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The Role of Prosody in Discourse Processing

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The influence of prosody and its visual analog, punctuation, in text comprehension was investigated in two experiments. In the first experiment 20 subjects listened to three taped passages of equal length and difficulty varying in intonation (normal, monotonous, or altered) and were tested on tasks of text comprehension and word recognition. In the second experiment 20 new subjects read the same passages but with varying punctuation (appropriate, no punctuation, or altered) and were also tested on text comprehension and word recognition. Subjects' reading time was also recorded. ANOVA results revealed that altered prosody and punctuation affect performance in a similar fashion and seriously impair text comprehension and word recognition. This sensitivity to altered intonation suggests that linguistic prosody not only supplies redundant cues for judging sentence structure but that it also manages attentional resources to help with semantic encoding of lexical units and with the organization of linguistic information in long term memory. © 2001 Academic Press

Recent theorizing pertaining to language processing posits it as an active strategic collection of parallel perception and comprehension processes. Among these processes are memory mechanisms that contribute to encoding and reconstruction of the linguistic message in memory. A variety of linguistic and nonlinguistic cues have been designated as facilitators of these processes. Current research is attempting to stipulate the nature of the contribution each cue makes. Theoretically, any of these cues can be exclusively or in combination with other cues influencing memory mechanisms as well as other processes of language perception and comprehension. The aim of this paper was to investigate the role of linguistic prosody, one of such cues, in the processing of discourse.

One source of information aiding in the decoding of the linguistic message can be the message itself. Hierarchically structured language incorporates phonological, morphological, syntactic, and semantic information. Speakers are able to use this information, as they are competent in a particular language. Additional nonlinguistic information, such as physical characteristics of the message and metalinguistic knowledge, also contribute to the communicative act. Interestingly, this nonlinguistic information can be a source of variability as well as similarity in the speech signal. Traditionally, variability has been regarded as a perceptual problem that the listener needs to resolve. Recently, there have been suggestions that speaker variability for example can become part of a rich representation in long-term memory which provides additional attention and resources, facilitating the decoding of the message (Nygaard, Sommers, & Pisoni,1995).

Prosody is among the above-mentioned contributors to the communicative process. It is the perceptual pattern of intonation, stress, and pause; the physical correlates of which are fundamental frequency (F0), amplitude, and duration, respectively (Nagel, Shapiro, & Nawy, 1994; Speer, Crowder, & Thomas, 1993). As a multifaceted phenomenon, prosody falls under both categories of linguistic and nonlinguistic cues. As a linguistic cue, a hypothesized independent prosodic representation, similar to phonological or syntactic representations, becomes an integral part of speakers' linguistic competence (Liberman & Prince, 1977; Speer, Kjelgaard, & Dobroth, 1996). Other prosodic cues are nonlinguistic. Emotional prosody marks the state of the speaker, anger, happiness, sadness, etc. Sentential prosody conveys intent by differentiating questions from statements or exclamations. Other types of nonlinguistic prosody are sources of variability. Pitch, together with vocal tract characteristics, distinguishes voices of different speakers (Allard & Henderson, 1976).

Hence, two conceptions of prosody are possible: one as part of linguistic structure and the other as a physical characteristic of the speech signal (Speer et al., 1993). Prosody, as part of linguistic structure, has commanded attention in the domain of psycholinguistics. Prosody, as part of surface physical characteristics of the speech signal, has been a factor of interest in research on verbal memory processes. Issues and findings pertaining to prosody within each domain are discussed next.

Prosody in Psycholinguistic Research

Prosody in psycholinguistic research has been investigated with the objective of designating the various cues that contribute to the decoding and interpretation of the linguistic message and characterizing the nature of their contribution. The prosodic level interacts with other levels of linguistic representation, aiding the hearer in the deconstruction of those levels during speech comprehension. At the lexical level prosodic structure interacts with lexical representation and is essential in distinguishing some lexical combinations, for example, *Red* Coat from Red*coat.* In some languages, such as Thai, prosody distinguishes single lexical units from other units (Van Lancker & Fromkin, 1973).

