CHAPTER 7

RESULTS AND DISCUSSION OF REPAIR INTERVALS

7.1 Introduction

This chapter presents the results obtained in relation to answering research question 2: what error-to-cut off, cut off-to-repair and error-to-repair intervals reveal about the process of self-monitoring and self-repair in spontaneous speech production (see 1.5). In order to do so, these three intervals were measured based on acoustic and auditory examination of the relevant portions of speech. Based on previous studies (see Chapter 3), short error-to-cut off intervals are considered to be a reflection of prearticulatory monitoring, whilst short cut off-to-repair and error-to-cut off intervals suggest that repair-planning commences even before speech is interrupted. These measurements were then analysed in relation to current findings about the process of self-monitoring and self-repair (see 3.3 and 4.4). This chapter discusses the findings of each of these intervals in relation to these processes.

7.2 Error-to-Cut off Intervals

Error-to-cut off intervals were only measured for self-repairs, since errors could not be identified in possible-repairs (Blackmer and Mitton, 1991; Howell, 2003, Levelt, 1983). As explained in Chapter 4, the durations were measured from the onset of the erroneous segment or word to the perceived interruption point. Figure 7.1 shows the frequency distribution of error-to cut off intervals for all 239 self-repairs, while Table 7.1 presents the means, median, modes, standard deviations and skewness of the error-to-cut off intervals for each type of self-repair. These intervals had a mean of 347msec, a median of 314msec, a mode of 175msec and a standard deviation of 230.6msec. The shortest error-to-cut off interval was 15msec, while the longest was 1785msec.

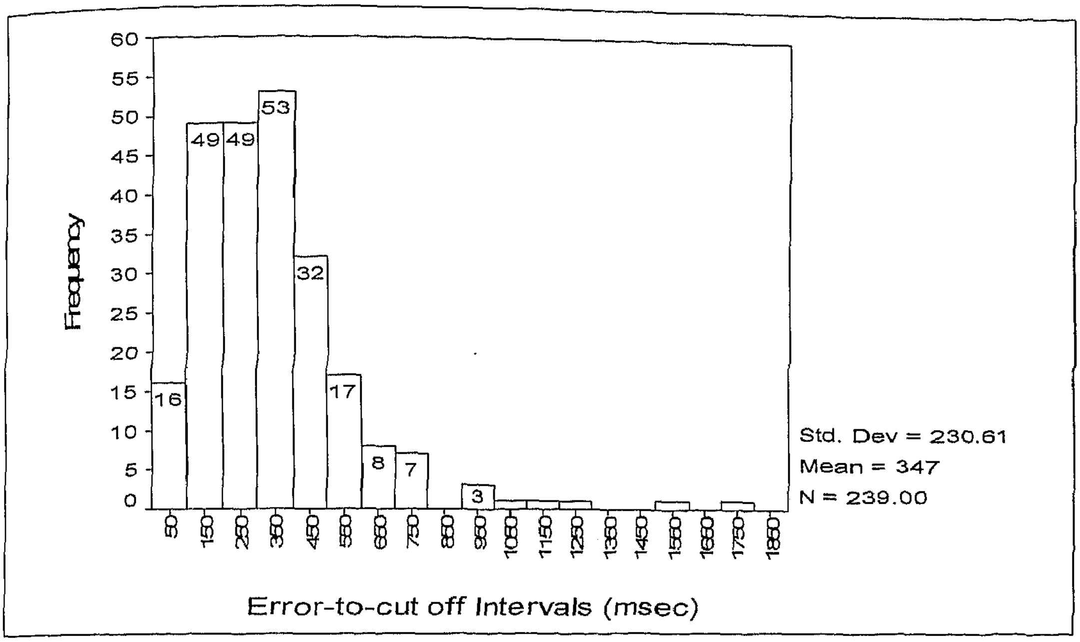

Figure 7.1

Frequency Distribution of Error-to-Cut off Intervals in Self-Repairs

Table 7.1

Error-to-Cut off Intervals for Self-Repairs

Self-Repairs	**Total**	**Mean (msec)**	**Median (msec)**	**Mode (msec)**	**s.d. (msec)**	**Skew-ness**	***less* than 100 msec (%)**	***less* than 150 msec (%)**
Repeats	131	346.1	316.0	175.0	219.3	2.2	10.9 (9)	14.7 (15)
Deletes	53	315.7	306.0	126.0	200.9	1.4	7.6 (4)	22.2 (12)
Substitution	36	364.8	316.0	196.0	191.9	1.7	2.8 (1)	8.3 (3)
Insertions	19	405.3	235.0	58.0	400.7	2.5	10.5 (2)	15.8 (3)
All Self-Repairs	239	346.9	314.0	175	230.6	2.4	6.7 (16)	13.8 (33)

As can be seen in Figure 7.1 and Table 7.1, most of the error-to-cut off intervals (about 97%) were 800msec and below, and long intervals above 1sec rarely occurred. This means that speech tended to be cut off within 800 msec after an error or part of an error, in the case of fragment repairs, had been produced. In approximately half (51%) of the self-repairs, speech was interrupted at about 400msec and below after the production of the error. The implication of this is that speech is not stopped immediately upon detection of a problem or production of an error. This is because there needs to be time for the the stop signal to be sent to the articulators upon error-detection, keeping in mind that inner speech recognition (see Figure 3.1) is thought to take about 150 to 200msec (Levelt, 1989).

Given that it is estimated to take about 180 to 200msec to stop articulation (see 3.5.1), speakers seem to have a tendency to go on speaking a little while longer before they interrupt themselves. This means that in most cases, the Main Interruption Rule (see 2.7) did not apply. Perhaps this is also because, as suggested by Seyfeddinipur and Kita (2001), prearticulatory repair-planning has commenced and is going on while a speaker continues his utterance. Thus, in the utterances examined, the speakers rarely stopped immediately after the error was produced. As Table 7.1 shows, although all self-repairs had intervals below 100msec, with repeats and insertions having the highest percentage of such intervals, only 6.7% (16/239) of error-to-cut off intervals in self-repairs were below 100msec, and 13.8% (33/239) were below 150msec.

In order to compare the error-to-cut off intervals in this study with those in Blackmer and Mitton's (1991) study, a separate analysis was done by omitting repetitions, which were considered as covert repairs in their study. The difference is shown in Table 7.2.

Table 7.2

Comparison of Error-to-Cut off Intervals in Overt Repairs

Error-to-cut off (msec)	**Deletions, Substitutions and Insertions (108)**	**Overt Repairs (391) (Blackmer and Mitton, 1991)**
Mean (msec)	348	528
s.d (msec)	245	300
less than 100msec (%)	6.5	5.3
less than 150msec (%)	16.7	14.5

Table 7.2 shows that the percentages of error-to-cut-of intervals that are below 100msec and below 150msec are around the same range. This is despite the fact that the categorization of the repairs is not the same in the two studies. However, this small percentage of error-to-cut off intervals that fall below 150msec still poses a problem for monitoring theories where error detection only begins after the production of the error, such as Laver's sensory register monitor (1980). This is because such post-articulatory monitoring would not be able to account for how post-articulatory error-detection, and the decision to halt speech could be made in such a short time, given that detection time and the instructions to stop production may take at least 180ms (see 3.5.1).

The only possible explanation to short error-to-cut off intervals is that error detection must have taken place prearticulatorily, as explained by Levelt's Perceptual Loop Theory (see Figures 2.1 and 3.1). Thus, the fact that speakers can cut themselves off under the 180msec range means that the decision to stop speech must have been made earlier, which in turn suggests that they had detected the problem prior to this. In fact, studies have shown that speakers report detecting errors in their inner speech. For instance, experimental studies by Dell and Repka (1993), Levelt, Roelofs and Meyer (1999), and Postma and Noordanus (1996) (see 3.3.2) have reported that speakers are able to monitor their internal speech, perhaps even as early as at the abstract phonological level.

Empirically, evidence for prearticulatory monitoring also stems from the fact that a high percentage of self-repairs with error-to-cut off times of less that 150ms were fragment repairs (67% or 12/18). Consistent with other studies (Blackmer and Mitton, 1991; Nakatani and Hirschberg, 1994; Shriberg, 1994), 29% (70/239) of the self-repairs had fragmented cut offs, as shown in Table 7.3. More than a quarter (29%) of these fragmented repairs had error-to-cut off times of less that 150ms. This means that, in these cases, the error was interrupted mid-segment, within 150msec. In only two cases was the word following the error interrupted as mid-segment.

Table 7.3

Fragmented Cut Offs in Self-Repairs

Type of Self-Repair	Number of Fragmented Cut off	Percentage %
Repetitions	34 (131)	26
Deletions	24 (53)	45
Insertions	6 (19)	32
Substitutions	6 (36)	17
Total	70 (239)	29

n.b. Figures in parenthesis indicate the total number of occurrences for that column

Figures 7.2 to 7.5 show the frequency distribution of error-to-cut off intervals for each of the self-repairs. The four histograms show that very large error-to-cut off intervals are not typical in all the four self-repairs. However, the existence of atypical large value means that the histograms are all positively skewed.

