR, all data points (n = 1902).

The first base assumption to be checked is again that the data in each set was normally distributed about their mean values.

7.2.1 NORMALCY OF THE DATA SET (CF. §5.2.1)

The following histograms show the distribution of the MVD data, separated by SR.

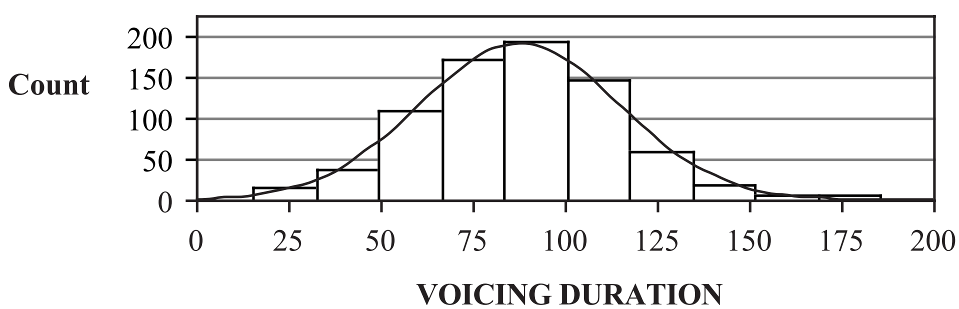

Figure 7.2 Histogram for VOICING DURATION, *slow* SR; n = 766 (all data points).

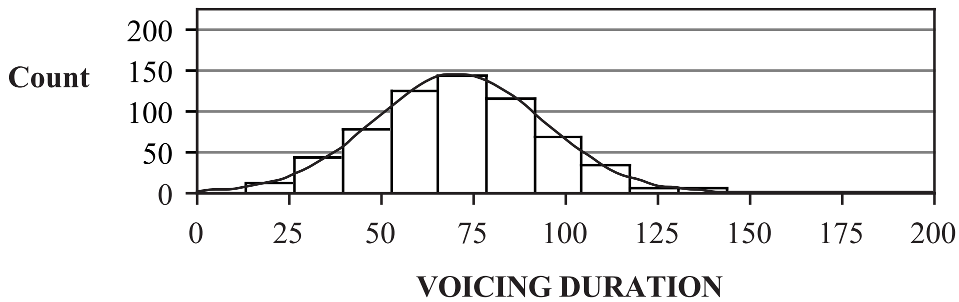

Figure 7.3 Histogram for VOICING DURATION, *normal* SR; n = 638 (all data points).

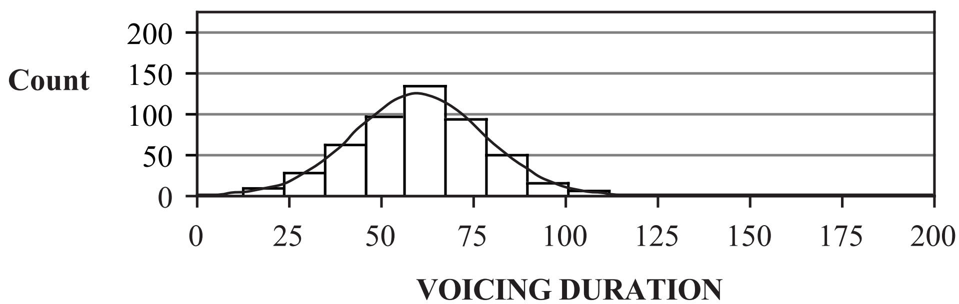

Figure 7.4 Histogram for VOICING DURATION, *fast* SR; n = 498 (all data points).

As can be seen from the histograms, the distribution of the sets of data are quite normally distributed about the fitted (i.e. ideal) normal distribution curve. Therefore the three data sets consisting of the vowel voicing durations are considered to satisfy the requirement for normal distribution.

As before, the more important base assumption of most statistical tests is that the data in the different data sets be distributed about their mean value in the same manner; that is, the data in the sets should be homogeneous in their variance about their means.

7.2.2 HOMOGENEITY OF VARIANCE OF THE DATA SET (CF. §5.2.2)

The descriptive statistics for the data sets, including the statistics for homogeneity of variance, are presented below.

Table 7.1 Summary statistics for the VOICING DURATION data, split by SR; all data points.