Prosodic structure also overlaps with syntactic structure and has been documented to facilitate syntactic processing. Wingfield (1975) demonstrated that sentences in which intonation was congruent with the underlying syntax were better able to withstand the effects of speech compression compared to those presented with anomalous intonation. Similarly, Speer et al. (1996) demonstrated facilitation effects when syntactic and prosodic boundaries coincided and interference effects when these boundaries conflicted. In addition, there is evidence for a contribution of prosody in resolution of attachment ambiguities and in processing of filler-gap sentences (Gerken, 1996; Marslen-Wilson, Tyler, Warren, & Grenier, 1992; Nagel et al., 1994; Shapiro & Nagel, 1995). Taken together, these results indicate that prosody affects the processing of language by providing clues for resolving other levels of linguistic structure be it lexical, syntactic, or semantic.

Prosody in Verbal Memory Research

Central questions in verbal memory research have been first, to specify aspects of the linguistic message that are encoded in memory representations, and second, to determine which existing representations are evoked from long-term memory to aid in the encoding and subsequent reconstruction of the message in memory (Mckoon & Ratcliff, 1998; Speer et al., 1993). In speech perception, certain physical characteristics of the signal may be actively encoded along with the linguistic content. A classical finding has been that of the primacy of general meaning over surface form characteristics in memory. Nevertheless, recent findings show that certain physical characteristics such as speaker variability and speaking rate can actively influence the encoding and subsequent reconstruction of the message in memory (Nygaard et al., 1995).

Prosody as component of the physical characteristics of the speech signal has been investigated as it pertains to the question of representation of the linguistic message in memory. In contrast to psycholinguistic investigation, the issue here is not the direct contribution of prosody to the resolution of linguistic structure but whether prosody is among the contributors to encoding and reconstructing of the message in memory.

At the word level, the prosodic dimension of amplitude has been investigated in explicit memory studies. No effects of amplitude on encoding or rehearsal were found during a serial recall task (Nygaard et al., 1995) or during a repetition–priming task (Church & Schacter, 1994). Nevertheless, Allard and Henderson (1976) showed that subjects' performance in a matching task was better when two stimuli shared the same intonation than when the intonation was different. The differential effects observed for amplitude and intonation can be attributed to the fact that different cues might differ in their strength in affecting language processes and that the level of linguistic structure in which they operate modulates this strength (Cohen & Elsabbagh, submitted).

At the sentential level, intonation is among the important cues marking prosodic structure. Recognition rates were found to be higher for sentences spoken with the same intonation than when it was different (Speer et al., 1993). Intonation was also demonstrated to eliminate repetition deafness effects observed for monotonous sentences (Miller & Mackay, 1996), supporting an influence of intonation on memory processes. Speer at al. (1993) performed a series of experiments where they examined the status of prosodic representation in memory. They concluded that prosody is an integral part of the final representation of an utterance in memory and that this contribution is independent from that of semantics or syntax. Pitch, another prosodic cue, was also found to have an effect on memory processes at the sentential level. Elevated pitch such as in a child's voice leads to enhanced processing compared to nonelevated pitch, as shown by higher recall for the gist of messages (Bugental & Lin, 1997).

The mechanism by which prosody contributes to memory processes is less clear. A few possibilities that are not mutually exclusive can be advanced. Prosody can command heightened attention from the hearer which would lead to enhanced processing at other levels, such as syntax or semantics (Bugental & Lin, 1997). Prosody can also provide an initial structure in working memory, where the utterance can be maintained until subsequent linguistic analysis takes place (Speer et al., 1993). Finally, the locus of prosody's effect might be implicit memory, where prosodic sentences activate a preexisting prosodic structure in long-term memory. Future research would further understanding of these mechanisms.

The Present Study: Prosody in Discourse Processing

As indicated, the role of prosody might vary depending on the level of linguistic structure. The studies discussed whether under language or verbal memory research focused mainly on the lexical and phrasal levels. Little attention has been paid to the level of discourse. Although investigation at those levels is insightful in drawing conclusions about the role of prosody in memory processes involved in language processing, it is possible that the nature of processing might be different at the level of text. There are two obvious differences that may lead to differential processing of text and words or sentences. One is the larger amount of linguistic material presented in discourse; the other is semantic coherence that needs to be maintained for several parts in discourse.