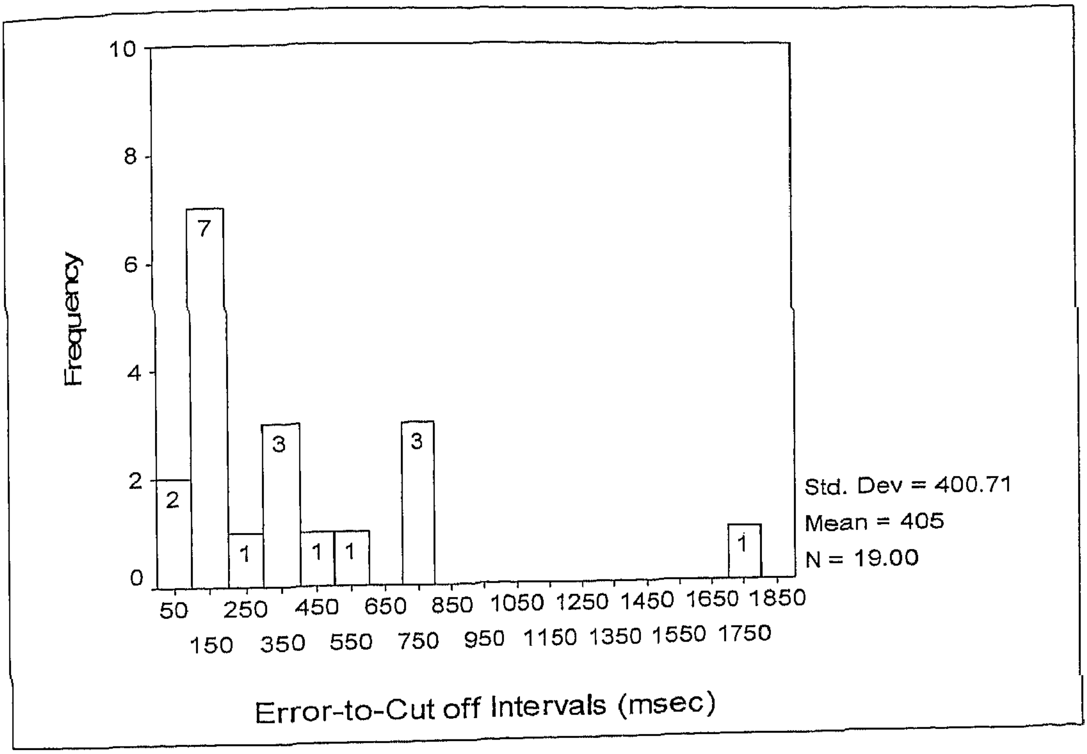

Figure 7.2

Error-to-Cut off Intervals for Insertions

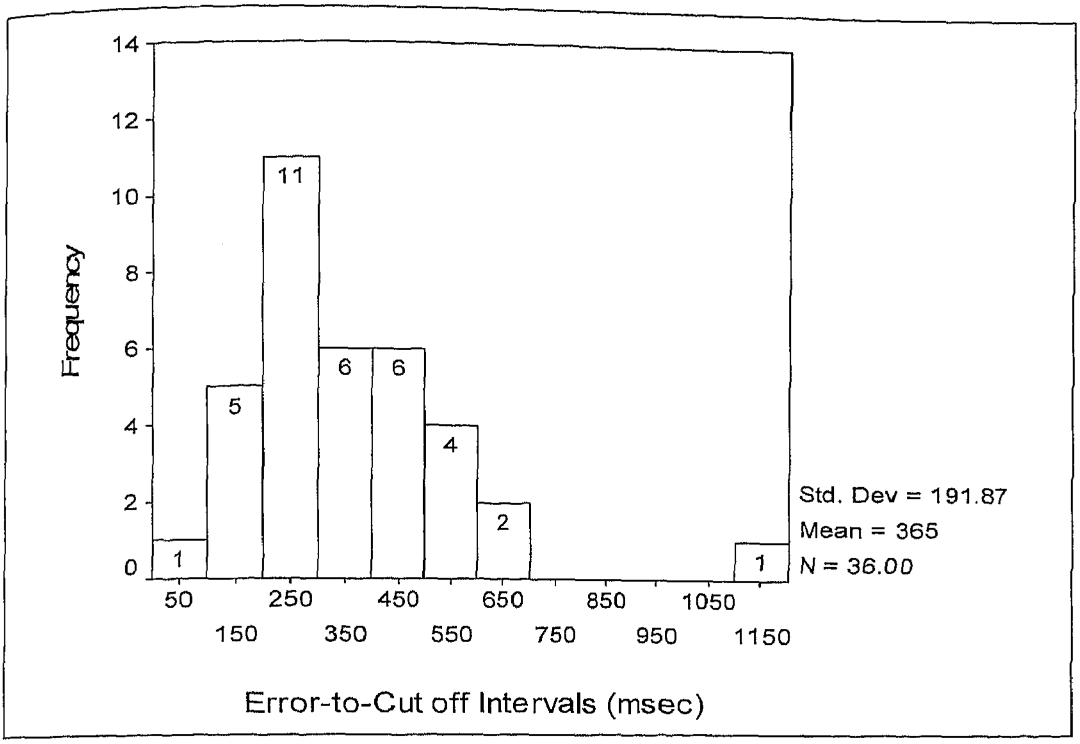

Figure 7.3

Error-to-Cut off Intervals for Substitutions

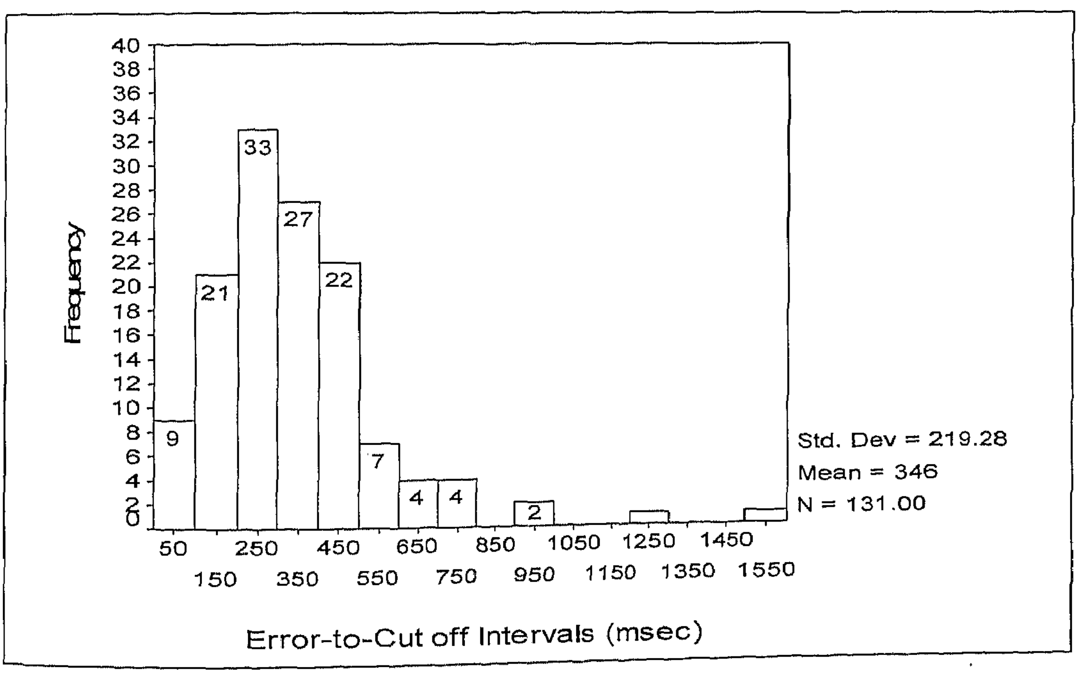

Figure 7.4

Error-to-Cut off Intervals for Repeats

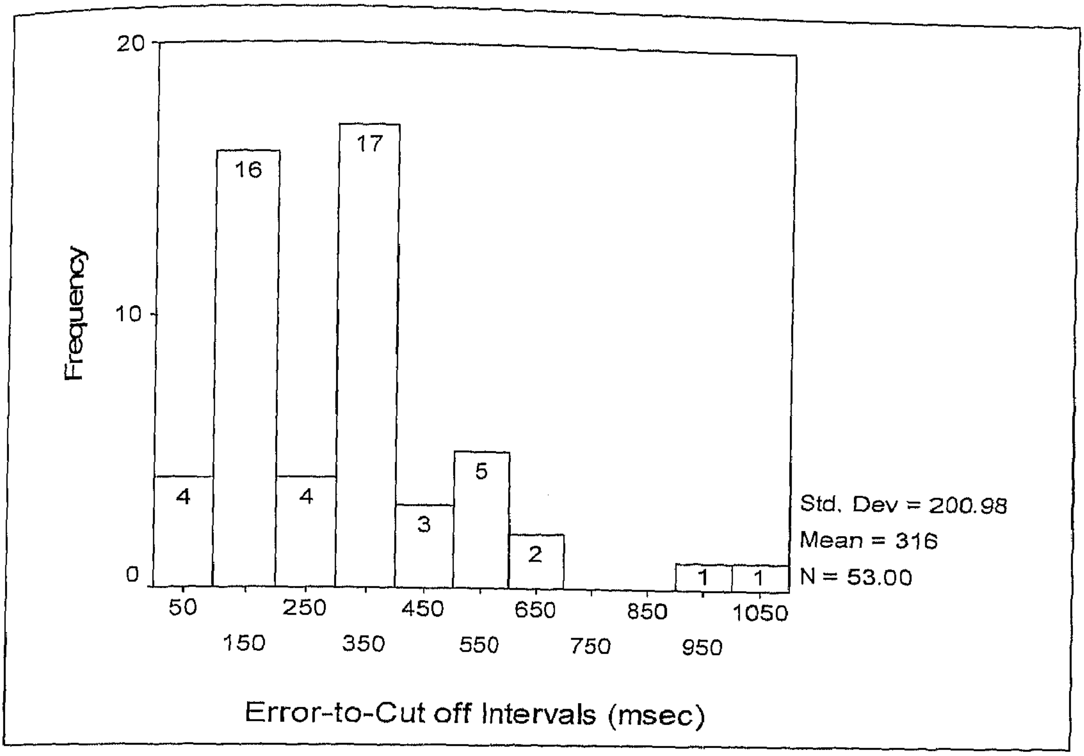

Figure 7.5

Error-to-Cut off Intervals for Deletions

Figure 7.6 compares the distribution of error-to-cut off intervals among the four self-repairs. Half of the intervals for insertions were approximately between 165 to 503msec, compared to approximately between 157 to 381msec for deletions, 255 to 452msec for substitutions and 210 to 431msec for repeats. The median intervals for repeats and substitutions were higher compared to insertions and deletions, with deletions having the lowest median interval. However, a *Kruskal Wallis test* showed that there was no significant difference in the error-to-cut off intervals among the four self-repairs, $\chi^2(3) = 2.64, p > 0.05$, n.s.

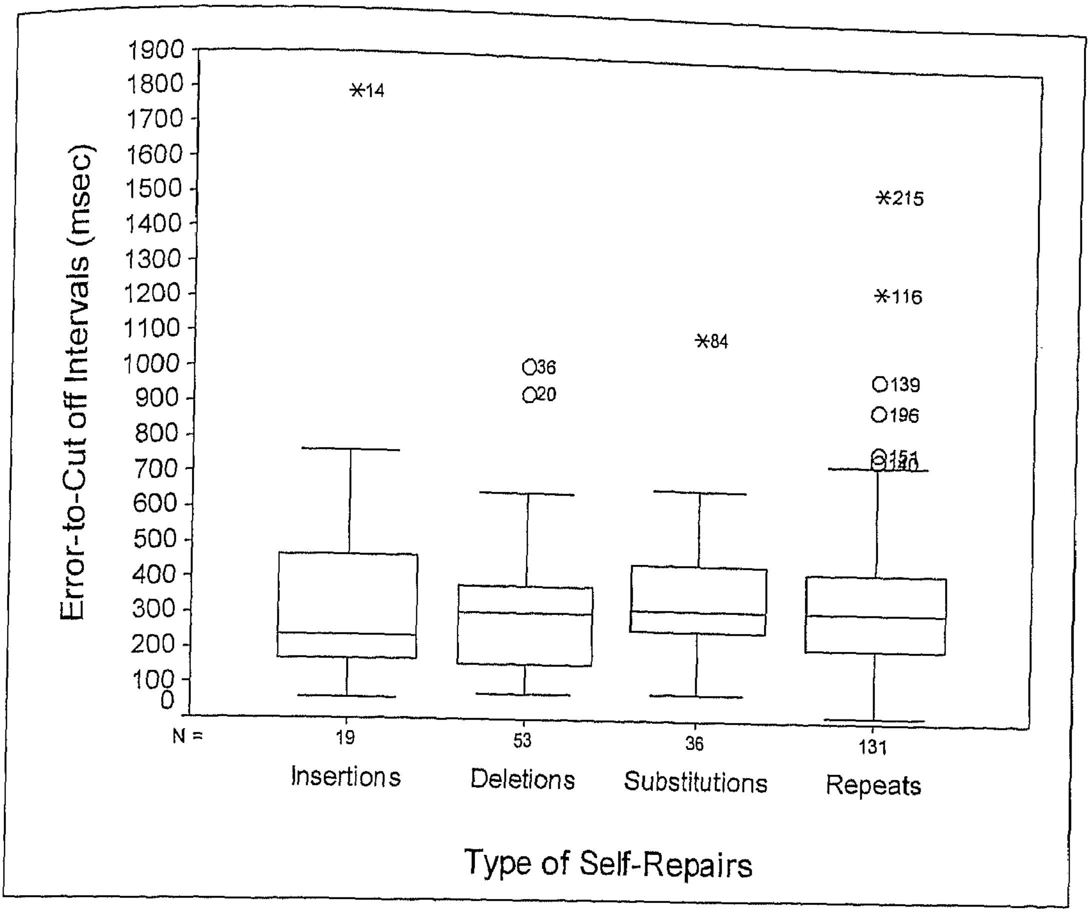

Figure 7.6

Boxplots of Error-to-Cut off Intervals for Each Self-Repair

7.3 Cut off-to-Repair Intervals

The cut off-to repair intervals were measured from the perceived interruption point to the onset of repair in self-repairs, and to the onset of the word following the hesitation in possible-repairs. As shown in table 7.4, the intervals for the entire sample (n = 377), comprising 138 possible repairs, 131 repeats and 108 repairs had a mean of 257.3msec, median of 90msec, mode of 0msec and a standard deviation of 364.1msec. Individually, self-repairs (n = 239) had a mean of 133.6msec, median and mode of 0msec, and a standard deviation of 261msec. In comparison, possible-repairs (n = 138) had a mean of 471.6msec, median of 391msec, mode of 0msec and a standard deviation of 415.3msec.