	VOICING DURATION, fast	*VOICING DURATION, normal*	*VOICING DURATION, slow*
Mean	60.41	71.02	87.75
SD	17.56	22.78	27.22
SE	.787	.902	.983
⇒ ***Variance***	308.2	518.9	740.8
Count	498	638	766
Minimum	13	14	16
Maximum	111	140	184
Range	98	126	168

Again, as in Chapter 5 with the token duration data sets, it can be seen that the variance of both the data sets for each SR fail to satisfy the base requirement of homogeneity of variance. In particular, the variance of the slow data set for all data points can be seen to be over twice that of the variance of the fast data. As stated in Rosenthal & Rosnow (1991: 315), there is cause for concern if the base assumption of homogeneity of variance is violated *and* the sample sizes are very different.

Unlike the data sets in Ch. 5, the sample sizes of the 3 full data sets here (n = 498, 638 and 766 for the fast, normal and slow data sets, respectively) can be considered to be quite different. However, as in Chapter 5, the source of this variation is understood to be the experimental design itself allowing the participants greater freedom in matching their productions to the display times of the carrier sentences. In addition, since the sample size of the smallest data set itself is quite large (almost 500 data points) and because the data in all 3 data sets are all from the same 10 participants (as opposed to the data in each set being from different participants), it is judged that the data can be subjected to ANOVA analysis without undue concern of generating spurious results (i.e. identifying patterns in the data that do not actually exist, or failing to identify patterns that do exist). These tests are discussed below, with the understanding that the findings are tentative in nature and indicative of the direction further research should take.

The design of those tests, almost identical to the design of those used in Chapter 6, will now be briefly discussed.

7.3 DESIGN OF THE ANOVA MODELS FOR TESTING EFFECTS ON MVDS

Examining the effect of the variables on VOICING DURATION will be done in the same manner as before, using an ANOVA test for significance. In this case, however, since the VOICING DURATION = 0 values are considered to have been produced by a different process than the non-zero values, only the non-zero values (i.e. the voiced vowels) will be included in the models. This constitutes the second stage of the logistic regression model introduced in Chapter 6.

As before, models were constructed on the advice of the statistical advising staff of the University of Washington. Again, PARTICIPANT could not be combined with GENDER in the same model (see §§4.3 to 4.6 for discussion of the experimental setup), therefore two models were constructed, one for each variable. The ANOVA runs for effects on mean vowel voicing durations were virtually identical to the runs on whether or not a vowel was devoiced.

VOICING DURATION = SR * TOKEN * MORA + PARTICIPANT * BLOCK +
PARTICIPANT * REPETITION (BLOCK)

and

VOICING DURATION = SR * TOKEN * MORA + PARTICIPANT * BLOCK +
PARTICIPANT * REPETITION (BLOCK)

where SR * MORA * TOKEN indicates the interaction of the 3 variables and all possible combinations, PARTICIPANT * BLOCK etc. indicates the interaction between each of the two variables and the variables by themselves, with REPETITION being nested within BLOCK (see §§4.4, 4.5 and 5.3 for further details).

As before, SR, MORA, and TOKEN are fixed effects (i.e. variables whose effects are being checked only for this data set), and PARTICIPANT, GENDER, BLOCK and

REPETITION (BLOCK) are random effects (i.e. variables whose effects are being extended to the population and experimentation at large).

As before, results are discussed in terms of interactions first, with results of each variable by itself after. Results of the effects of variables on VOICING DURATION are also discussed in the context of those variables' effect on TOKEN DURATION for the tokens containing the voiced vowels to see if vowel voicing durations are directly correlated with the token durations.

7.4 RESULTS OF THE ANOVA MODELS FOR EFFECTS ON MVDS

The results of the two ANOVA run to check for effects of the variables on voicing durations of all voiced vowels (no outliers excluded) are presented in the following two tables (again, §5.3 contains further discussion of the model setup). *F*-ratios are again given to two significant digits, while *p*-values are given as generated by the statistical program.

Table 7.2 Results of ANOVA including the variable GENDER.

Variable(s)	***df***	***F*-ratio**	***p*-value**
MORA * SR	2	27	.0001
MORA * TOKEN	9	11	.0001
MORA	1	290	.0001
SR	2	260	.0001
TOKEN	9	5.3	.0001
GENDER * BLOCK	1	16	.0162
GENDER	1	14	.0002
residual	1871[1]		

[1]As in Tables 6.2 and 6.3, there are 5 degrees of freedom (*df)* not reported in Tables 7.3 and 7.4. These correspond to the degrees of freedom for the variable REPETITION (BLOCK) which, although not directly included in the ANOVA calculations, was included in the model to serve as the error term for the variable BLOCK.

