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THE TIMING OF SELF-REPAIRS IN SECOND LANGUAGE SPEECH PRODUCTION

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The study explores the psycholinguistic processes underlying L2 self-repair behavior by means of analyzing the timing of various types of self-corrections found in the speech of 30 Hungarian speakers of English at three levels of proficiency (pre-intermediate, upper-intermediate, and advanced). The paper discusses the relevance of timing data for the existing models of speech monitoring and examines how the level of proficiency of L2 learners affects the speed of error detection and the execution of correction. The results obtained indicate that the perceptual loop theory and the activation spreading theory of monitoring both rightly assume that monitoring involves the same mechanisms as speech comprehension. The analysis of the timing data reveals that corrections of pragmatically inappropriate lexical choice have detection times very similar to those of lexical errors. This may be regarded as indirect evidence for the claim that lexical entries in the mental lexicon also contain specifications concerning their pragmatic value. The results show that the level of proficiency of the participants affects the time necessary for the lexical, grammatical, and phonological encoding of the repair, which is caused by the difference in the degree of automaticity of these mechanisms at various stages of L2 development.

The timing of speech production processes has always been of great interest to psycholinguists, as it provides indirect evidence for the functioning of underlying cognitive mechanisms. The length of filled and unfilled pauses has

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been assumed to indicate planning processes (for a comprehensive treatment of this issue, see Dechert & Raupach, 1980) and the speed of producing the utterance in L2 to signal the degree of automatization (for a review of theories of the development of automaticity in L2 production, see Schmidt, 1992). In self-repair research, the examination of the aspects of timing can yield insights into the psycholinguistic mechanisms of error detection, the functioning of the monitor, as well as the difficulty and automaticity of the implementation of the correction. The analysis of timing data can also contribute to the empirical validation of the various theories of monitoring.

At present, there are three basic psycholinguistic models of monitoring for which the analysis of the timing of self-repairs can be relevant: the editor theories (Baars, Motley, & MacKay, 1975; Laver, 1980; Motley, Camden, & Baars, 1982), the activation spreading theory (Berg, 1986; Dell, 1986; Dell & O'Seaghda, 1991; MacKay, 1987, 1992; Stemberger, 1985), and the perceptual loop theory (Levelt, 1983, 1989, 1993; Levelt, Roelofs, & Meyer, 1999; for a more detailed review of the various theories of monitoring, see Kormos, 1999). Editor theories of monitoring assume that the editor can veto and replace the incorrect output of the speech production processes. In this model, the editor has its own system of rules against which the output is checked (Baars et al.; Motley et al.). In order to account for the occurrence of errors, these theories presume that either the system of rules the editor uses is incomplete (e.g., Garnsey & Dell, 1984) or the rules used at a given moment vary (e.g., Motley et al.). The major shortcoming of such models is that the editor can only check the final outcome of the processes and is unable to intercept erroneous output at intermediary levels. Several researchers working in the paradigm of editor theories of monitoring (e.g., Laver, 1980; Nooteboom, 1980) propose that there should be a specialized monitor at each stage of the processing system, which checks the correctness of the outcome of each process. Such a model is called the *distributed editor theory* because the monitor has access to the different stages of production.

Stemberger's (1985) and Dell's (1986) model of *interactive activation spreading* in speech production is based on an interactive network of units (e.g., words, morphemes, phonemes), as well as generative rules that create slots for the units. In this theory, decisions concerning which unit to select are made on the basis of the activation levels of *nodes* representing these units. Dell hypothesized that activation can spread in two directions: top-down (e.g., from words to morphemes) and bottom-up (e.g., from phonemes to morphemes). He also assumed that speech perception proceeds through the bottom-up flow of activation and that this mechanism is in operation when speakers monitor their own speech. Therefore, in this theory, monitoring is "an automatic by-product of bottom-up activation spreading" (Berg, 1986, p. 139). There are several problems with this conceptualization of monitoring. First of all, if errors are detected automatically, the monitor would perceive all errors, which, in turn, would be automatically corrected (Levelt, 1989). Empirical research, however, proves that speakers do not correct every mistake

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in their speech (Levelt, 1983). Second, monitoring involves not only recognizing linguistically erroneous output but also perceiving the pragmatic inappropriacy of the message and the inadequacy of the information conveyed (Levelt, 1983). The activation spreading models do not account for this significant aspect of monitoring at all (Levelt, 1992).

Levelt (1983, 1989, 1993; Levelt et al., 1999) proposed a new model for monitoring: the *perceptual loop theory*. Based on Postma and Kolk (1992, 1993) and Postma, Kolk, and Povel's (1990) research, which lent proof to the existence of covert repairs, Levelt's perceptual loop theory adopts the idea that prearticulatory output can be inspected. It was also proposed that the same mechanism could be applied both for checking one's own message and for perceiving and checking other speakers' utterances. In order to avoid the necessity for reduplication of knowledge, in this model, the speech comprehension system is used for attending to one's own speech as well as that of others. In the model, there are three loops for inspecting the outcome of processes. The first loop is the phase when, before being sent to the formulator, the *preverbal plan,* which specifies the speech-act intentions and their information structure, is compared to the speaker's original intentions. During the second loop, the message is monitored before articulation; this is called *covert* or *prearticulatory monitoring* (see also Postma & Kolk and Postma et al.). Finally, the generated utterance is checked after articulation, which constitutes the final, external loop of monitoring.