As Table 7.4 shows, more than 50% of each of the self-repairs had 0msec cut off-to-repair intervals compared to only 15.2% of the possible-repairs. Similarly, all the self-repairs had a much higher percentage of intervals that were below 100msec (71%) and 250msec (79%), compared to possible-repairs, where the intervals, in general, tended to be longer.

Table 7.4
Cut off-to Repair Intervals for Self-Repairs

Repairs	N	Mean (msec)	Mode (msec)	Median (msec)	Skew (msec)	s.d. (msec)	0msec %	less than 100 msec %	less than 250 msec %
Possible-repairs	138	471.6	0	391	1.73	415.3	15.2 (21)	15.9 (22)	28.3 (39)
Self-Repairs	239	134.0	0	0	2.53	261.0	67 (160)	71 (170)	79 (190)
Repeats	131	85.5	0	0	2.85	197.7	64 (98)	74.4 (105)	82.4 (113)
Deletes	53	229.0	0	0	1.66	345.6	54.7 (29)	56.6 (30)	69.8 (37)
Substitution	36	143.8	0	0	3.23	300.0	66.7 (24)	69.4 (25)	75.0 (27)
Insertions	19	179.8	0	88.0	1.21	229.1	47.4 (9)	52.6 (10)	68.4 (13)
All Repairs	377	257.3	0	90.0	2.07	364.1	48 (181)	50.9 (192)	60.7 (229)
Blackmer & Mitton (1991) All Repairs	1525	530				223	12.4	32.1	44.8
Self-Repairs-repetitions	108	192.0		0	2.1	312.8	57.4 (62)	60.2 (65)	71.3 (77)
Blackmer & Mitton (1991) Overt Repairs only	391	332				282	19.2	48.6	

The figures of 0msec, 100msec and 250msec were used to enable comparison with Blackmer and Mitton's (1991) findings. An analysis of the cut off-to-repair intervals in this study shows that a higher percentage of these intervals were shorter than 100msec and 250msec as shown in Table 7.4. More than half (60.7%) of these intervals were shorter than 250msec, compared to 44.8% in Blackmer and Mitton's sample, while 50.9% of the sample had intervals of less than 100msec compared to 32.1% in Blackmer and Mitton. Blackmer and Mitton also reported that 12.4% of their overall sample had a cut off-to-repair time of 0msec, compared to 48% of the entire sample in this study. The differences between this study and Blackmer and Mitton can be attributed to the different manner used to categorize the repairs. However, more importantly, both sets of data show that short cut off-to-repair intervals can be found in naturally-occuring spontaneous speech.