Table 7.3 Results of ANOVA including the variable GENDER.

Variable(s)	*df*	***F*-ratio**	***p*-value**
MORA * SR	2	38	.0001
MORA * TOKEN	9	17	.0001
SR	2	320	.0001
MORA	1	300	.0001
TOKEN	9	7.4	.0001
PARTICIPANT * BLOCK	9	11	.0172
PARTICIPANT	9	53	.0001
BLOCK	1	18	.0128
residual	1855		

As can be seen by comparing the results in these tables to those in Tables 6.2 and 6.3, the significant interactions and variables are virtually identical to those that affected whether or not a vowel was voiced, with the sole exception of the additional significant effect of BLOCK on mean voicing durations in the model containing the variable PARTICIPANT.

The effects of each of the interactions and variables on MVDs are discussed below, along with interaction line plots for each effect.

7.4.1 EFFECTS ON VOICING INVOLVING MORA

*7.4.1.1 Effects of the 2-way interaction MORA * TOKEN*

The effects of the 2-way interaction between MORA and TOKEN means that although the mora that contained the vowel made a difference in the voicing duration of that vowel, the differences in voicing duration seen between the two vowels of the two moras varied depending on the token. This effect on mean vowel voicing durations can be seen below in the interaction line plot below for these two variables.

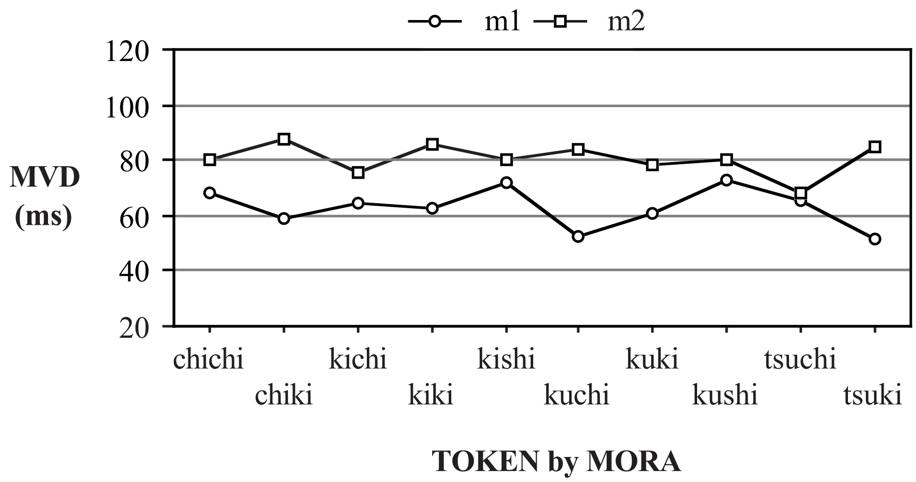

Figure 7.5 Interaction line plot for the effects of MORA * TOKEN on vowel voicing durations.

The MVDs of the voiced vowels contained in the 1st mora of a token can be seen in the segmented line marked with circles (the lower of the two segmented lines). The MVDs of the voiced vowels contained in the 2nd mora of a token can be seen in the segmented line marked with squares (the higher of the two segmented lines). This shows that voiced vowels contained in the 1st mora of the tokens had a shorter voicing duration than the vowels contained in the 2nd mora.

The effect of the different tokens can be seen in the varying slope of the segments of each line—if different tokens had no effect, the slopes of all the segmented lines would be the same (i.e. each segmented line would be one horizontal line segment).

The effect of the interaction between the mora the voiced vowel is in and the different tokens can be seen in the difference in each set of two data points for each token—the two segmented lines do not vary in tandem as one moves from one token to the next across Figure 7.5. It can be readily seen that the MVDs observed in each mora of each token varied depending on which token is being looked at. In particular, the MVDs for the 1st vowel in the tokens *kuchi* and *tsuki* were shorter than the MVDs of the 1st mora vowels of the other tokens.

As in Chapter 5, the interplay of all of the effects at work here (different segmental material in each mora and clitic and different pitch locations) cannot be conclusively described in the current data set due to lack of sufficient stimuli control. However, segregating the tokens in the plot above by the various components as in Chapter 5 does provide some indications for further research.

In Figure 7.6, the tokens are segregated by the following clitic (*to* or *ka)*; in Figure 7.7 the tokens are segregated by the material in the first mora of each token; and in Figure 7.8 the tokens are segregated by the material in the second mora of each token.