At present, only a few studies have investigated the exact timing of different types of self-repairs and the relevance of timing data for different theories of monitoring (e.g., Blackmer & Mitton, 1991; Levelt, 1989; van Hest, 1996). Research on speech comprehension has shown that word recognition takes place about 200 ms (milliseconds) after word onset (Marslen-Wilson & Tyler, 1980). On the basis of this, Levelt (1989) assumed that, in the case of overt repairs, the shortest time between the detection of the error and the cut-off point is also 200 ms. He estimated that the recognition of one's internal speech lasts for approximately 150 ms, and that the time between the delivery of the phonetic plan and the articulation is between 200 and 250 ms. Thus, speakers have a maximum of 100 ms for prearticulatory monitoring, which may not be enough to prevent the articulation of the erroneous utterance. Thus, the erroneous word is interrupted shortly after its articulation begins—that is, the time between the onset of the error and the point of interruption will be less than 200 ms. Because Levelt's (1989, 1993) model allows for parallel processing, it is possible that there is already some processed material ready for articulation in the articulatory buffer; consequently, speakers can intercept erroneous output before it is articulated (covert repair).

In order to verify Levelt's (1989) estimations, Blackmer and Mitton (1991) carried out an empirical study in which they found a high number of repairs with short error-to-cut-off and cut-off-to-repair intervals (less than 150 ms). They argued that, with respect to corrections with cut-off-to-repair intervals shorter than 150 ms, it is unlikely that utterance replanning could take place

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within this period of time. Therefore, they assumed that speakers often start processing the repair before the flow of speech is interrupted. This hypothesis was confirmed by significant negative correlations between the error-to-cut-off and the cut-off-to-repair intervals in the case of fast repairs in their database. On the basis of these results, Blackmer and Mitton did not accept the cut-off point as a reliable measure of the point of error recognition, and they also argued that the cut-off-to-repair intervals do not equal the total period of time spent replanning the utterance. Additionally, the very short cut-off times found in their study did not lend proof to the existence of distributed editors (Laver, 1980; Nooteboom, 1980), because in the distributed editor models, detection is assumed to take at least 200 ms and parallel processing is not allowed.

Because the very fast repairs analyzed by Blackmer and Mitton (1991) occurred infrequently in van Hest's (1996) study, which was based on a corpus of self-repairs produced by Dutch speakers both in their mother tongue and in English in three different types of tasks (picture description, story telling, and personal interview), she adopted a less rigid approach to analyzing the timing of self-repairs. She assumed that the error-to-cut-off intervals are mainly indicative of the time of detection, and that the error-to-repair intervals signal the time spent replanning the utterance. The results of van Hest's project suggest that phonological errors are detected and interrupted faster than lexical errors, whereas inappropriate words seem to be recognized with the slowest speed. Van Hest explained these findings by arguing that, in Levelt's (1989, 1993) model, the correction route of phonological errors is the shortest, as all the other types of errors or inappropriacies need to be checked in the conceptualizer against the original communicative intention. This study also revealed that the cut-off-to-repair intervals of L2 speakers were longer than those in L1 speech, which van Hest assumed was due to a lower degree of automatization of the L2 production processes. The effect of L2 proficiency on the timing of self-repairs, however, was not investigated in this study.

As can be seen from this literature review, only one study investigated the timing of various L2 self-repairs (van Hest, 1996). There is a great need, however, for comprehensive research that involves typologically more different languages than Dutch and English. Studies utilizing reliable tools of data analysis are also needed because they have immediate relevance for the theory of L2 speech production. The research reported here attempts to explore in greater depth, by means of modern computer technology, the timing of various subtypes of self-repairs.

In order to enhance the reliability of the classification of self-corrections, retrospective verbal reports were also collected. Two main issues were investigated in this respect: (a) What underlying psycholinguistic processes are indicated by the differences in the timing of various types of self-corrections?; and (b) how does the level of proficiency influence the speed of error detection and the execution of the correction? I will begin by describing the method of data collection, the classification of self-repairs, and the analysis of the tim-

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Table 1. The analysis of variance of the C-test scores of the participants

Group	*M* (max. *n* = 63)	*SD*	Source of variance	*df*	*SS*	*MS*	*F* ratio
Pre-intermediate	23.20	5.67	Between groups	2	5913.87	2956.93	
Upper-intermediate	47.00	5.43	Within groups	26	612.00	22.66	130.45*
Advanced	56.60	2.50	Total	28	6464.00		

*$p < .001$.

ing of self-repairs. The findings are then presented and discussed. Finally, the effect of proficiency on the speed of error recognition and the implementation of repairs is examined.

METHOD

Participants

The participants in the study were 30 native speakers of Hungarian. Ten participants attended an exam preparation course in a language school. Their ages ranged from 16 to 22 years. Ten subjects attended an evening course for retraining teachers at Eötvös University, Budapest, and were between 25 and 35 years old. Ten students studied English as day students at Eötvös University and were from 19 to 22 years old. Based on their proficiency test scores (the procedures used for measuring their proficiency are discussed in the next section), the participants were classified as advanced speakers (more than 54 points out of 63; Group 3), upper-intermediate speakers (between 53 and 41 points; Group 2), and pre-intermediate learners (below 40 points; Group 1). The proficiency levels of the three groups were found to be significantly different from each other, $F = 130.45$, $p < .001$ (see Table 1).

Setting and Procedures

The proficiency test administered to the participants was a C-test, in which every second half of every second word had been deleted. C-tests have proven to be a fairly reliable measure of global L2 competence (e.g., Dörnyei & Katona, 1992; Klein-Braley, 1985; Klein-Braley & Raatz, 1984). The test used in this study was validated by Dörnyei and Katona, who correlated the achievement of both university and secondary school students on the C-test and the TOEIC (Test of English for International Communication), which is considered to be a highly reliable measure of language proficiency.[1] The C-test administered to the participants consisted of three texts with 21 gaps each.

Following administration of the C-test, the subjects were interviewed one by one. First, the participants were asked to act out an approximately 5-min-

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ute-long information-gap-type role-play activity adapted from Jones (1991, p. 218) with the researcher as the interlocutor. The subjects' task was to answer an inquiry concerning a private room in a restaurant. Instructions and the necessary background information were provided in the subjects' native language.