Figures 7.7, 7.8 and 7.9 show the frequency distribution of the cut off-to-repair intervals for the entire sample, possible-repairs and self-repairs respectively. The three histograms show that long cut off-to-repair intervals are not common in all repairs, although the intervals in possible-repairs tend to be longer than in self-repairs. Most of the intervals were 600msec and below for possible-repairs compared to most of them being 200msec and below for self-repairs. In fact, a *Mann-Whitney U Test* showed that there was a significant difference between the cut off-to-repair intervals for self-repairs and possible-repairs, U ($N_1 = 239$, $N_2 = 138$) 6637, $p < .001$. As discussed in 5.4.2, the shorter intervals for self-repairs imply that the repair is ready soon after, or even immediately, in the case of 0msec intervals when speech is interrupted. This suggests that repair-planning may have been ongoing even during the production of speech prior to the cut off.

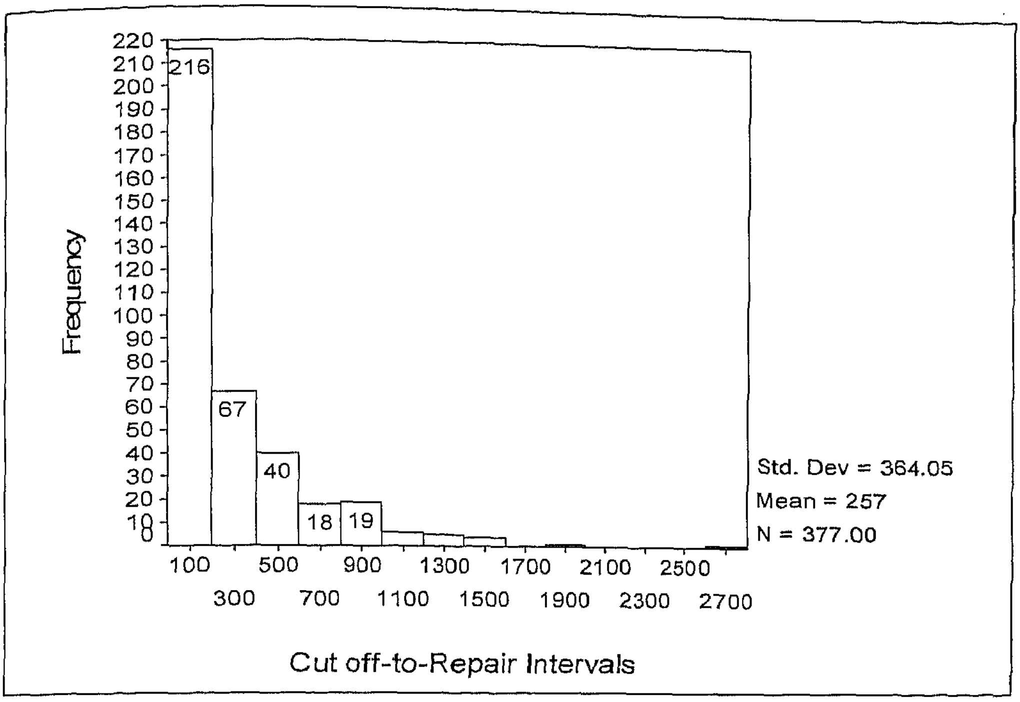

Figure 7.7

Cut off-to-Repair Intervals for Self-Repairs and Possible-Repairs

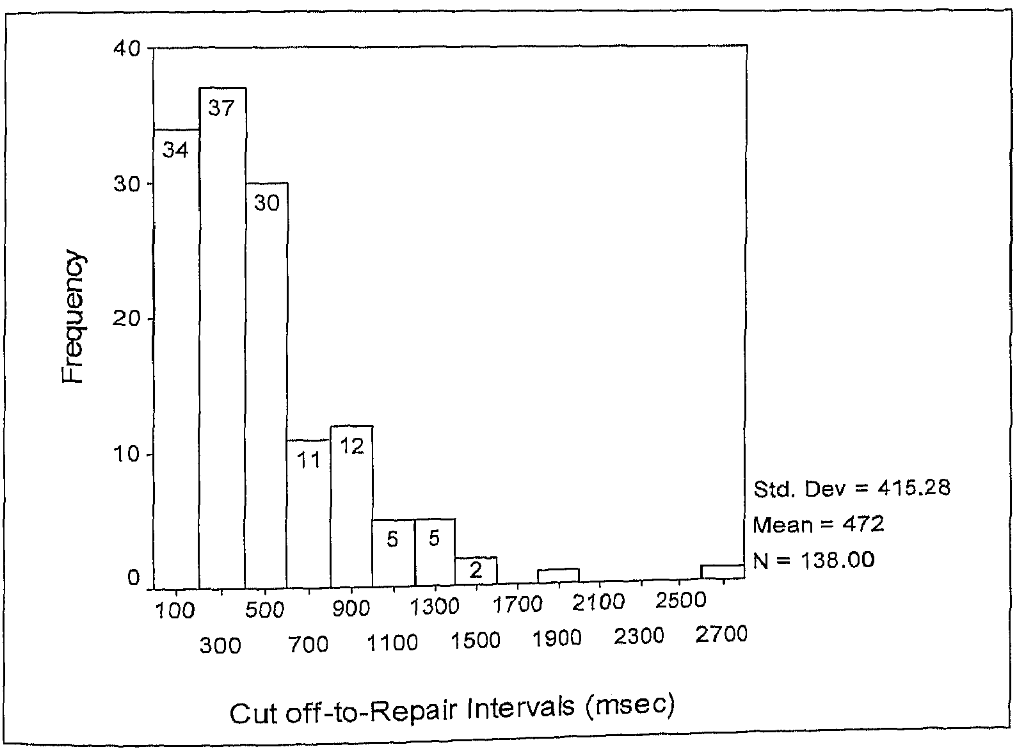

Figure 7.8

Cut off-to-Repair Intervals for Possible-Repairs

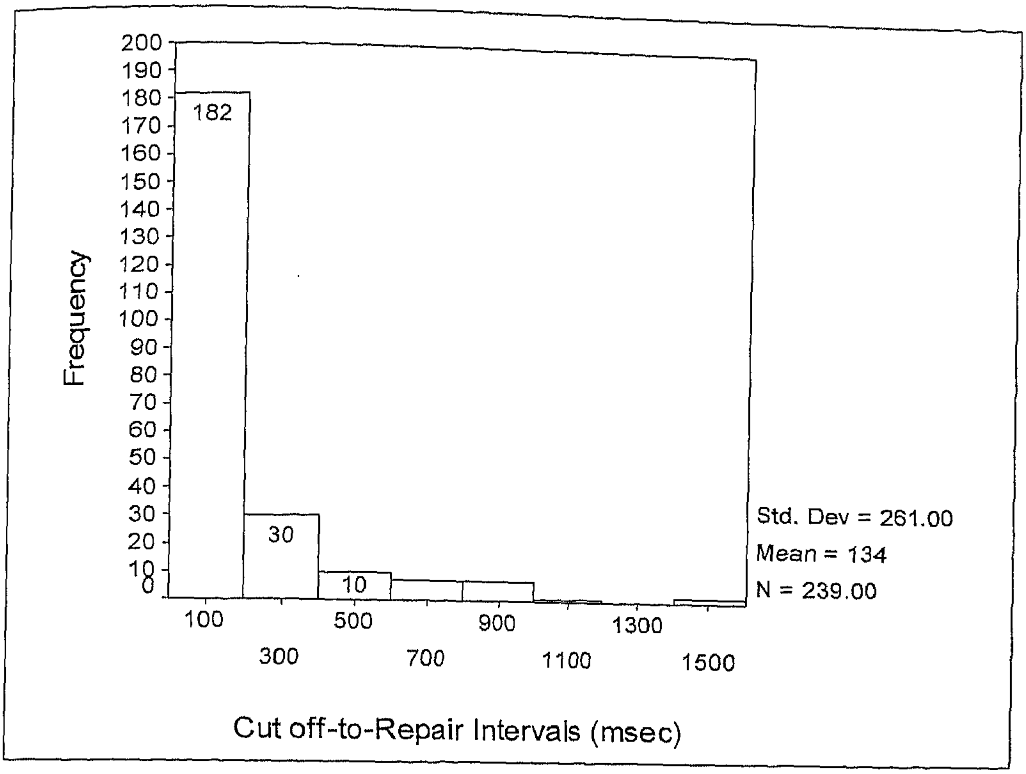

Figure 7.9

Frequency Distribution of Cut off-to-Repair Intervals for Self-Repairs

Figures 7.10, 7.11, 7.12 and 7.13 show the frequency distribution of cut off-to-repair intervals for each of the self-repairs, while Figure 7.14 compares the distribution of this interval in all the self-repairs and possible repairs. The histograms show that short cut off-to-repair intervals of 100msec and below were common in all the self-repairs. The distributions were all positively skewed, and this can be attributed to the large numbers of 0msec intervals (see Table 7.4) in all the self-repairs. The means, medians and modes of each of the self-repairs are reported in Table 7.4.