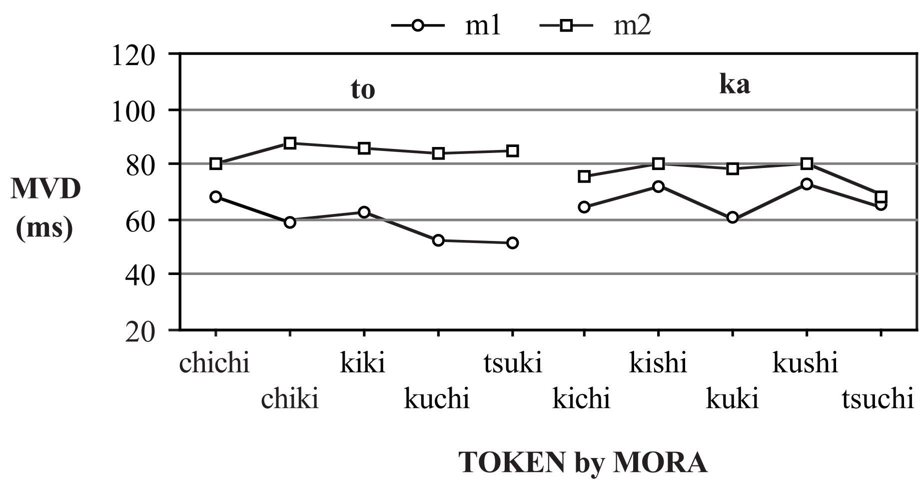

Figure 7.6 Interaction line plot for the effects of MORA * TOKEN on vowel voicing durations, tokens segregated by following clitic.

As can be seen, the effects of the following clitic are not at all consistent; both groups of tokens vary widely. It can be tentatively suggested that a following clitic *ka* tends to stabilize the MVDs so that there is not such a large difference between the MVDs for the 1st mora and the 2nd. This is indicated by the lesser difference between the MVDs of the 1st and 2nd mora vowels in the tokens followed by *ka.* The MVDs seen for the tokens *chichi* and *kuki* do not support this generalization, however.

Segregating the tokens by the material in the first mora of each token also does not provide a consistent account of the variation seen in the MVD data.

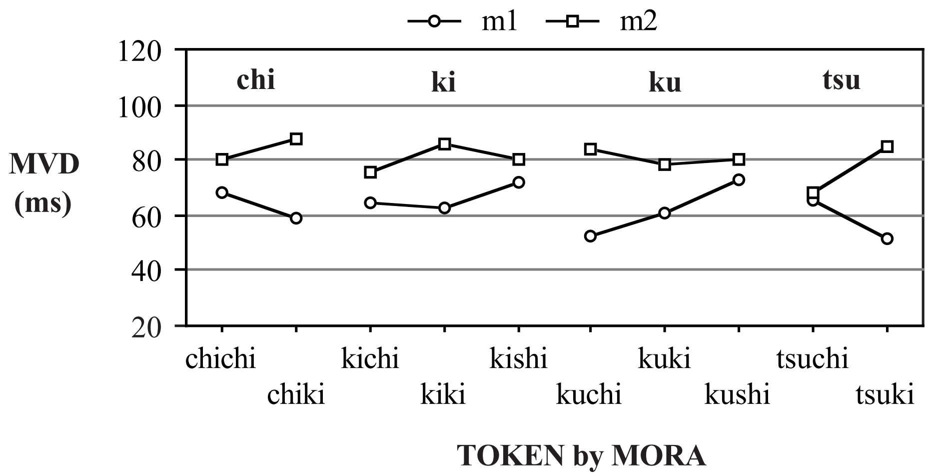

Figure 7.7 Interaction line plot for the effects of MORA * TOKEN on vowel voicing durations, tokens segregated by the segmental material of the 1st mora.

There does not seem to be any regular pattern that emerges from this segregation, as with the frequency of vowel devoicing discussed in Chapter 6, the fact that a token contains [t͡ʃi] or [t͡su] in the 1st mora, the allophonic variants of [t], seems to make the MVD more sensitive to the segmental content of the 2nd mora (i.e. [t͡ʃi] or [ki]). This can be seen in the consistent differences between the tokens *chichi* and *chiki,* and *tsuchi* and *tsuki.*

As the following plot shows, the segmental content of the 2nd mora may also have an effect for some of the tokens.