The role-play task was followed by a 25- to 35-minute-long retrospective interview, conducted in the subjects' native language. In this interview, the participants, upon listening to their own speech, were requested to recall what problems they experienced in formulating their message in the L2 and how they had tried to solve these problems. The retrospective interview was conducted on the basis of guidelines set up by Ericsson and Simon (1980, 1993) to ensure the reliability of the data.

The performance of the task and the subsequent retrospective interview were both video and audio recorded. The transcriptions of the tasks were done by trained transcribers and were checked by the researcher. The retrospective interviews were transcribed by the researcher.

Analysis

With the help of the retrospective comments, a psycholinguistic system of classifying the self-repairs found in the corpus was devised on the basis of previous taxonomies of self-corrections (Brédart, 1991; Levelt, 1983; for a detailed discussion of the taxonomy, see Kormos, 1998a, 1999). Four major groups of self-repairs were distinguished: different information, appropriacy, error, and rephrasing. Owing to the small number of self-corrections of the various subtypes within the major groups of self-repairs, I only discuss the four main groups of self-repairs here (subtypes are listed and illustrated with examples in the Appendix).

The first main group of corrections is the different-information repair, which is used when speakers decide to encode different information than what they are currently formulating (Levelt, 1983). An example is given in (1).

(1) *You have to we have to make a contract.* (different-information repair)
Retrospection: *I realized that it is stupid to say that you have to make a contract, it's the restaurant that has to write it.*

The second main type of repair is the appropriacy repair, which differs from different-information repairs because it is employed when the speaker decides to encode the originally intended information in a modified way (Levelt, 1983). Speakers resort to appropriacy repairs, as in (2), when they have encoded information that needs to be made more precise, more coherent, pragmatically more appropriate, or less ambiguous.

(2) *There are er er twenty er tables er about twenty tables.* (appropriacy repair)
Retrospection: *Here I was thinking about the number of the tables in the restaurant.*

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The third main category—error repairs—involves mechanisms different from those of the two main correction types just discussed: In this case, speakers repair an accidental lapse, as in (3). Such lapses can occur at every phase of speech processing, that is, while accessing words, grammatical and phonological encoding, and articulating (for a detailed review of mechanisms of speech processing, see Levelt, 1989; Levelt et al., 1999).

(3) *You have to er rent it er for 35 person um it's max . . . minimum minimum yes.* (error repair)
Retrospection: *I realized that I was not using the right word. It's not maximum, but minimum, since it is a room for 40 people.*

The fourth main type of repair, a rephrasing repair, involves revising the form of the speaker's original message without changing its content. In this case, the speaker repeats a slightly modified version of a word or phrase because of uncertainty about its correctness, by either adding something or paraphrasing, or both. Rephrasing repairs are different from error repairs in that error repairs merely involve the correction of accidental lapses and, consequently, the issuing of the same preverbal plan in an unmodified form, whereas rephrasing repairs are signs of a lack of L2 competence:

(4) *We will er reflect er to you in another letter we will answer you.* (rephrasing repair)
Retrospection: *What happened here was that I was not sure whether "reflect" really means "answer." I knew what "reflect" means, but I do not know whether you can use it for writing as well, that is, whether it means the same in writing as in speech that you "reflect" on something.*

A digital recording of all the self-repairs found in the corpus was made. These digitized recordings were then entered into a computer. For analyzing the length of pauses, a computer program called Goldwave was used. This program can display amplitude and time-wave forms as well as create spectrograms with the help of a built-in double oscilloscope. By means of the parallel analysis of the spectrograms, the time-wave forms, and the transcripts, it was possible to establish the length of the necessary stretches of speech in milliseconds. Out of the 289 self-corrections, only 282 could be examined accurately, owing to the sometimes poor quality of the recordings. In the case of each correction, the time between the onset of the error and the point at which the flow of speech was interrupted (i.e., the cut-off point), the interval between the cut-off point and the onset of the repair, and the length of the reparatum (i.e., the correction itself) were measured in milliseconds. The total time of the self-repair was calculated by adding up the length of these three phases in the correction processes. In order to gain an accurate picture of the planning mechanisms involved in making the repairs, corrections containing lexical editing terms ($n = 50$) were excluded from the statistical analyses of the cut-off-to-repair intervals and the total time of self-repairs. Therefore, the cut-off-to-repair intervals and the total time of self-repairs were analyzed in a data-

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Table 2. Timing of the main groups of self-repairs, in milliseconds

	Error to cut-off ($n = 282$)		Cut-off to repair ($n = 232$)		Length of reparatum ($n = 282$)		Total repair time ($n = 232$)	
Repair type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
E-repairs	571	618	572	795	792	987	1960	1823
A-repairs	878	953	442	483	1342	941	2442	1355
D-repairs	1154	1182	1191	1592	2179	1746	4155	2480
R-repairs	1079	1107	698	728	1150	978	2810	1640

Note. E-repairs = error repairs; A-repairs = appropriacy repairs; D-repairs = different-information repairs; R-repairs = rephrasing repairs.

base of 232 self-repairs, whereas the analysis of error-to-cut-off times and the length of the reparatum was carried out with 282 self-repairs.

For establishing the fluency of the participants' speech, a measure of speech rate (the number of syllables articulated per minute) was used. In order to enhance the reliability of the analysis, their utterances were digitized by means of the Goldwave computer program, with the help of which the exact length of time they spent speaking, including pause time, was measured. The number of syllables was counted manually, and the speech rate was calculated by dividing the number of syllables by the total number of seconds the participants spent speaking.

All the data obtained as a result of these analyses were computer coded and processed by the *SPSS* statistical package.