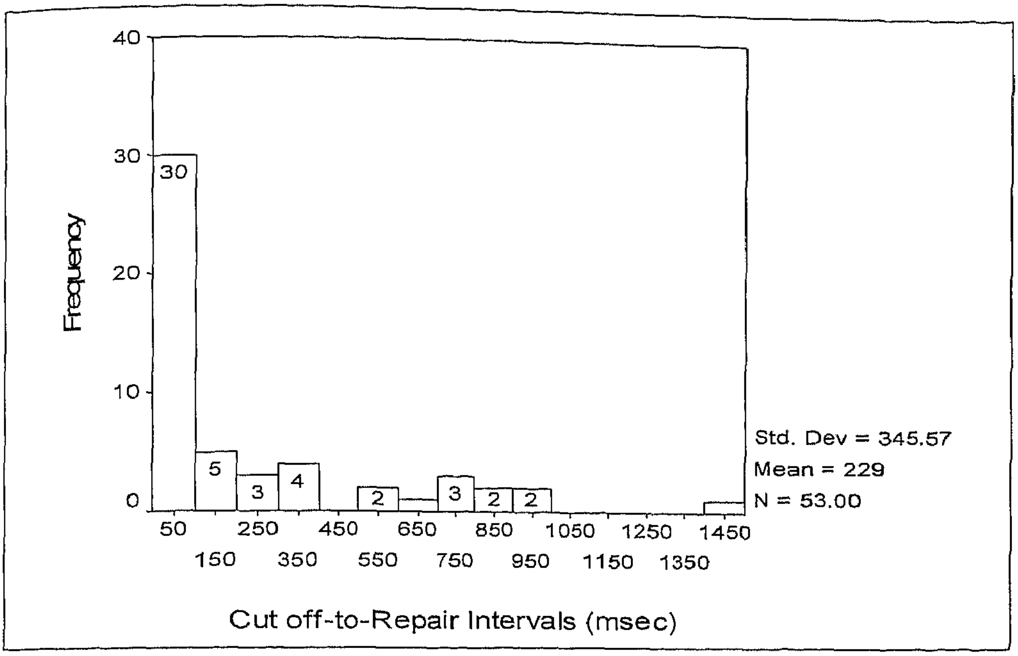

Figure 7.10

Cut off-to-Repair Intervals for Deletions

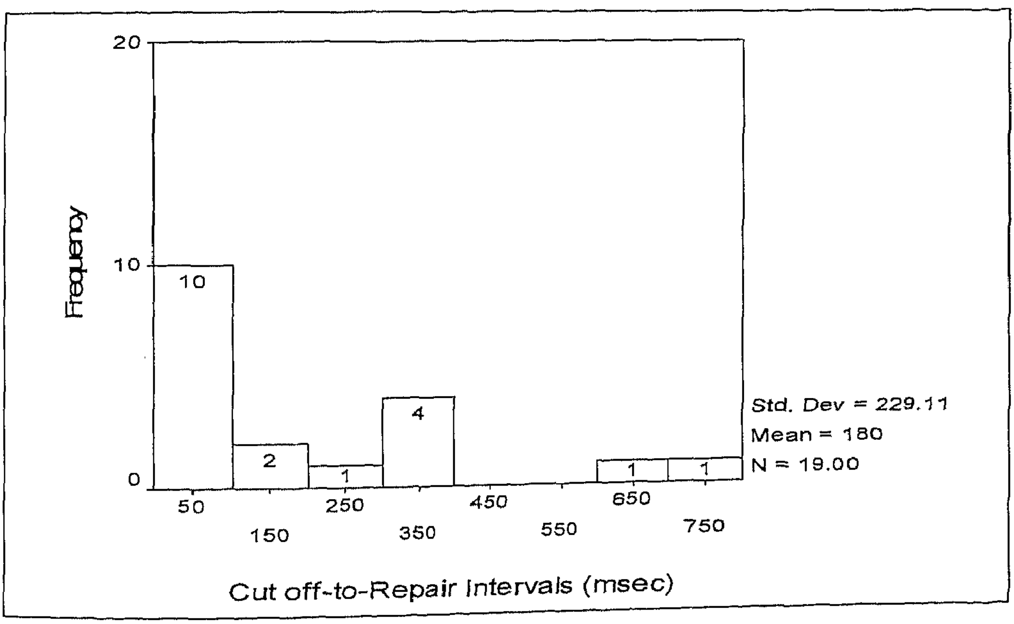

Figure 7.11

Cut off-to-Repair Intervals for Insertions

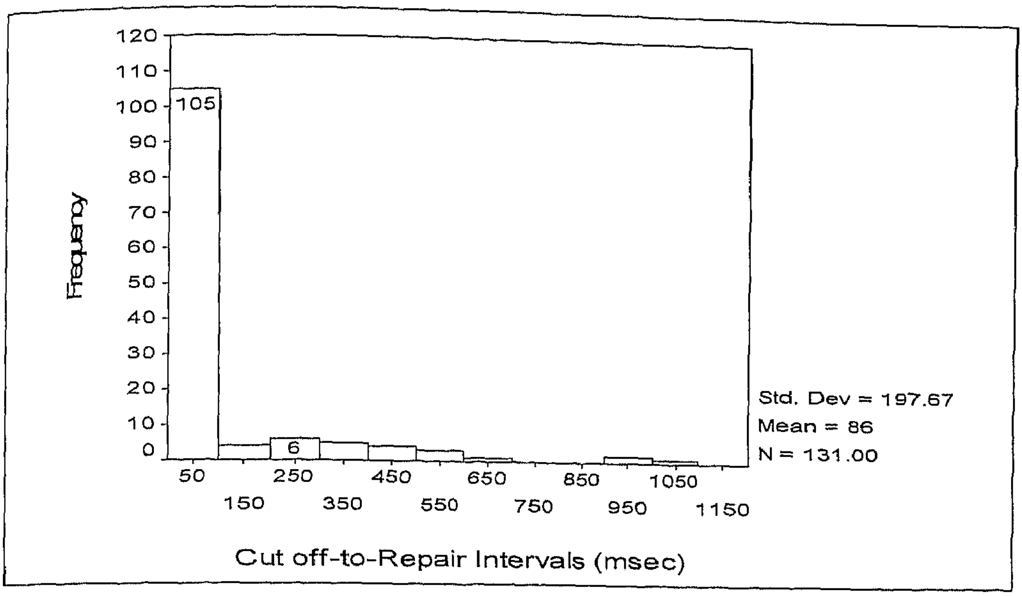

Figure 7.12

Cut off-to-Repair Intervals for Repeats

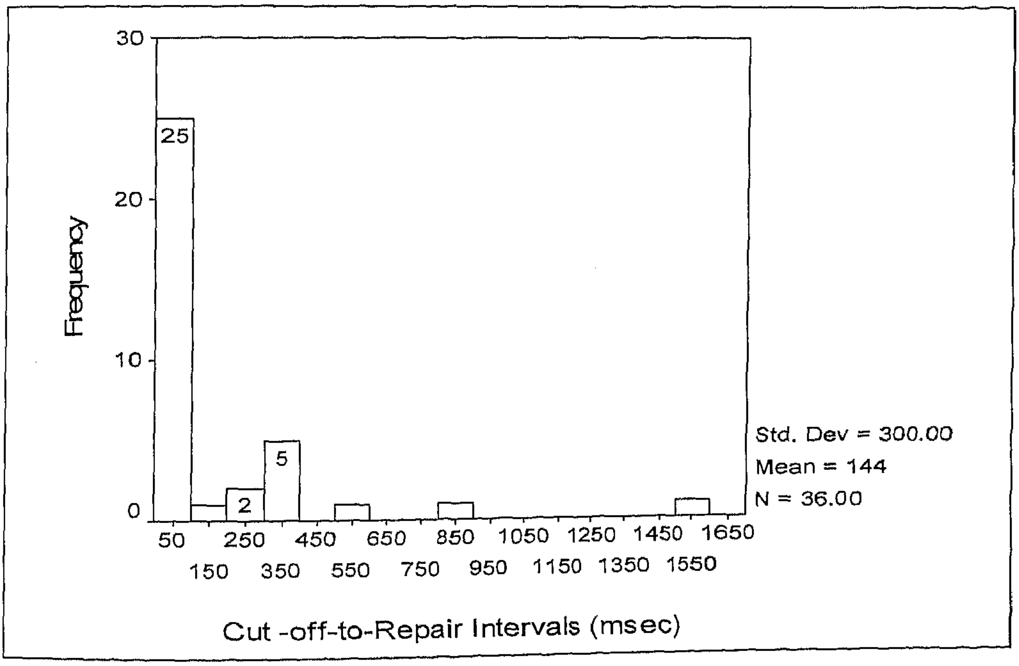

Figure 7.13

Cut off-to-Repair Intervals for Substitutions

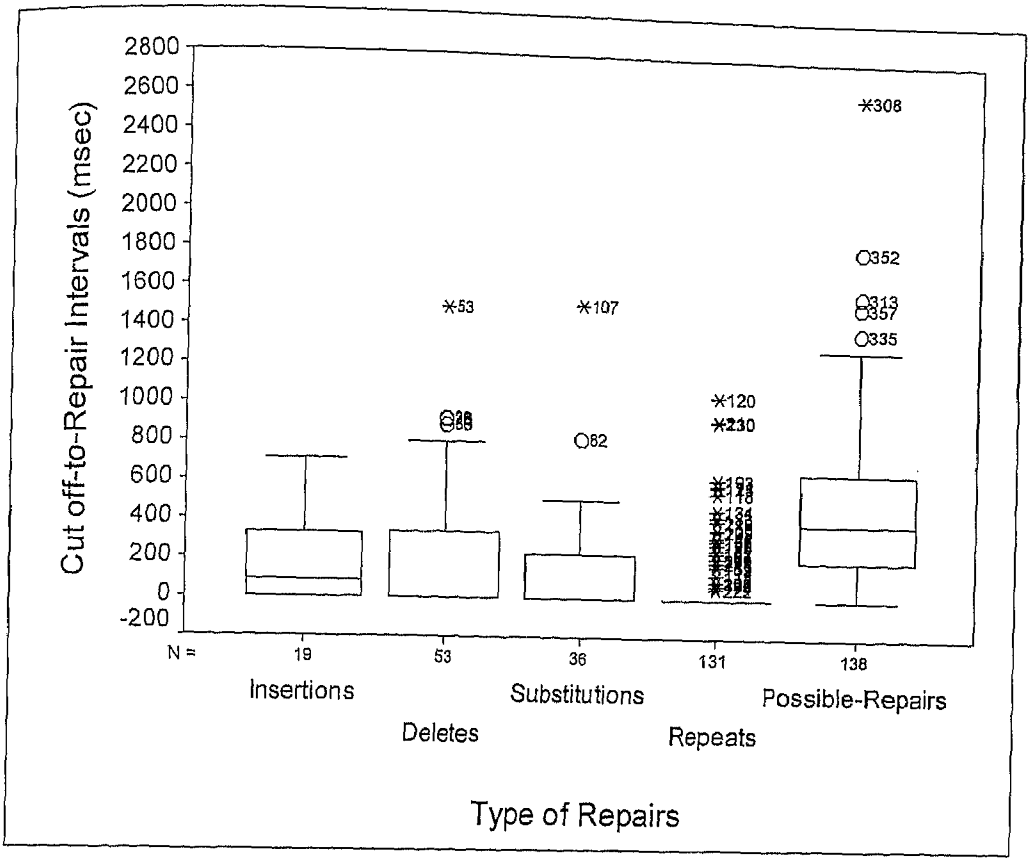

Figure 7.14

Boxplots of Self-Repairs and Possible-Repairs

The boxplots in Figure 7.14 show that half of the intervals for deletions, insertions and substitutions were approximately between 0msec to 356msec, 351msec and 241msec respectively. Insertions had the highest median among the self-repairs (88msec), while the others all had medians of 0msec. In contrast, the intervals for possible-repairs tended to be longer, with half of the possible repairs intervals falling approximately between 200 to 656msec. The median of possible-repairs was also much higher at 391msec. A *Kruskal-Wallis Test* shows that there was a significant difference in the cut off-to-repair intervals between the self-repairs and possible-repairs, $\chi^2(4) = 115.075$, $p < 0.05$. The same test also showed that there was a significant difference in the cut off-to-repair intervals of self-repairs, $\chi^2 (3) = 13.128, p < 0.05$.

Such short cut off-to-repair intervals have implications for planning time. This is because most monitoring theories suggest that the planning of a repair commences after the point of interruption and that this intervals reflects repair-planning time. However, the substantial number of cut off-to repair intervals of 0msec (see Table 7.4), which have no editing phase, found in the sample challenges this notion, because in such cases the repair must have been ready at the moment of interruption. This in turn suggests that the repair must have been planned prior to the cut off, with the possibility of repair-planning taking place even during the production of speech following the detection and, in the case of overt repairs the production of the speech. Therefore, in such cases, the notion of post-articulatory error-detection and repair-planning commencing upon the cessation of speech does not explain the short intervals. Thus, Hartsuiker and Kolk (2001), suggest that the process of interruption and repair are simultaneously triggered when a problem is detected (see 3.5.2.1), which means that a repair can be ready upon or soon after interruption. In other words, repair does need to commence only upon interruption.