If prosody proves to play a role in discourse processing, additional investigation can shed light onto the locus of contribution of prosody to memory processes. If the locus is exclusively working memory then prosody is not expected to play a more important role in discourse processing where there are higher demands on long-term memory processes relative to that required by words or phrases.

This paper is an exploration of the role of prosody in discourse processing in two modalities. Experiment 1 examines the role of prosody in the processing of aurally presented text. Experiment 2 examines the role of the visual analog of prosody, punctuation, in the processing of visually presented text.

Experiment 1: Prosody in Processing of Oral Discourse

The goal of this experiment was to assess the role of prosody in the comprehension of gist and recognition of lexical units in aurally presented text. Three conditions were introduced: normal, monotonous, or altered prosody. The latter condition presents conflict between prosodic structure and syntactic structure in positions where they normally overlap. The following is an example of normal and altered stimuli where % indicates a prosodic frontier while / indicates a syntactic boundary:

Normal. After traveling for a long time/% Liz decided to stop and ask for directions.

Altered. After traveling % for a long time/Liz decided to stop and ask for directions.

Such conflict between prosody and syntax is expected to not only prevent any facilitation of syntactic decoding provided by normal prosody but also to create an interference effect which would seriously impair task performance relative to the normal condition.

Method

Subjects. Participants were 20 university students, 5 men and 15 women. The mean age of subjects was 23.1 years (SD = 3.34), and their mean educational level was 16.2 years (SD = 1.61). They were all native speakers of Canadian French and reported no history of neurological or psychological problems.

Stimuli. Three texts equivalent in the degree of difficulty (the number of words read per second) and length (total number of words) were selected for the experiment. Table 1 presents the length and average difficulty for each text. Six control subjects participated in a preselection process of these texts. Three selected texts were re-

TABLE 1
Length and Degree of Difficulty of the Texts Presented

Text	Length (Number of words)	Reading time (s) Mean	Reading time (s) *SD*	Degree of difficulty (Number of words/s) Mean	Degree of difficulty (Number of words/s) *SD*
Text 1	214	57	15.3	3.9	0.9
Text 2	215	55	11.3	3.9	0.7
Text 3	210	55	9.7	3.8	0.8

Note. All texts were selected from Franz Kafka's (1973) *L'Amérique*.

corded while being read by a male native speaker. The first text was read with altered prosody, the second with a monotonous prosody, and the third with normal prosody.

Tests. Two tests, of text comprehension and word recognition, were given to subjects. The story comprehension test was refined based on the evaluation of five naïve subjects where questions that could not be answered based on knowledge of the content of the texts or the ones that could be answered without knowledge of the texts were excluded. The word recognition test included 15 target and 15 distractor words. Distractors were selected to have equal frequency of appearance in contemporary French literature (Imbs, 1971) as that of target words.

Procedure. Each subject listened to the three texts. The order of presentation was systematically varied across subjects. The two tests of text comprehension and word recognition were administered after each text. A distraction task (arithmatic calculation) was included between the two tests.

Results

ANOVAs with repeated measures were performed on scores of the text comprehension and word recognition tests. Prosody, the main factor, had three levels: Normal, Monotone, and Altered. Comparisons of performance on the story comprehension test demonstrated a significant effect of prosody on comprehension ($F(2, 18) = 21.85$), $p < .001$). Post hoc (Scheffé) tests indicated better comprehension under conditions of normal prosody than with altered ($t(2,18) = 5.48, p < .001$) or monotonous prosody ($t(2,18) = 5.18, p < .001$).

Comparisons of performance on the word recognition test also revealed a significant effect of prosody on the number of words recognized ($F(2, 18) = 18.32$), $p < .001$). Post hoc tests reveled that recognition of words was better when prosody was normal than when it was altered ($t(2,18) = 5.55, p < .001$) or monotonous ($t(2,18) = 5.52, p < .001$). Figure 1 illustrates the effects of variation in intonation on text comprehension and word recognition in the auditory condition.

Discussion

Results of this experiment showed that prosody plays a role in oral discourse processing. The detrimental effect of alteration of prosody on comprehension indicates that prosody facilitates in extracting meaning of the message in normal oral discourse. Impaired recognition of words for conditions of monotone and altered prosody also suggests that prosody facilitates memory processes implicated in oral discourse processing.