DIFFERENCES IN THE TIMING OF VARIOUS CLASSES OF SELF-REPAIRS

Results

The results of analyzing the timing of the four main self-repair groups indicate that the type of self-correction affects all of the variables investigated in the study. Table 2 provides an overview of the error-to-cut-off and cut-off-to-repair intervals, the length of the reparatum, and the total repair times of the various types of repairs.[2]

The one-way analysis of variance (ANOVA) of the difference between the timing of different types of repairs (see Table 3) and the consecutive Scheffé test showed that error repairs were interrupted significantly earlier, $F = 6.28$, $p < .05$, than appropriacy, rephrasing, and different-information repairs. The cut-off-to-repair intervals of different-information repairs were significantly longer, $F = 5.66$, $p < .05$, than those of appropriacy, error, and rephrasing repairs. The length of the reparatum of error repairs was significantly shorter, $F = 17.77$, $p < .001$, than that of both appropriacy and different-information re-

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Table 3. One-way ANOVA of the timing of the main groups of self-repairs

Variable	Source of variance	*df*	*SS*	*MS*	*F* ratio
Error-to-cut-off time	Between groups	3	16127053.19	5375684.39	
	Within groups	270	231278035.70	856585.31	6.28*
	Total	273	247405088.89		
Cut-off-to-repair time	Between groups	3	14923378.46	4974459.48	
	Within groups	223	195956751.40	878729.83	5.66*
	Total	226	210880129.86		
Length of reparatum	Between groups	3	74863855.92	24954618.64	
	Within groups	270	379208686.80	1404476.61	17.77**
	Total	273	454072542.72		
Total repair time	Between groups	3	144541230.90	48180410.29	
	Within groups	223	761573212.30	3415126.51	14.11**
	Total	226	906114443.20		

*$p < .05$; **$p < .001$.

pairs. Significant differences were also found between different-information repairs and both rephrasing and appropriacy repairs in this respect, $F = 17.77$, $p < .001$. With regard to the total time of self-repairs, different-information repairs were significantly longer, $F = 14.11$, $p < .001$, than all the other types of corrections, and error and rephrasing repairs also differed to a significant extent, $F = 14.11$, $p < .001$.

The differences in the timing of the specific subtypes of self-repairs were also investigated by means of a one-way ANOVA and the Scheffé test (see Tables 4 and 5). The error-to-cut-off times of both phonological- and lexical-error repairs were significantly shorter, $F = 2.69$, $p < .05$, than those of the message-replacement, rephrasing, appropriate-level-of-information, and inappropriate-information repairs. Inappropriate information was also detected significantly later than grammatical errors and pragmatic and stylistic inappropriacies, $F = 2.69$, $p < .05$. The shortest detection time found in the corpus of repairs was 54 ms.

With respect to cut-off-to-repair intervals, only message-replacement repairs were found to be significantly longer, $F = 5.66$, $p < .05$, in this respect than phonological-, lexical-, and grammatical-error repairs and rephrasing repairs. Message-replacement repairs were also longer than corrections concerning pragmatic and stylistic problems and the appropriacy of the information provided. The shortest cut-off-to-repair interval was 10 ms.

Producing the correction in the case of different-information repairs, ordering-error repairs, and message-replacement repairs lasted significantly longer, $F = 5.68$, $p < .001$, than in the case of repairing phonological, lexical, and stylistic errors. The length of reparatum of grammatical-error corrections, pragmatic-appropriacy repairs, and rephrasing repairs was significantly shorter than that of the message-replacement and inappropriate-information repairs, $F = 5.68$, $p < .001$. Producing the correct form in the case of phonological-

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Table 4. Timing of the various subtypes of self-repairs, in milliseconds

	Error to cut-off		Cut-off to reparatum		Length of reparatum		Total repair time	
Repair type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
EL-repairs	522	434	553	575	630	524	1744	1109
EG-repairs	711	821	724	1030	1092	1346	2526	2350
EF-repairs	355	138	280	219	432	287	1068	466
AL-repairs	1099	1118	487	540	1583	1054	2980	1489
AA-repairs	368	415	613	381	1269	311	2251	417
AC-repairs	472	251	857	336	674	37	2004	121
AP-repairs	476	161	273	465	1107	464	1790	718
AG-repairs	508	225	279	178	563	201	1258	370
DM-repairs	1074	1120	1248	1723	2146	1668	4238	2513
DI-repairs	1432	1392	957	1028	2168	2084	3773	2689
DO-repairs	631	237	1045	1450	2670	711	4106	2331

Note. EL-repairs = lexical-error repairs; EG-repairs = grammatical-error repairs; EF-repairs = phonological-error repairs; AL-repairs = appropriate-level-of-information repairs; AA-repairs = ambiguous-reference repairs; AC-repairs = coherent-terminology repairs; AP-repairs = pragmatic-appropriacy repairs; AG-repairs = repairs for good language; DM-repairs = message-replacement repairs; DI-repairs = inappropriate-information repairs; DO-repairs = ordering-error repairs.

Table 5. One-way ANOVA of the timing of the various subtypes of self-repairs

Variable	Source of variance	*df*	*SS*	*MS*	*F* ratio
Error-to-cut-off time	Between groups	10	27249541.75	2270795.14	
	Within groups	262	220982138.90	843443.27	2.69*
	Total	272	248231680.65		
Cut-off-to-repair time	Between groups	10	19591331.23	1632610.93	
	Within groups	215	191541086.40	890888.77	1.83*
	Total	225	211132417.63		
Length of reparatum	Between groups	10	94080111.96	7840009.33	
	Within groups	262	361616737.70	1380216.55	5.68**
	Total	272	455696849.66		
Total repair time	Between groups	10	21028787.80	17523989.82	
	Within groups	215	704138256.50	3275061.65	5.35**
	Total	225	914426134.30		

*$p < .05$; **$p < .001$.

error repairs was found to take significantly less time than providing the appropriate level of information and rephrasing the original utterance, $F = 5.68$, $p < .001$. Finally, the length of the reparatum of appropriate-level-of-information repairs was shorter than that of lexical-error repairs, $F = 5.68$, $p < .001$.[3]

The total repair times of different types of self-corrections were also found to vary to a considerable extent. Message-replacement repairs took a signifi-

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cantly longer time, $F = 5.35$, $p < .001$, to implement than error (phonological, lexical, and grammatical), rephrasing, pragmatic-appropriacy, and appropriate-level-of-information repairs, and took longer than corrections for good language. Additionally, phonological-error repairs were found to be shorter than grammatical-error, rephrasing, appropriate-level-of-information, and inappropriate-information repairs, $F = 5.35$, $p < .001$. Furthermore, corrections of lexical errors took less time than those concerning inappropriate information (i.e., different-information repairs) or insufficient information (i.e., appropriate-level-of-information repairs), and also took less time than rephrasing repairs, $F = 5.35$, $p < .001$. Finally, the total length of inappropriate-information repairs was longer than that of repairs for good language, $F = 5.35$, $p < .001$.