If we assume that a problem is detected in internal speech (see Figure 3.1) or possibly at the level where a message has been phonologically encoded (Levelt, 2001: Levelt, Roelofs & Meyer, 1999), and the signal to interrupt has been sent, according to the Perceptual Loop Theory, repair-planning involves going back to the Conceptualizer and Formulator, subsequently sending the repair to the Articulator (see Figure 3.1) to be produced. However, a comparison of the structure of the four self-repairs reveal that in repeats, no overt 'error' is produced. The assumption is that the repeat is an indication of pre-articulatory error-detection and repair-planning in progress. Based on this assumption and the fact that a repeat involves the production of the same word or words, it has been shown (Nota & Honda, 2003) that the production of the repeated element may not actually involve going back to the Conceptualizer (see 3.5.2.2). In relation to this, we would anticipate that the cut off-to-repair interval for repeats should, therefore, be shorter than the other actual repairs.

A *Mann Whitney U Test* shows that there was a difference in the intervals between repeats and the other self-repairs (deletions, insertions and substitutions), U ($N_1 = 98$, $N_2 = 131$) 52615, p<0.5. However, when the cut off-to-repair intervals of repeats were independently compared to each of the other self-repairs, there was found to be a significant difference in duration with only deletions, U ($N_1 = 53$, $N_2 = 131$) 2637, $p<0.05$. An *Independent Sampel T-Test* also showed that the mean for deletions was bigger than that of repetitions, $t(2.839) = 66.215$, $p < .05$. However, there were no significant differences between repeats and deletions and repeats and substitutions. Perhaps the difference between repeats and deletions may be due to the fact that deletions mean that speakers have to produce a completely new utterance as there is no repetition of any part of the utterance preceding the interruption point, unlike repeats.

7.4 Error-to-Repair Intervals

The error-to-repair intervals for self-repairs were analysed by measuring the duration from the onset of the error to the onset of the repair. The interval for all the self-repairs had a mean duration of 506msec, a median of 373.4msec, a mode of 265msec and a standard deviation of 537msec. The frequency distribution of error-to-repair intervals for all the self-repairs is shown in Figure 7.15, where it can be seen that, similar to error-to-cut off and cut off-to repair intervals, long error-to-repair intervals were not common, with most of the intervals falling below 1 second

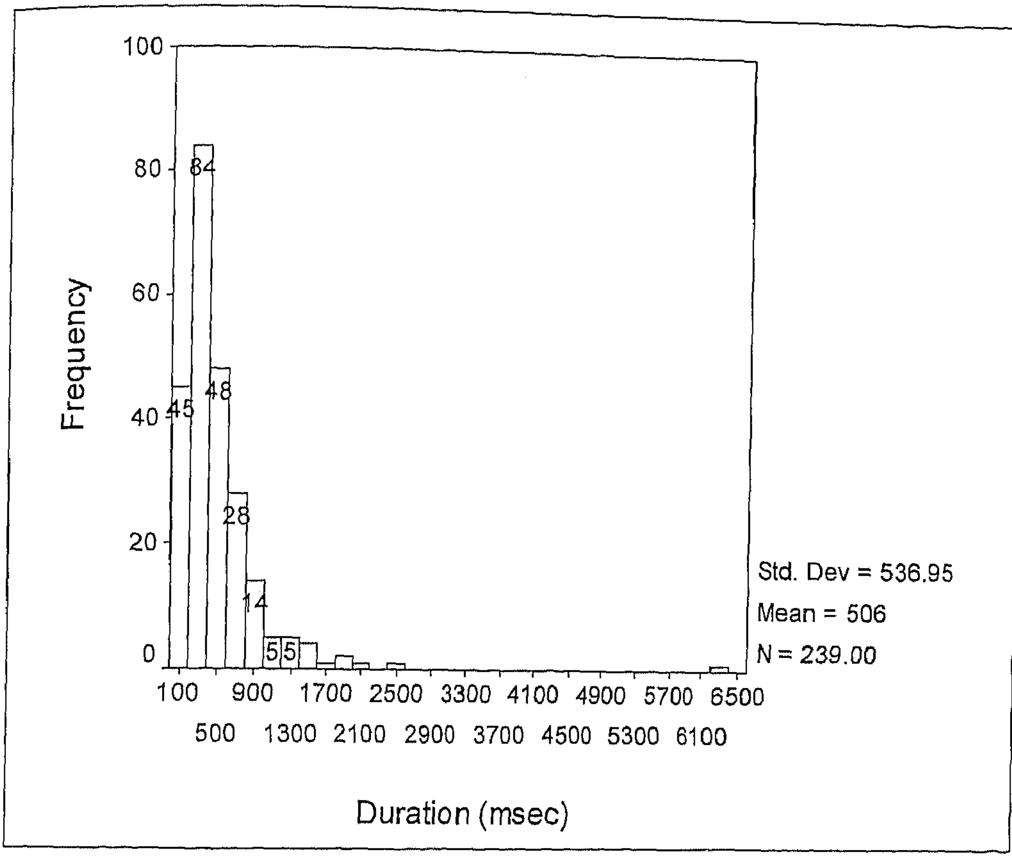

Figure 7.15

Frequency Distribution of Error-to-Repair Intervals for Self-Repairs

As shown in Table 7.5, error-to-repair intervals of less than 200msec were found in all the repair types. They accounted for 19.2% (46) of all self-repairs, and 20.4% (22) of the self-repairs if repetitions were excluded. The latter figure is almost twice the percentage cited by Blackmer and Mitton (1991), who found that 10% of their overt repairs had error-to-repair intervals below 200msec (see 3.5.3). The mean duration of self-repairs without the repetitions of 595msec is shorter than the mean of 838msec for overt repairs found in Blackmer and Mitton (1991).