Prosody can be exerting its influence in at least three processing loci. The first is psycholinguistic processing. Prosody can directly facilitate the resolution of semantic

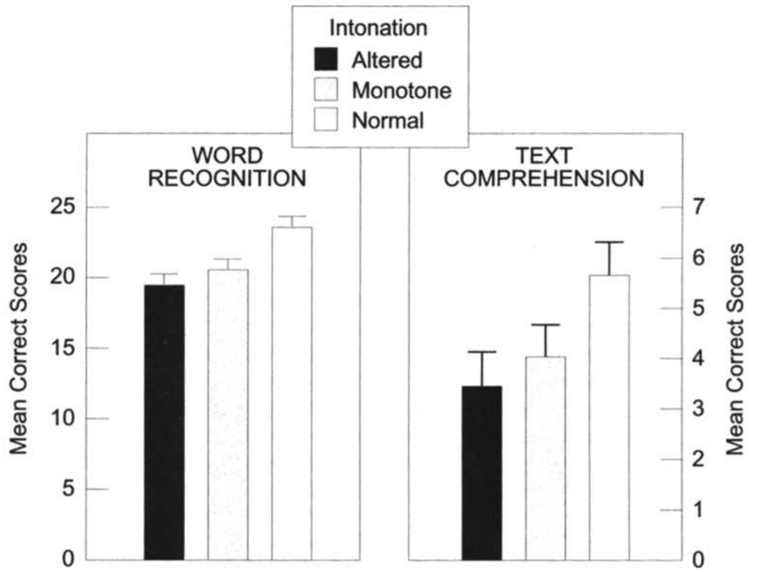

FIG. 1. Mean performance scores for each condition of prosody in the listening experiment.

and syntactic structure, a condition that is necessary to determine meaning. The second is short-term memory processing where prosody can provide an initial structure in memory, in which incoming input is situated. Finally, the locus of the prosodic effect might be long-term memory. Prosody can be facilitating the activation of meaningful associations. The loss of prosodic contribution in altered and monotone conditions and thus the reduction of its facilitative effects on any of these processes may explain the impairment observed in recognition and comprehension under those conditions.

Experiment 2: Prosody in Processing of Written Text

The goal of this experiment was to assess the role of punctuation, a visual analog of prosody in comprehension of text and in recognition of lexical units in visually presented text. In written text, punctuation aids in the resolution of linguistic structure at both phrase and discourse levels.

Three conditions of punctuation were introduced: normal, absent, and altered. The latter condition presents a conflict with underlying syntactic structure similar to that introduced in Experiment 1 with altered prosody. The altered condition, introducing a conflict with syntax, was expected to seriously impair comprehension of text and recognition of words in visually presented discourse compared to the other conditions.

Method

Subjects. Twenty new subjects, 5 men and 15 women, participated in this experiment (mean age 23.9 years, $SD = 3.77$; mean educational level 15.7 years, $SD = 1.66$). All participants were native speakers of Canadian French and reported no history of neurological or psychological problems.

Stimuli and tests. The same texts used in Experiment 1 were used here and were printed on plastic posters. The first text was printed with altered punctuation, the second with no punctuation, and the third with normal punctuation. The same tests

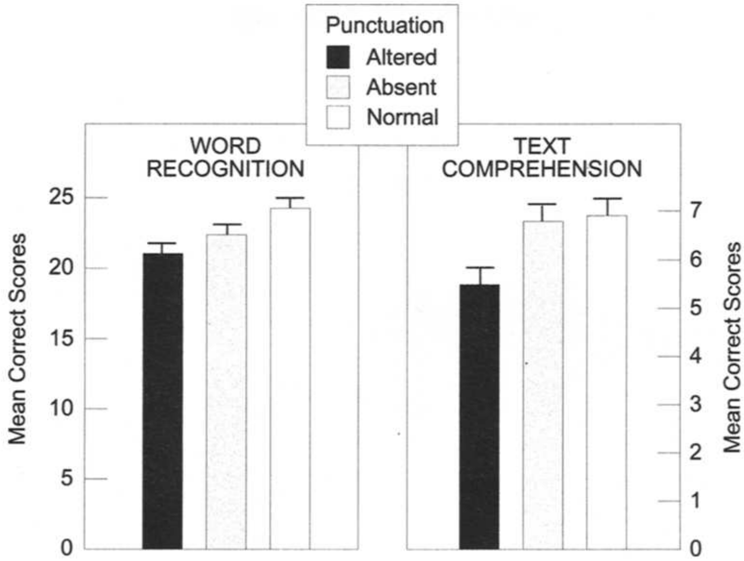

FIG. 2. Mean performance scores for each condition of punctuation in the reading experiment.

of word recognition and text comprehension used in Experiment 1 were employed here.