Discussion

On the basis of the arguments put forward in Blackmer and Mitton's (1991) study—namely, that the error-to-cut-off intervals and the cut-off-to-repair intervals were not reliable measures—firm conclusions concerning error detection and the execution of the repair processes could not be drawn based on the variables investigated in the project. The present study, however, differed from that of Blackmer and Mitton in that its participants were nonbalanced bilingual speakers of English who are only partially capable of executing the mechanisms of speech processing parallel and, therefore, they may not be able to start replanning a new message before interrupting an erroneous or inappropriate utterance. This hypothesis is supported by the fact that repairs with cut-off-to-repair times under 150 ms ($n = 13$) constituted only 4.8% of the corrections analyzed, and these were all exclusively produced by participants belonging to the advanced group. Therefore, there is sufficient reason to assume that, in this study, the error-to-cut-off times and the cut-off-to-repair times in the majority of the repairs (95.2%) mainly reflect intervals necessary for error detection and planning the correction. Thus, these variables can be used as reliable measures of the detection and planning times respectively (see van Hest, 1996, for a similar line of argumentation).

Error-to-Cut-off Times. The results of the analysis of the error-to-cut-off times suggest that linguistic errors are detected significantly earlier than inappropriate (appropriacy repairs) or false information (different-information repairs) and output of the correctness of which speakers are uncertain (rephrasing repairs). This order of detecting errors is parallel to the bottom-up sequence of decoding processes in comprehension. In linear models of comprehension, phonological decoding is assumed to take place first, followed by lexical access, syntactic decoding, and discourse processing (e.g., Forster, 1979). The results indicating that the detection of inappropriate or false information takes longer than the detection of phonological, lexical, and grammatical errors can be explained with reference to the hypothesis of linear bottom-up speech comprehension theories—namely, that discourse processing constitutes the last step in decoding the output (e.g., Forster).

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As previously mentioned, in the case of rephrasing repairs, speakers experience problems comparing their output with the existing L2 linguistic system because it does not contain all the relevant information for the monitor to be able to decide with certainty that the process of linguistic encoding was erroneous. As the results also suggest, the inability to make this judgment slows down the detection process to a considerable extent.

With respect to the detection times of specific subtypes of self-repairs, it was assumed that, owing to the fact that phonological decoding takes place first in linear bottom-up models of speech comprehension, the detection times of phonological errors would be shorter than those of lexical errors (van Hest, 1996). In the present study, however, no significant differences were found between the error-to-cut-off intervals of these two types of self-corrections. On the one hand, this finding might be due to the relatively small number of phonological-error repairs in the corpus. On the other hand, it might suggest that linear bottom-up models of speech comprehension are not able to account for processes of monitoring. Recent theories of comprehension assume that there is an interaction between levels of processing and that mechanisms of comprehension take place in parallel fashion (e.g., Marslen-Wilson, 1987; Marslen-Wilson & Tyler, 1980; McClelland & Elman, 1986; Tyler & Warren, 1987). In the case of detecting phonological and semantic errors in one's own output, this would mean that speakers attend to both types of errors simultaneously rather than in a serial manner.

The parallel and interactive nature of speech comprehension and levels of monitoring is also supported by the result that corrections of ambiguous, incoherent, and pragmatically inappropriate lexical choice, as well as repairs for good language, showed detection patterns similar to those of lexical errors. Moreover, pragmatic-appropriacy repairs and repairs for good language were distinctively different from inappropriate-information repairs. On the one hand, the importance of this finding lies in the fact that it supports the assumption that lemmas might contain specifications concerning not only their phonological form, argument structure, and semantic form (Bierwisch & Schreuder, 1992), but their pragmatic value as well (Dörnyei & Kormos, 1998). Therefore, upon parsing the utterance, the monitor might compare the intended pragmatic force of the selected lexical entry simultaneously while checking its phonological, grammatical, and semantic features, which is reflected in the similar detection times of lexical-error and pragmatic-appropriacy repairs. On the other hand, the results also suggest that checking the discourse-level aspects of the utterance, such as the use of coherent and unambiguous terms, proceeds simultaneously with lexical decoding and the comparison of the message's informational content with its communicative intention. This finding lends additional support to the existence of parallel and interactive mechanisms in speech comprehension and monitoring.

It can be concluded that the findings concerning the error-to-cut-off times of self-repairs support both the activation spreading theories (Berg, 1986; Dell, 1986; Dell & O'Seaghda, 1991; MacKay, 1987; Stemberger, 1985) and the per-

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ceptual loop theory of monitoring (Levelt, 1989, 1993; Levelt et al., 1999) because both models assume that monitoring mechanisms are similar to comprehension processes. The fact that repairs with shorter than 150-ms error-to-cut-off times also occurred in the corpus rules out the possible existence of distributed editors in L2 speech (e.g., Laver, 1980), because in these models the minimum time necessary for detection is 150 ms (Levelt, 1989).