Table 7.5

Error-to-Repair Intervals for Self Repairs

Self-Repairs	N	Mean (msec)	Median (msec)	Mode (msec)	s.d (msec)	Skewness (msec)	less than 200 msec (%)
Repeats	131	431.6	357.0	265	299.5	1.7	18.3 (24)
Deletes	53	544.8	373.0	126	455.3	1.4	24.5 (13)
Substitutions	36	675.1	441.5	76	1042.8	4.9	8.6 (3)
Insertions	19	585.1	377.0	748	585.0	2.1	30 (6)
All Self-Repairs	239	505.6	373.0	265	537.0	6.1	19.2 (46)
Self-Repairs *-repetitions*	108	347.9	310.0	197	244.7	2.5	20.4% (22)
Blackmer & Mitton (1991) overt Repairs	391	838.0			452.0		10 (34)

n.b. Figures in parenthesis indicate number of occurrences

The error-to-repair intervals of less than 200ms is not accounted for by Laver's editor monitoring theory, which would require about 180ms for detection time alone beginning with the onset of overt speech (see 3.3.2.1). Levelt's (1983; 1989) Perceptual Loop Theory, while explaining prearticulatory monitoring, still leaves the question as to how early such monitoring begins. This theory estimates that it takes at least 100ms to monitor inner speech (see Figure 3.1). If an error is detected, then instructions to halt speech must be given, which is thought to take up to 200ms. The planning of the repair is then said to begin after interruption. Such a model would not be able to account for short error-to-repair intervals, unless as suggested by Blackmer and Mitton (1991), there is the presence of an articulatory buffer, which would allow sufficient time for error detection, while the intended utterance is in storage in the buffer (see 3.5.3). However, repair-planning would still involve conceptualizing and formulating the repair (except it is posited, for repeats), thus adding to the time taken from error-detection to the production of the repair. Alternatively, as discussed earlier, it has been suggested that the process of error-detection simultaneously triggers the processes of interruption and repair (Hartsuiker and Kolk, 2001).

Figures 7.16 to 7.19 show the frequency distribution of error-to-repair intervals for each of the self-repairs, while Figure 7.20 compares the distribution of error-to-cut off intervals among the self-repairs. The histograms show that long intervals did not frequently occur in all the self-repairs.