Procedure. Subjects were instructed to silently read the texts presented and were told that they will be asked to answer some questions on what they have read. The time of reading was recorded for each text. Tests of comprehension and recognition were administered in a fashion similar to that in Experiment 1.

Results

ANOVAs with repeated measures were performed on scores of the comprehension test, the recognition test, and reading time. The main factor, punctuation, had three levels: Normal, Absent, and Altered.

Comparisons of performance on the comprehension test showed a significant effect of punctuation on text comprehension ($F(2, 18) = 9.34$, $p = .002$). Post hoc tests (Scheffé) indicated that comprehension was better when punctuation was normal ($t(1, 19) = 4.13$, $p < .001$) or absent ($t(1, 19) = 2.68$, $p = .015$) than when it was altered.

Comparisons of performance on the word recognition test also showed a significant effect of punctuation on the number of words recognized ($F(2, 18) = 9.65$, $p = .001$). Post hoc tests indicated that word recognition was higher when punctuation was normal than when it was absent ($t(2, 18) = 2.38$, $p = .03$) or altered ($t(2, 18) = 4.48$, $p < .001$). Mean scores on the comprehension and recognition tests are presented in Fig. 2.

Punctuation also had a significant effect on reading time ($F(2, 18) = 3.62$, $p = .048$). Post hoc tests indicated that texts presented with altered punctuation required a longer reading time than when the texts were presented with normal punctuation ($t(1, 19) = -2.67$, $p < .015$). Reading times are presented in Fig. 3.

Discussion

Results of this experiment suggest that punctuation plays an important role in reading. Alteration of punctuation impaired subsequent recognition of words and compre-

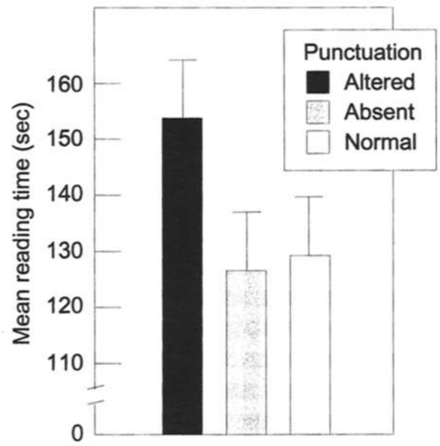

FIG. 3. Mean reading time for each condition of punctuation.

hension of visually presented text. In addition, extended reading times were required in cases of altered punctuation.

Appropriate punctuation marks structural relations by marking syntactic boundaries for example. This marking facilitates the resolution of linguistic structure, speeding the reading process. Altering punctuation in a way that is incongruent with the underlying syntax renders the reading task more time consuming and more difficult in terms of the number of word read per second.

Only recognition of words but not comprehension of text was impaired in the absent punctuation condition. The lack of effect on comprehension in this condition can be attributed to the fact that subjects while reading can go back in the text. The longer reading time observed in this condition would compensate for the lack of punctuation. Although it did not affect comprehension, the absence of prosodic structure provided by punctuation impaired later recognition of words. It is possible that the absence of prosodic structure prevented any facilitation that prosodic structure provides for memory processes.

Similar to prosody in aurally presented discourse, there are a few possible mechanisms by which punctuation in visually presented text can exert its effects. As indicated, punctuation can facilitate visual analysis during reading by marking syntactic boundaries. In addition, it can also affect working memory processes and/or facilitate the activation of associations from long-term memory.

General Discussion

Taken together, results of both experiments suggest that prosody and its visual analog, punctuation, contribute effectively to comprehension and reconstruction in memory of aural and written discourse, respectively. The contribution of prosody is manifested in supplying necessary cues which influence language processing at multiple levels: (a) syntactic analysis, aiding in the resolution of syntactic structure; (b) working memory, contributing to the integration of phrases in a global structure; or (c) long-term memory, facilitating elaborative processing through activating meaningful associations.