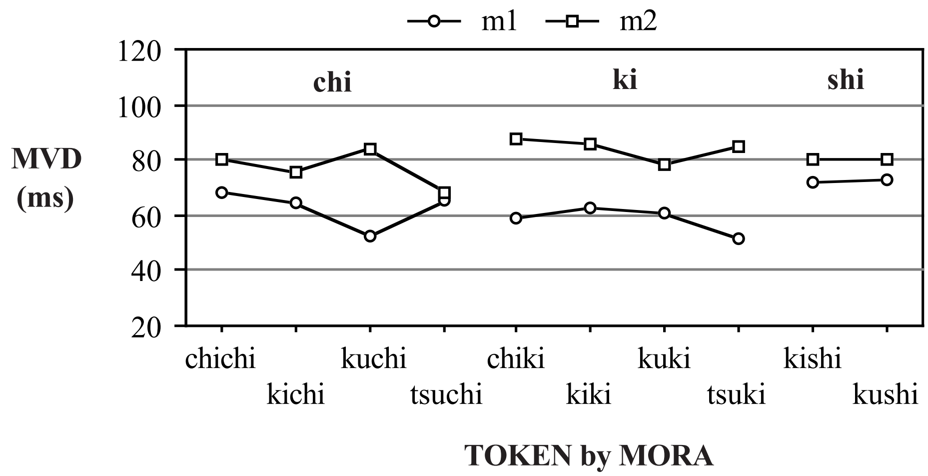

Figure 7.8 Interaction line plot for the effects of MORA * TOKEN on vowel voicing durations, tokens segregated by the segmental material of the 2nd mora.

The two tokens containing a 2nd mora of [ši] (and in this study, an initial [k]) displayed very similar MVDs for those vowels that were voiced. This is attributed to the fact that these two tokens were both followed by the clitic *ka,* and therefore differed only in the 1st vowel of the CVCV-CV token-clitic combination. Further, the 1st vowel in each combination was a high vowel in both cases. The lack of segmental differences shows up in the MVDs for the vowels in those two tokens.

However, the effect of having a 2nd mora of [t͡ši] or [ki] does not seem to have had a consistent effect. It cannot be said that having [t͡ši] in the 2nd mora or [ki] n the 2nd mora led to longer MVDs for the vowels in the 2nd mora (the higher of the two segmented lines for [t͡ši] and [ki] in the plot).

Finally, segregating the tokens by the prescribed standard pitch accent placement[2] (1st mora, 2nd mora, unaccented, indicated by **unacc**, **1st**, and **2nd** within the plot, respectively) also does not provide a consistent account of the observed variation.

[2]See Chapter 3 for discussion of pitch accent placement and variation seen in the current data set.

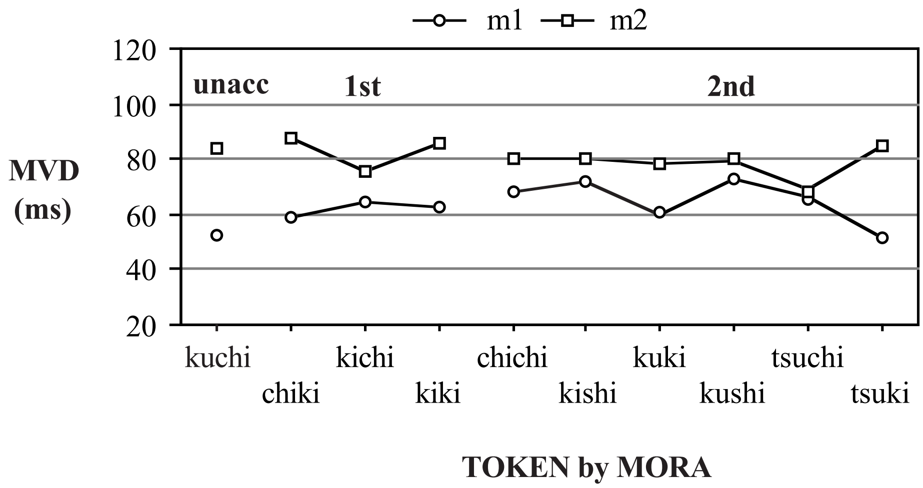

Figure 7.9 Interaction line plot for the effects of MORA * TOKEN on vowel voicing durations, tokens segregated by standard pitch placement.

While the number of tokens having standard pitch accent on the 1st mora is limited in this study (only 3, as opposed to the 6 tokens with standard accent on the 2nd mora), there is no clear indication that standard pitch accent placement has a consistent effect on MVDs. This can be seen in the fact that the voiced vowels in the tokens with a generally accented 1st mora (*chiki, kichi,* and *kiki)* display a shorter MVD than the voiced vowels in the 2nd mora of those same tokens. Indeed, the 2nd mora vowels in those tokens often display a longer MVD than the 2nd mora vowels in the other tokens generally accented on the 2nd mora vowel. This is inconsistent with the findings of Kuriyagawa & Sawashima (1989), who found that accented vowels in that study's productions were in general of longer duration.