Cut-off-to-Repair Times. The analysis of the cut-off-to-repair times of the main self-repair groups revealed that speakers need a considerably longer period of time to replan their utterance if they have to implement a major change in the information to be conveyed (different-information repairs). In the case of error repairs, the preverbal plan does not need to be modified; thus, the cut-off-to-repair intervals mainly indicate the time necessary for the linguistic processing of the correction. With respect to appropriacy repairs, one part of the utterance needs further specification, which, as shown by the results, does not last considerably longer than processing the unmodified preverbal message. Upon analyzing the rephrasing repairs in the corpus, it was found that the two most frequent strategies applied in this case were approximation and restructuring (Kormos, 1998b). Approximation involves changing one chunk of the preverbal message, usually by deleting one or more conceptual specifications and restructuring a shift in the focus or topic of the utterance in the microplanning phase (Dörnyei & Kormos, 1998; Poulisse, 1993). The findings concerning the timing of rephrasing repairs indicate that such alterations of the preverbal message do not require considerable effort, because the execution of rephrasing repairs does not last significantly longer than that of error repairs. These results lend strong support to the assumption that, in the case of uncertainty in the correctness of a lexical entry, the psycholinguistically simplest strategies tend to be used because they require little processing effort (Kormos, 1998b).

With respect to the specific subtypes of self-corrections, the results suggest that it is only message-replacement repairs that differ significantly from most other types of corrections. Therefore, it can be assumed that replanning the utterance takes the longest if the previous message is completely abandoned and a totally new one needs to be encoded. On the basis of analyzing the cut-off-to-repair intervals of the different types of self-repairs, it can be concluded that small-scale modifications of the linguistic form and the information content do not considerably increase the cognitive load of replanning the message. Major changes in the informational content, however, require significantly greater processing effort, which is reflected in the extended interval between the point at which the flow of speech is interrupted and the onset of the correction.

The finding that, in a small number of cases (4.8% of the repairs, all produced by advanced learners), the cut-off-to-repair times were shorter than 150 ms shows that highly proficient L2 speakers can occasionally plan the repair in the process of articulating the error. This implies that certain participants were

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able to execute detection and planning in parallel, which rules out theories in which only serial processing is allowed (e.g., Laver, 1980; Nooteboom, 1980).

The Length of the Reparatum and the Total Time of Self-Repairs. The length of the reparatum and the total time of self-repairs are not directly indicative of the planning and detection processes, but they do reveal the amount of the necessary changes in the form of the utterance. Thus, it is understandable that different-information repairs take the longest time to complete (because the complete previous message needs to be replaced). With respect to error, pragmatic-appropriacy, and rephrasing repairs, as well as repairs for good language, however, it is mainly one word that is substituted with another; therefore, these repairs do not last as long as conveying reordered or modified information.

THE EFFECT OF PROFICIENCY ON THE TIMING OF SELF-REPAIRS

Results

First, a correlational analysis of the frequency of the various types of self-repairs and the participants' proficiency measure was conducted. Learners with a high proficiency level produced significantly fewer error repairs, $r = -.43$, $p = .01$, and more appropriacy repairs, $r = .36$, $p = .04$, than their less proficient peers. The frequency of different-information, $r = .01$, $p = .96$, and rephrasing repairs, $r = -.06$, $p = .75$, however, was not found to correlate with the level of L2 proficiency.

A correlational analysis of the C-test scores and the four timing variables of self-repairs in general was also conducted. The results did not show any significant correlation between the level of proficiency and the timing of self-repairs in general (see Table 6). Additionally, the correlational analysis of the C-test scores and the timing measures of the main self-repair groups did not reveal any proficiency effect in the case of the error-to-cut-off intervals and the length of the reparatum of error, appropriacy, different-information, and rephrasing repairs (see Table 6). Moreover, the total length of the correction and the cut-off-to-repair intervals of different-information and rephrasing repairs were not influenced by the participants' proficiency level. As can be seen in Table 6, the length of the cut-off-to-repair intervals and the total time of the repair in the case of appropriacy repairs were found to be affected by the students' level of L2 proficiency. In the speech of learners at a higher proficiency level, the cut-off-to-repair intervals of appropriacy repairs were shorter than in the speech of their less proficient peers, $r = -.32$, $p = .02$. Additionally, the more proficient the participants were, the shorter the total length of appropriacy repairs was, $r = -.30$, $p = .03$. The results also showed that the level of L2 proficiency influences the length of the cut-off-to-repair intervals of error repairs, $r = .29$, $p = .01$. The correlational analysis indicated that the speech rate of the participants was affected by L2 proficiency, $r = .78$, $p < .001$.

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Table 6. Correlational analysis of proficiency level and the timing of self-repairs

Variable correlated with C-test score		All the repairs	Error repairs	Appropriacy repairs	Different-information repairs	Rephrasing repairs
Error-to-cut-off interval	*r*	–.01	–.13	–.03	–.02	–.06
	n	282	109	67	62	44
	p	.75	.19	.79	.82	.70
Cut-off-to-repair interval	*r*	–.12	–.29	–.32	–.08	–.09
	n	232	101	50	44	37
	p	.12	.01	.02	.52	.54
Length of reparatum	*r*	.05	–.04	–.10	–.06	.13
	n	282	109	67	62	44
	p	.45	.66	.42	.66	.41
Total time of self-repair	*r*	–.06	–.19	–.30	–.08	–.08
	n	232	101	50	44	37
	p	.34	.06	.03	.52	.56

Discussion

The lack of significant proficiency effect in the case of the timing of the total number of repairs is unsurprising. Speakers with an increased level of L2 proficiency can be assumed to detect errors and execute correction with augmented speed, but at the same time, they produce fewer error repairs (Kormos, 1998b; O'Connor, 1988; van Hest, 1996). Because error repairs are significantly shorter than appropriacy and different-information repairs (see Tables 2 and 3), the timing differences investigated separately in the case of the main self-repair groups are better indicators of the effect of proficiency on the various measures of timing.

