Syntactic difficulty in English and Japanese: A textual study[*]

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Abstract

This paper presents statistical analyses of the syntactic structures found in some spoken texts in English and Japanese. By studying the products of performance - spoken English and Japanese texts in particular - we will examine how much strain is caused on the working memory of speakers and hearers during the processes of speech production. By measuring difficulty in terms of "dependency distance" it is possible to compare texts in the two languages. The results show that Japanese texts are syntactically no more difficult than English ones.

1 Introduction

1.1 Working memory in Word Grammar

Working memory, with which different researchers may refer to different entities, here is considered as the information currently active in our brains for solving a problem. Working memory therefore, refers to all transient information including the auditory and visual information in the sensory buffers (Moray, Bates, and Barnett 1965, Darwin, Turvey, and Crowder 1972, Neisser 1967, Sakitt 1976, Coltheart 1983), the rehearsal loops (Baddeley, Thomson, and Buchanan 1975, Baddeley and Lewis 1981, Baddeley 1986), and the information activated in permanent memory, i.e. our knowledge held in memory as an associative network.

Word Grammar (Hudson 1984; 1990) - a branch of cognitive linguistics (Lakoff 1987, Taylor 1989, Langacker 1987; 1990) - assumes that any knowledge, not only encyclopaedic knowledge but also linguistic knowledge is represented in a single network. Thus, from the viewpoint of Word Grammar, the contents of working memory in terms of processing are the current and previous words available for processing in the sensory

[*]I am grateful to Dick Hudson for his guidance throughout my research.

memory, the words still held in rehearsal systems, and any information relating to these words that is currently in a state of high activation in memory.

1.2 Syntactic difficulty

In the whole processes of comprehension, there is a stage where we construct the syntactic structure of words that have been identified and whose meanings have been accessed. Ways that make comprehension difficult at this syntactic processing level are considered as syntactic difficulty. A notable source of syntactic difficulty consists of local ambiguity which leads one to re-analyse the syntax due to an initial preference for one reading turning out to be incompatible with the rest of a sentence, e.g. a garden-path sentence (1), but another important source is a syntactic structure which is itself too complex to be processed such as a nested dependency structure (2).

(1) #While Mary was singing a song played on the radio. (Gibson 1991)

(2) #Because if when the baby is crying, the mother gets upset, the father will help, the grandmother can rest easily. (Gibson 1997)

It may however, be taken for granted that the most common cause of syntactic difficulty would be memory overload, which makes inaccessible the words which are required for syntactic processing but which have been already deactivated owing to the limited space of working memory. The working memory overload effect might not be extreme to the extent that it causes sentence processing breakdown, but we are readily able to perceive this psychological pressure, if we make a readability judgement on the following two sentences; (3) should be relatively easier to process than (4).

(3) The case was found on Thursday by four biologists who had been working for two months in Birmingham. (Hudson 1998)

(4) The bag was found by three historians who had been living for several years in Liverpool on Monday. (Hudson 1998)

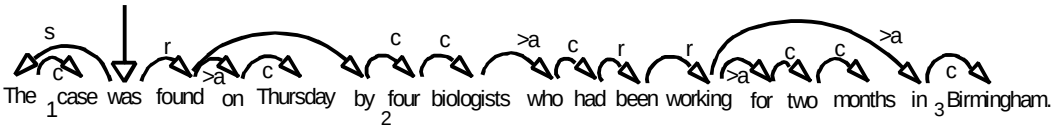
One reason why (4), a case of heavy-NP shift is harder to read than (3) is that the memory load for building a syntactic structure for (4) is heavier than that required for (3). In Word Grammar, there is a simple scale of mental energy consumed by working memory for

syntactic processing, namely dependency distance (Hudson 1995), which will be explained in brief below.