The exact source of the MORA * TOKEN interaction and its effect on MVDs must be left for future, more controlled research involving phonetically balanced combinations of segmental moraic material in tokens controlled for pitch accent placement and following clitic.

7.4.1.2 Effects of the 2-way interaction MORA * SR

The significant effect of the 2-way interaction between MORA and SR means that not only did the effect of which mora the vowel is in vary by token, it also varied by SR. That is, the effect of MORA on MVDs is different for each SR. This can be seen below in Figure 7.10.

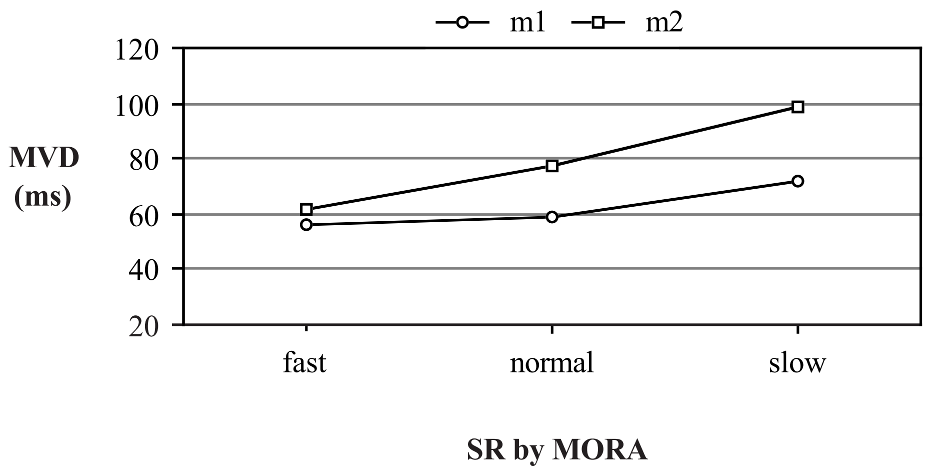

Figure 7.10 Interaction line plot for the effects of MORA * SR on vowel voicing durations.

In this plot the effect of MORA on MVDs can be seen in the vertical separation of the two segmented lines. As with mean token durations, the MVD of voiced vowels in the first mora (marked by the circles) can be seen to be greater than the MVD of voiced vowels in the second mora (marked by the squares) at all SRs.

The effect of SR can be seen in the slope of the segmented lines. The MVDs of voiced vowels can be seen to decrease as SR increases (i.e. from the slow to the fast SR) for both mora.

Finally, the source of the significant effect on MVD due to the interaction between the two variables can be seen in the fact that the two segmented lines are not parallel. The MVDs of the 1st mora vowels were of shorter duration than the 2nd mora vowels at the slow SR, but the 2nd mora vowels decreased in MVD more quickly so that at the fast SR the MVDs of vowels of both mora were approximately the same.

This indicates that the 2nd mora vowels are more robust at the slower SR, being more well developed than the 1st mora vowels. This is consistent with the findings of Sagisaka & Tohkura (1984), as cited by Kuriyagawa & Sawashima (1989), who also found 2nd mora vowels to be of longer duration. However, in the current study this difference is neutralized at the faster SR due to the shortening of both vowels.

7.4.2 EFFECTS ON VOICING INVOLVING GENDER and PARTICIPANT

*7.4.2.1 Effects of the 2-way interaction GENDER * BLOCK*

The significant effect of the 2-way interaction between GENDER and BLOCK indicates that, while the females and males displayed a MVD difference, the difference was not consistent between repetition blocks. This can be seen below.