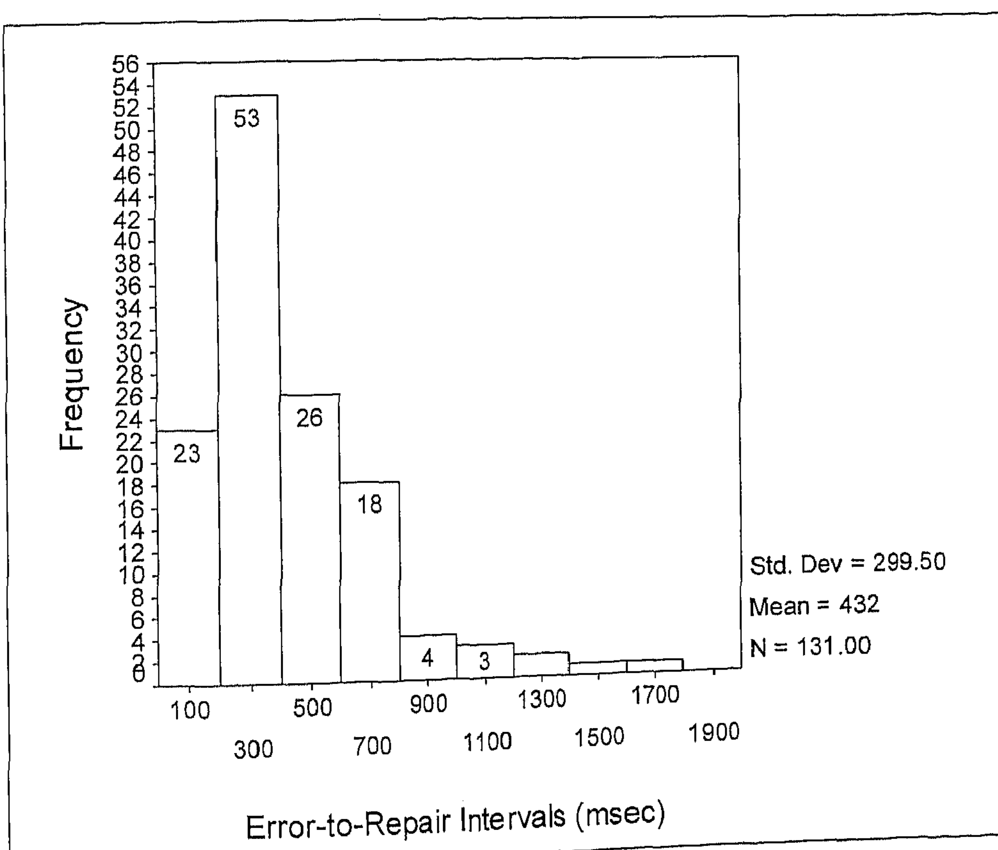

Figure 7.16

Error-to-Repair Intervals for Repeats

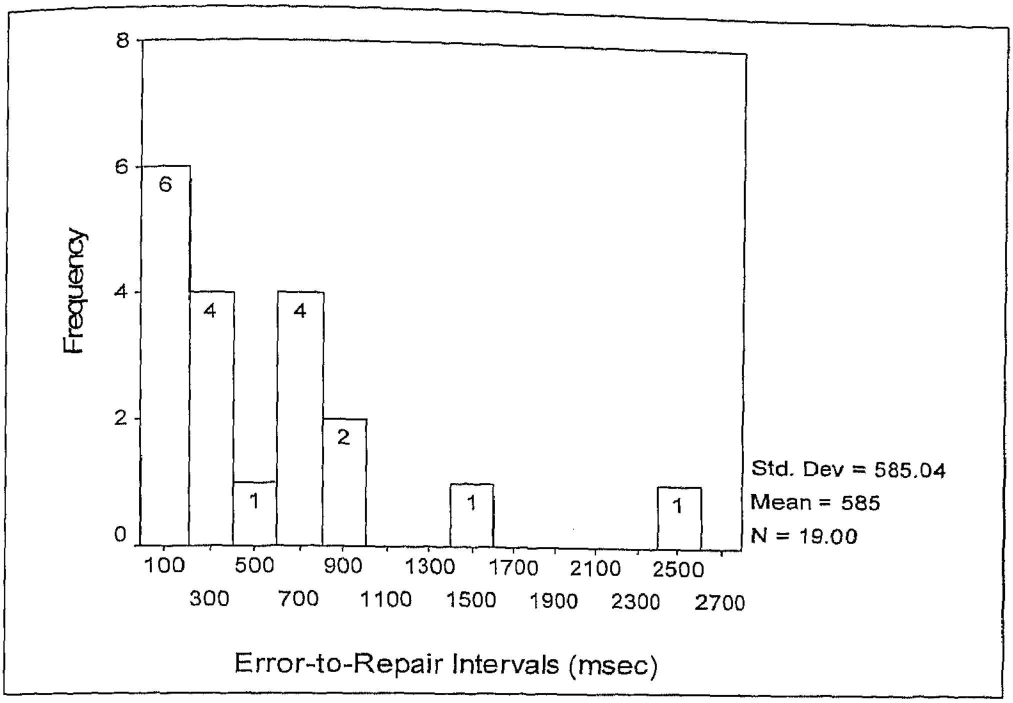

Figure 7.17

Error-to-Repair Intervals for Insertions

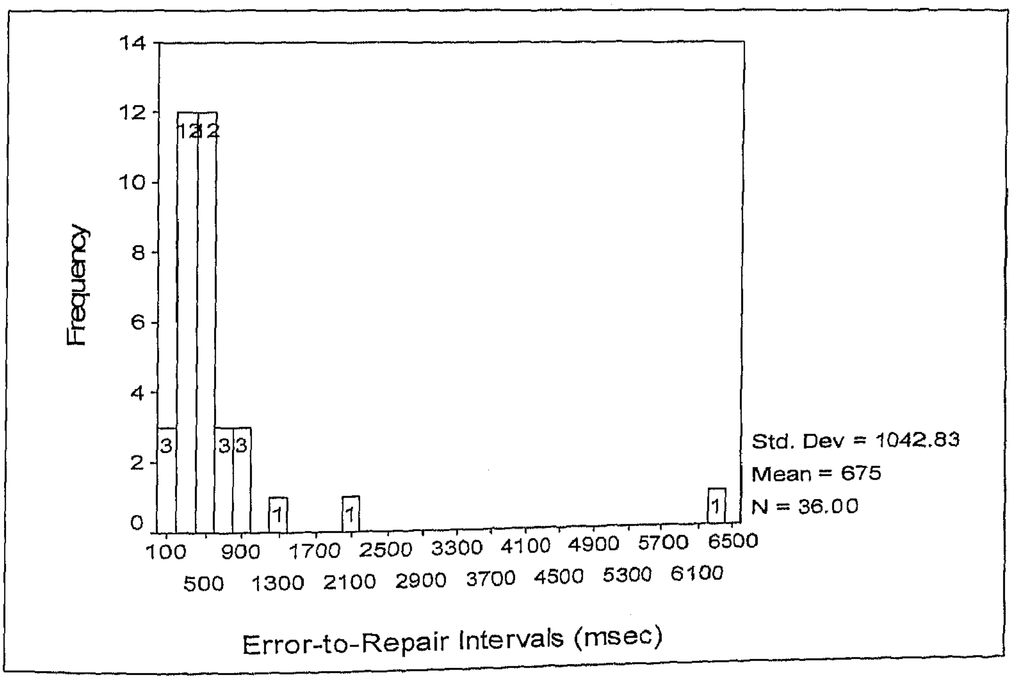

Figure 7.18

Error-to-Repair Intervals for Substitutions

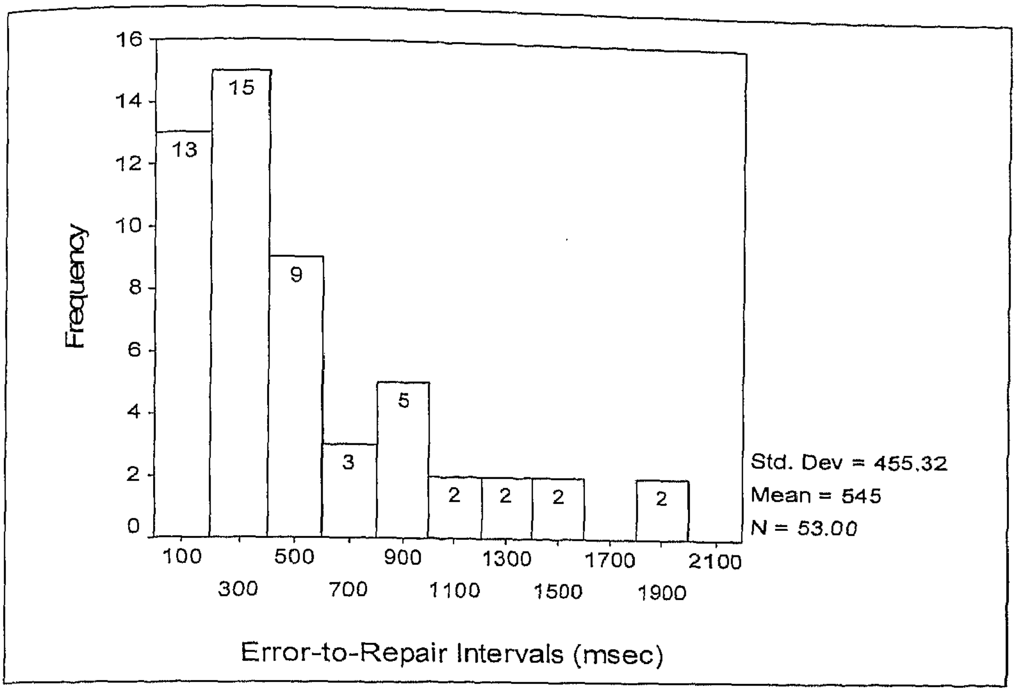

Figure 7.19

Error-to-Repair Intervals for Deletions

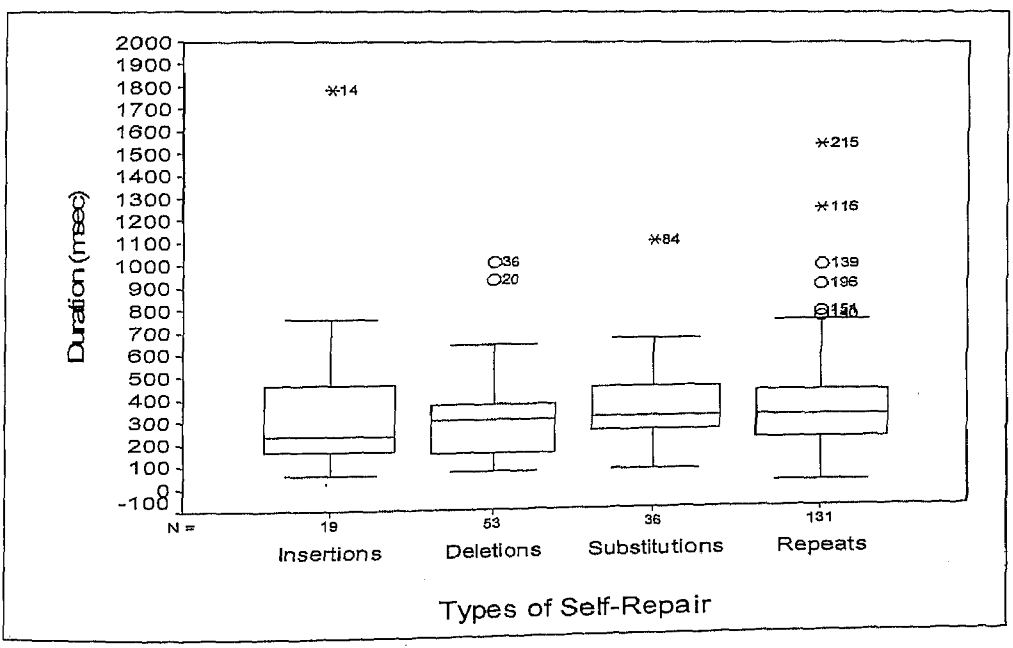

Figure 7.20

Boxplots of Error-to-Repair Intervals for Each Self-Repair

Although a comparison of the boxplots in Figure 7.20 shows that the median of substitution was higher than the other self-repairs which were all within 357 to 377msec, a *Kruskal-Wallis Test* showed that there was no significant difference in the error-to-repair intervals of self-repairs, $\chi^2(3)=3.101$, $p > 0.05$, n.s. Hence, the substitutions in this study did not have a significantly longer error-to-cut off interval than any of the other self-repairs. Neither did repeats have a significantly shorter interval that each of the other self-repairs, even though repeats are said to be restarts requiring backing up to the Articulatory Buffer, and not to the Conceptualizer (Blackmer & Mitton, 1991; Nota & Honda, 2003). Perhaps, this is because even though the production of the repeatable element only involves retrieving this item from the Articulatory Buffer, a speaker might be in the process of planning the repair for a prearticulatorily detected error. This is based on the assumption that repeats are indications of prearticulatory error-detection and repair-planning.

7.5 Summary

The findings of the error-to-cut off, cut off-to-repair and error-to-repair intervals indicate the possibility of prearticulatory monitoring, error-detection and repair-planning. The presence of short error-to-cut off intervals, particularly those below 150msec strongly suggest the presence of prearticulatory error detection. This is because such short intervals show that speech can be interrupted very soon after the production of the error, which in turn, means that the error must have been detected prior to the production of the error, giving enough time for the signal to interrupt speech to be given. This possibility is especially strengthened by the fact that about one third of these short intervals were instances where the error (including the repeatable element) was cut off as a fragment. Further, the large number of cut off-to-repair intervals of 0msec among the self-repairs (71%) questions the possibility of repair-planning commencing at the point of interruption, as the repair must have been planned earlier in order for it to be ready immediately upon interruption, without the need for filled and/or silent pauses. It could well be that repair-planning also begins upon the detection of an error as suggested by Hartsuiker and Kolk (2001) or at least earlier than upon interruption of speech. This is further supported by short error-to-repair intervals, whereby the majority of these intervals were below 1 second.

While this chapter has reported on the three time intervals related to self-monitoring: error-to-cut off, cut off-to-repair and error-to-repair intervals, and discussed the results in relation to Levelt's (1983; 1989) model of self-monitoring and findings from other studies, the next chapter will summarize the main findings and implications of this study and suggest directions for future research.