Another interesting issue is the relative contribution of prosody to implicit or explicit memory processes. The tasks employed in the present study, comprehension and recognition, measured the effects of prosody where the test phase did not require conscious recollection of the prosodic structure during the study phase. For that, the effects obtained can be attributed to implicit memory processes. Additional studies can verify the existence of similar effects of prosody in explicit memory tasks.

Prosody and punctuation differed in their effects to the extent that different processes are involved in listening and reading tasks. The absence of punctuation did not impair comprehension of visually presented text while the equivalent condition in the aural mode did impair comprehension. The main difference is that reading allows subjects to backtrack in cases of difficulty or ambiguity while this option is not available in the listening condition. The altered prosody condition affected comprehension in the two modalities, as it represents an obstruction for the extraction of meaning in both written and aural presentations of linguistic information.

Recently, there have been suggestions that the garden path effect obtained in visual in reading experiments can be eliminated if material is presented aurally and prosody is incorporated (Gerken, 1996; Nagel et al., 1994; Steinhauer, Alter, & Friederici, 1999). Likewise, such effects are most likely to be eliminated if punctuation is incorporated, where ambiguity introduced by syntax is resolved with prosody. Moreover, models of speech perception and comprehension, in the visual or aural modes, have not considered prosody as a contributor to these processes. In light of converging evidence supporting its contribution to language processing, prosody needs to be integrated into these models, at levels where previous investigation showed its effect.

In conclusion, experiments presented in this paper support an important contribution of prosodic structure to comprehension and memory processes at the level of discourse. The results are situated as part of converging evidence for the contribution of prosody to language processing. The locus of this contribution and the relative strength of prosody compared to other cues are issues yet to be resolved.

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Position of the Egocentric Reference and Performance in Line Bisection and Subjective Vertical Estimation Tasks

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Egocentric body coordinates such as the sagittal midline have been proposed to act as a reference for ballistic movements in extracorporeal space. Symmetrical functioning of the multiple neural structures processing sensory information would account for the normal sagittal position of the egocentric reference. According to this hypothesis a unilateral parietal lesion would induce a ipsilesional deviation which would prevent neglect patients from responding to stimuli that occur on that side. In this line of reasoning, an experimental manipulation of the position of the egocentric reference by way of a postural perturbation should have an effect on visuospatial tasks performance in normal subjects. Seventeen right-handed subjects were submitted in the dark to two visuomotor tasks: the adjustment of a luminescent rod to the vertical and the bisection of a luminescent line, either with the trunk and the head aligned at 0° or with a 30° trunk rotation to the right or to the left. Results revealed no significant effect of trunk rotation on the performance in both tasks. We discuss these findings and their implication for the understanding of the neglect syndrome. © 2001 Academic Press

Introduction

Unilateral neglect is a neurological disorder clinically characterized by the inability to perceive or orient to stimuli presented to one side of space despite the absence of significant sensory or motor deficit (Heilman, Watson, & Valenstein, 1997).

Line bisection is a task that requires subjects to mark the perceived midpoint of a line. Patients with left hemineglect usually transect lines to the right of true line center (Schenkenberg, Bradford, & Ajax, 1980). Applied to normal subjects, this task has enabled several authors to describe a phenomenon of asymmetric perception of space: the "pseudoneglect." Normal subjects were thus found to bisect the line slightly to the left of the center (Bowers & Heilman, 1980). This bias has been hypothesized (i) to reflect the subject's hemispheric activity (Bradshaw et al., 1987), (ii) to be dependent upon the scanning direction of the line (Chokron & Imbert, 1993), and (iii) to reflect the position of the egocentric reference (ER) (Jeannerod & Biguer, 1989).

This last reference is also involved in what is the subjective visual vertical (Guerraz, Poquin, & Ohlmannm 1998). In darkness, tilts of the head, the trunk, or the whole body are well known to induce constant errors in the subjective vertical (SV) which becomes displaced, according to the magnitude of the postural disturbance, either in the direction of postural inclination (the Aubert or A-effect) or in the opposite direction (the Muller or E-effect).

Recently, the hypothesis has been proposed that the crucial mechanism leading to