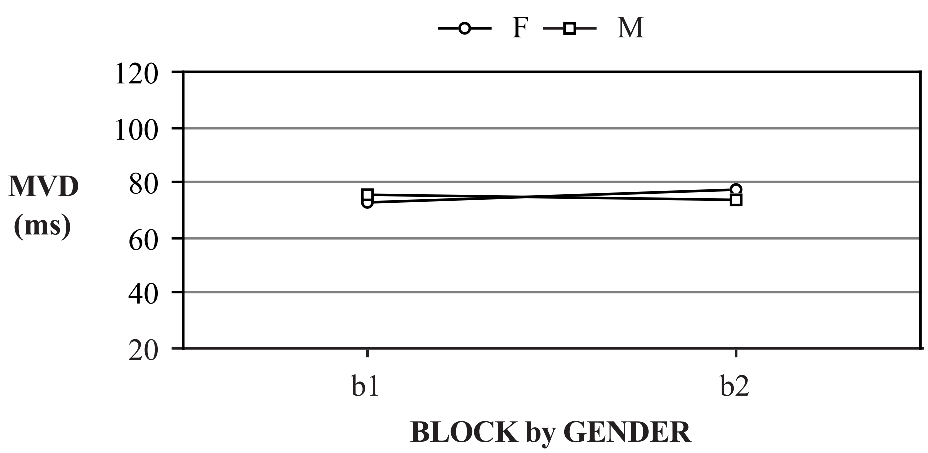

Figure 7.11 Interaction line plot for the effects of GENDER * BLOCK on mean voicing durations of voiced vowels.

The effects of having participants of both genders in the study can be seen in the vertical separation of the line segments on the plot. The females are represented by the segmented lines marked with circles and males are represented by the segmented lines marked with squares.

The effects of having two repetition blocks can be seen in the slope of the line segments. The MVDs of the first block of repetitions on the left of each line segment and the MVDs of the 2nd block of repetitions on the right of each line segment.

The effects of the interaction between the two variables can be seen in the different slopes of the line segments. As always, slopes of opposite sign (i.e. one rising and one falling) indicates an interaction between two variables. In this case, the value of the MVDs for the males in the study can be seen to drop slightly from the 1st repetition block to the 2nd, while for the females it rose slightly; i.e. the males produced longer vowel voicing durations in the 1st block, and the females produced longer voicing durations in the 2nd block. Note that this is in spite of the general trend for the males to have a faster overall SR than the females (see Figure 5.19 in §5.4.2.1).

The source of this effect can only be guessed at within the current experimental setup. As mentioned in Chapter 5, it is thought to be due to different strategies employed for matching productions to the sentence display times. From the plot above, it appears that the females began their productions in the 2nd repetition block at a slightly slower SR, resulting in longer MVDs, while the males began their productions in the 2nd repetition block at a slightly faster SR, resulting in shorter MVDs. Presumably the males then lengthened the latter parts of the sentence productions to match the stimuli display times, although this has not yet been verified by examining the data.

*7.4.2.2 Effects of the 2-way interaction PARTICIPANT * BLOCK*

Finally, the significant effect of the 2-way interaction between PARTICIPANT and BLOCK means that, just as for the females and males, each participant's MVDs varied depending on repetition block. This can be seen below in the line plot for the interaction between these two variables.

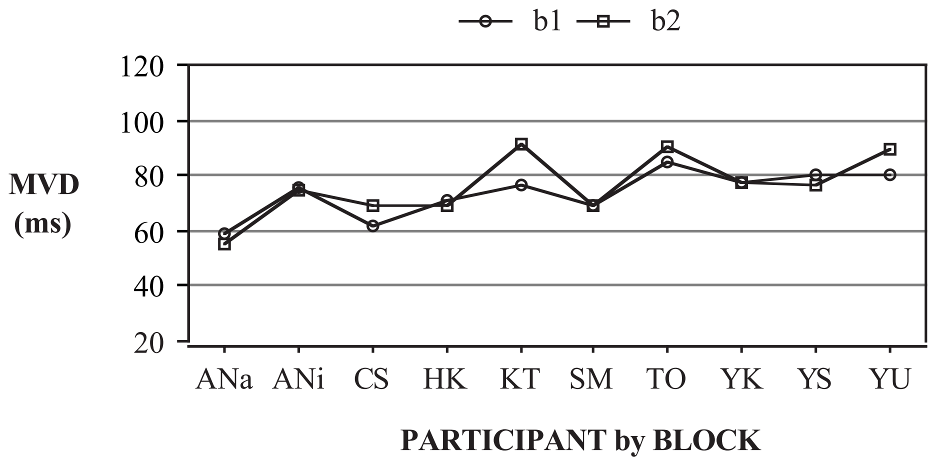

Figure 7.12 Interaction line plot for the effects of PARTICIPANT * BLOCK on voicing.

In this plot, the effects of PARTICIPANT can be seen in the 10 sets of data points along the x-axis. This is consistent with the results for mean token durations seen in Figure 5.20; participant ANa produced both the shortest MTDs and MVDs, while participants TO and YU produced the longest MTDs and MVDs.