Error-to-Cut-off Times. In a related study, van Hest (1996) did not find any significant differences between L1 and L2 error-to-cut-off times. The results of the present project also indicate that learners at various levels of L2 proficiency do not differ with respect to the length of the error-to-cut-off intervals in any of the main self-repair groups. These findings strongly suggest that the speed of error detection is not significantly affected by L2 proficiency. The reason for the similarity of detection times across groups of learners at different proficiency levels could be that monitoring involves the use of comprehension processes, which are generally fast, and the lack of L2 proficiency does not slow them down to a considerable extent.

Cut-off-to-Repair Times. The effect of proficiency on the cut-off-to-repair intervals of error and appropriacy repairs can be explained with reference to differences in the automatization of the speech-encoding mechanisms at various levels of L2 proficiency. During the processing of appropriacy repairs, speakers only need to implement minor changes in the informational content of the preverbal plan, whereas error repairs do not require a modification in

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this respect. Therefore, it was concluded that, in these cases, cut-off-to-repair times indicate the length of the linguistic processing of the preverbal plan, that is, lexical, grammatical, and phonological encoding. Because the degree of the automatization of these encoding processes is assumed to be higher with increased proficiency (de Bot, 1992; DeKeyser, 1997; Towell, Hawkins, & Bazergui, 1996), highly proficient learners can execute them faster than speakers at a low level of L2 proficiency. In this respect, the findings presented here are also supported by van Hest's (1996) research, in which the cut-off-to-repair intervals of appropriacy repairs were significantly shorter in the L1 than in the L2. It must be noted, however, that the definition of appropriacy repairs in the present study is slightly different from that of van Hest, who also included repairs for syntactic and tense-and-aspect appropriateness in the category of appropriacy repairs.

Despite the assumption outlined above (i.e., that rephrasing repairs also involve a small-scale change in the preverbal plan), the level of L2 proficiency did not affect the length of the cut-off-to-repair intervals in the case of this correction type. Perhaps this is because, regardless of the level of L2 proficiency, learners have to face a problem when implementing rephrasing, which might slow down the execution of the correction to a similar extent in the case of all three groups of participants. Regarding different-information repairs, the cognitive load of replanning the informational content of the preverbal message affects repair-processing speed similarly across groups at different levels of L2 proficiency.

The Length of the Reparatum. The length of the reparatum did not seem to be influenced by the participants' proficiency level in any of the main self-repair groups. The reason for the lack of significant differences in the present study may be that, as argued above, speakers mainly used the cut-off-to-repair intervals for planning and processing the reparatum. Therefore, upon making the repair, the already planned and processed bits of the reparatum are articulated. Despite the fact that the speech rate was found to significantly correlate with the proficiency level of the learners, it is likely that the articulation rate (i.e., the amount of time necessary for producing the utterance, excluding pause time, divided by utterance length) in such short stretches as a reparatum does not noticeably vary with proficiency level. Although the articulation rate of the participants was not measured, Towell et al.'s (1996) findings lend support to the assumption that the level of L2 proficiency does not significantly affect this timing variable. In their study, which investigated the development of fluency of advanced learners of French, articulation rate was found to be a less reliable indicator of fluency than speech rate or the mean length of fluent runs.

The Total Time of Self-Repairs. The results concerning the differences in the total time of self-repairs suggest that a higher degree of automatization only results in a faster manner of remedying the problematic part of the utterance in the case of appropriacy repairs. The comparison of the error-to-repair

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times in L1 and L2 in van Hest's (1996) study yielded identical results. Even though there were differences in the cut-off-to-repair intervals of error repairs among learners at different proficiency levels, it seems that, owing to the fact that error repairs are generally short and fast (see Tables 2 and 3), these differences are not reflected in the total time of error repairs. In the case of different-information and rephrasing repairs, none of the phases of correction implementation were found to vary significantly across groups of differing proficiency levels; consequently, the total time of the execution of the repair cannot be expected to vary, either.

CONCLUSION

The results of this analysis of the timing of self-repairs provide valuable information on the psycholinguistic processes of monitoring. One interesting finding in this respect is that, on the basis of the difference in the detection times of error, appropriacy, and different-information repairs, the assumption of both the activation spreading theory and the perceptual loop theory—that monitoring involves the same mechanisms as speech comprehension—gained support. The study also reveals that the speed of detecting pragmatically inappropriate words and lexical errors was very similar, which might mean that, during monitoring, the pragmatic features of the lexical entry are checked simultaneously with its phonological and semantic form, as well as its argument structure. This finding therefore provides indirect evidence for the assumption that lexical entries do not contain only phonological, semantic, and grammatical specifications, but also information concerning their pragmatic value (Dörnyei & Kormos, 1998). The analysis of detection times supported the distinction of error and rephrasing repairs, because it revealed that speakers' uncertainty about correctness of the utterance in the case of rephrasing repairs slows down the detection process to a considerable extent.

The findings concerning the cut-off-to-repair intervals yielded valuable information concerning the replanning of the utterance when carrying out self-corrections. The results indicate that slight modifications in linguistic form (e.g., error and rephrasing repairs) and informational content (e.g., appropriate-level-of-information repairs) take less time to implement—that is, they require less processing effort—than large-scale changes in the informational content of the message (e.g., message-abandonment repairs). The similarity of the time periods necessary for replanning the utterance, in the case of error repairs and rephrasing repairs, strongly confirms the assumption that L2 speakers use the psycholinguistically simplest strategies in the case of uncertainty about the correctness of the output.

Analysis of the effect of proficiency on repair times revealed that, owing to the fact that comprehension mechanisms used for error detection are generally fast, the level of L2 proficiency does not influence them to a considerable extent. In the case of self-corrections that do not require major modification to the preverbal plan (e.g., error and appropriacy repairs), however, differ-

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ences between low- and high-level learners were found in the times necessary for reprocessing the utterance. Because during the production of these repairs only a minor change is needed in the preverbal plan, it can be assumed that the cut-off-to-repair intervals mainly reflect the time necessary for the lexical, grammatical, and phonological encoding of the correction. Thus, in the case of proficient speakers, the high level of automaticity of these mechanisms can result in the speeding up of speech processing. This difference between learners at various levels of L2 proficiency, however, disappears if they have to face a problem (i.e., upon implementing rephrasing). The speed of producing the correction was not found to be affected by L2 proficiency either, which can be explained with reference to the fact that this interval reflects the time necessary for articulating the already planned and processed bits of the message.