The effects of having two repetition blocks can be seen in the vertical separation of the two segmented lines. Again, the data above for MVDs parallels the data in Figure 5.20 for MTDs; i.e. ANa produced shorter duration tokens and voiced vowels in the 2nd block. (Note that in Figure 5.20 differences between blocks are indicated by horizontal separation.)

The effect of the interaction between the two variables can be seen in the differences in location of the pairs of points on the graph, in particular where the lines connecting the pairs cross. The differences in MVDs due to the individual variation of the participants was not consistent between the two repetition blocks. Participants ANa, HK, and YS produced longer MVDs in the 1st repetition block, while CS, KT, TO, and YU produced longer MVDs in the 2nd repetition block; ANi, SM and YK produced very close to the same MVDs for each repetition block despite fairly clear differences in MTDs seen in Figure 5.20.

The plot above shows the individual variation in the percentage of vowels devoiced within the group of participants, even though an attempt was made to select participants from within the Tokyo area who were raised in Tokyo, had parents who were either from or had been in the Tokyo area for a long time, and had minimal contact with other languages. This is consistent with the individual variation in devoicing rate reported in other studies (e.g. Kuriyagawa & Sawashima 1989; Kondo 1990; Maekawa 1993).

As noted earlier, the only difference in the significant interactions and variables in this model and that testing for effects of the variables on whether or not a vowel was voiced was that the variable BLOCK was also significant in this model as a main effect (i.e. BLOCK as well as PARTICIPANT contributed to the significance of the interaction).

7.5 SUMMARY OF CHAPTER 7

As in Chs. 5 and 6, the base requirements for the use of ANOVA in checking for effects of independent variables on a dependent variable are that the data be normally distributed in each data set being compared (i.e. the majority of data points in each set fall close to the mean value for that set), and that the data in each set display homogeneity of variance (i.e. the data in all sets be distributed about their means in approximately the same manner). As with the data in Ch. 5, the vowel voicing duration data satisfies the requirement for normal distribution but not for homogeneity of variance.

However, it was noted that the variance of the data in all 3 sets is a function of the experimental design. Since participants had more time to produce the stimuli sentences at the slow SR, they were more able to manipulate the timing of the sentences' segments to achieve a match between sentence display time and production time. This greater freedom is what is responsible for the increase in variance seen in the normal and slow SR data sets. In addition, all data sets contain many data points, and all data were generated by the same participants performing exactly the same task.

Therefore it was decided that the data could be subjected to ANOVA checks for effects of the variables on vowel voicing durations, just as the data in the two previous chapters were.

In contrast with the enormous effect of SR on token durations seen in Ch. 5, the variable that most influenced voicing durations here was MORA, the mora of a token that contained the voiced vowel. The voicing associated with vowels in the 1st mora of the tokens was consistently shorter than the voicing associated with vowels in the 2nd mora of the tokens. This is consistent with the findings of Kuriyagawa & Sawashima (1989). However, the effect of MORA was dependent on both which token a vowel was contained in, and the SR the vowel was produced at.

As for which token a voiced vowel was contained in, some indications for further research were noted, but a much more controlled experimental setup is needed that includes an exhaustive set of tokens so that effects of the segmental material in the 1st mora, 2nd mora, and following syntactic particle can be deduced.

As for the SR a vowel was produced at, it was noted that although the voicing durations of 1st mora vowels at all SRs were shorter than the voicing durations of 2nd mora vowels, as SR increases the voicing durations of the 2nd mora vowels decreased much more quickly. At the fast SR, the difference in voicing duration between the two mora seen at the slow SR was almost neutralized.

The effect of gender on the vowel voicing duration was consistent with the effects of gender on token durations seen in Ch. 5—the males of the study in general produced voiced vowels of shorter duration. However, this effect was also dependent on which repetition block a vowel was produced in. The females in the study produced vowels with shorter voicing durations in the 1st block and slightly longer durations in the 2nd block. In contrast, the males in the study produced slightly longer voicing durations in the 1st block than in the 2nd.

As was seen when the plot for all participants was examined, this effect held true for 5 of the 6 female participants and 3 of the 4 male participants. In addition, the plot for the individual participants' voicing durations in each block showed the great individual variation seen despite the attempt at controlling the dialectal region participants were drawn from. This is consistent with the large individual variation reported in other studies.

This chapter concludes the checks for effects of the variables in the study on the productions of the participants. The next chapter will give a summary of the dissertation as a whole, and suggest directions for further study.