Finally, it should be noted that the number of self-repairs found in the present corpus was not sufficient to establish significant differences in the timing of certain subtypes of self-repairs. A larger database is needed for a more detailed study of the detection times of different errors and inappropriacies. For compiling a larger corpus, however, not only do elicited speech production data need to be collected, but research under laboratory conditions is necessary as well (van Hest, 1996).

Another shortcoming of the research project described here is that no L1 data was collected from participants; consequently, their performance in their L1 and L2 could not be contrasted. Moreover, the comparison of the results of this study with previous research findings was not without problems, given the differing taxonomies used in this and previous studies.

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NOTES

1. The results of the comparison of the TOEIC and the C-test showed relatively high correlations both in the case of university and secondary school students ($r = .65$ for university students, $r = .64$ for secondary school students). The results of Dörnyei and Katona's (1992) study also indicated that, despite the fact that the difficulty level of the C-test varies across groups of learners at different proficiency levels, its measuring ability remains stable.

2. As shown in Table 2, the various measures of the timing of a number of self-repair types show high variability because many of the standard deviation values are relatively high. Nevertheless, the frequency polygons of the timing measures have shown that the distributions of these measures are not skewed. Therefore, the means are the best measures of central tendency, which allows for the use of parametric statistical procedures such as correlations or the one-way analysis of variance.

3. The correction rate of errors was not investigated in this study. For background information, it can be noted that participants corrected approximately 20% of their lexical errors and 15% of their grammatical inaccuracies (for further details, see Kormos, 1998b).

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APPENDIX

Table A1. The classification of self-repairs

Name of repair	Definition	Example
Different-information repair	The speaker decides to encode different information from what is currently being formulated (Levelt, 1983)	
Inappropriate-information repair	The speaker repairs the message because its information content is faulty (Levelt, 1983)	*The room is er um er thirty thirty thousand er too much er ten thousand er forint er forints per day.*
Ordering-error repair	The speaker decides to encode parts of the intended message in a different order (Levelt, 1983)	*Um well there's a big dining table for forty person. And then we've also got er well it's well the dining table occupies half of the room.* Retrospection: *I thought, I did not tell you first how big the room was, so I said that the dining table occupies half of the room, and then I said what I originally wanted to say.*
Message-abandonment repair	The speaker abandons the originally intended message and replaces it with a different one	*We have some er er v . . . maybe you have vegetarians in your group.* Retrospection: *Here the idea of vegetarians suddenly popped up, and I abandoned what I was going to say because I would not have been able to list any more types of food anyway.*
Appropriacy repair	The speaker decides to encode the original information in a modified way (Levelt, 1983)	
Appropriate-level-of-information repair	The speaker decides to further specify the original message (Levelt, 1983)	*There are very wide choice of er main courses er er steak er er several kind of steak.* Retrospection: *I wanted to say it more precisely that we do not only have one kind of steak but several kinds of steak.*

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Table A1. Continued

Name of repair	Definition	Example
Ambiguous-reference repair	The speaker repairs the referring expression because of ambiguity (Levelt, 1983)	*In this um in this part of the town er there are many vegetarians. Er this is because the university is here and vegetarians like it er like this restaurant.* Retrospection: *I noticed that "it" could also mean the university, so I wanted to make it clear that it is the restaurant that the vegetarians like and not the university.*
Coherent-terminology repair	The speaker repairs incoherent terminology (Levelt, 1983)	*In this case er if it is so urgent and important for you, we would like er you to to write us an order er in er 24 hours that you make sure that you will er come and book this er room.* R: *I see, all right and then I can only pay the deposit next week when I er find out how many people come and when I have talked to all of the people.* S: *Er but this letter is er—the order—er your request is er anyway—needed and we . . .* *Retrospection: I remembered that I had used the word "order" earlier, and I wanted to stick to the same terms, so I replaced "letter" with "order."*
Pragmatic-appropriacy repair	The speaker repairs the part of the message that is pragmatically inappropriate in the given situation (based on Brédart, 1991)	*It doesn't it's not a problem.* Retrospection: *First I wanted to say "it does not matter," but I realized that in a business deal you cannot say "it does not matter."*
Repair for good language	The speaker repairs the part of the message that is judged to be not sophisticated enough concerning the manner of expression	*Thirty-five per—people.* Retrospection: *First I wanted to say "persons" but I had used "persons" several times before, so I said "people."*

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Table A1. Continued

Name of repair	Definition	Example
Error repair	The speaker repairs an accidental lapse in the speech production process (i.e., repair of a slip of the tongue; Levelt, 1983)	
Lexical-error repair	Repair of a slip of the tongue that occurs in the lemma retrieval phase	*Will er have to pay er five er sorry er twenty-five percent.* Retrospection: *Here I said "five" instead of "twenty-five" accidentally.*
Grammatical-error repair	Repair of a lapse in the grammatical encoding phase	*I think it a very nice it's a very nice* Retrospection: *I left out "is," and I corrected it.*
Phonological-error repair	Repair of a slip of the tongue that occurs in the phonological encoding or articulation phase	*We could arrange er more smaller [taibiɛ] tables if you would like that better.*
Rephrasing repair	The speaker repairs an utterance because of uncertainty about its correctness	*Um our fish fish meals er foods are very good too.* Retrospection: *I corrected "fish meals" for "fish food" because I was not sure you can say "fish meals" and "fish foods" sounded a bit better.*

Note. For examples of the main classes of repairs, see the text of the article.

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