1.3 A measure of syntactic difficulty

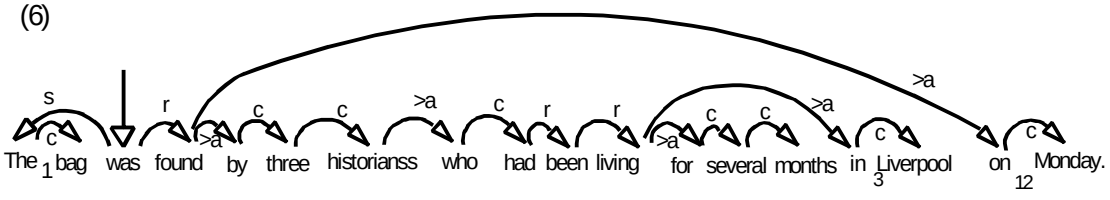
In dependency terms, the syntactic difficulty of (4) in comparison with (3) is due to the fact that the distance between the adjunct *on* and its parent *found* in (4) is longer than the distance of the corresponding dependency in (3) where no words separate *found* from *on.* This illustrates the general tendency for parsing to favour short dependency links. Also this yields a straightforward measure for calculating the mental energy consumption at working memory for a sentence or even for a whole text: dependency distance (the number of words between a dependent and its surface parent) and the mean distance (the mean value for all words in a sentence or a text concerned). (5) and (6) illustrate the surface dependency structures (3) and (4) and their distances. These diagrams clearly demonstrate the relative difficulty of (4), with its mean distance 0.889, which is more than double the distance of (3), viz. 0.333.

(5)



mean distance = 0.333

(6)



mean distance = 0.889

The relative difficulty of (4) compared to (3) is also supported by empirical evidence: the experiments conducted by Hudson (1998). His subjects were twenty native English students at the Phonetics and Linguistics department of University College London, tested

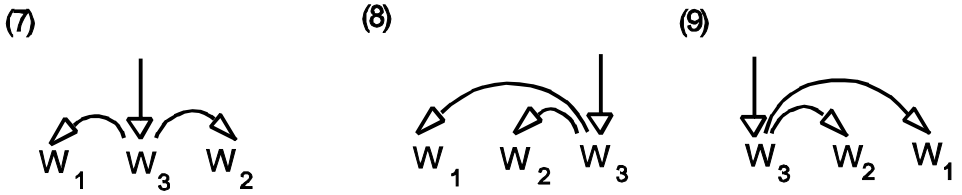
in experiments held at various times in 1997 and 1998. The technique used in the experiments was immediate recall; subjects were instructed to transcribe a sentence immediately after it was dictated. Each sentence consisted of 18 words and was read out once. Only the complete reproduction of a sentence was counted as success. The results were that as dependency distance correctly predicted, the success rate of (3) was higher (35% of subjects) than that of (4), i.e. 5%.

2 Hypotheses 1 & 2

The assumption that protracted linking dependencies consume more mental energy inevitably gives rise to a question concerning both human language production and comprehension: how highly effective communication is possible in such languages as Japanese which are unidirectional in dependency direction (e.g. SOV or VSO) in comparison with languages bidirectional in direction (e.g. SVO) such as English, which might be expected to have lower overall dependency distance. One way to survey this topic would be by analysing spontaneous spoken texts both in English and in Japanese, for spoken materials offer a faithful record of performance during language communication.

There is no psychological evidence that some languages are harder to process than others, so one hypothesis concerned with cross-language processing can be deduced: there is no difference between unidirectinal and bidirectional languages in their processing difficulties. To assess the validity of this hypothesis, I should like to concentrate on Japanese and English as samples of unidirectional and bidirectional languages respectively. Hence, I will specifically attempt to evaluate the following hypothesis which stems from the Equal Difficulty Hypothesis stated above; Japanese is no more syntactically difficult than English [Hypothesis 1].

Hypothesis 1 seems to conflict with the view that the sooner a word can be linked to its parent, the easier for the parser to process, i.e. the fewer words that separate them, the more undemanding for parsing. We shall call this the Distance-Difficulty Hypothesis. The structural constraint on dependents located on one side of their parents would inevitably increase syntactic difficulty in comparison to bidirectional dependency structure. Take the two simple three-word dependency structures below.



In (7), the instance of bidirectional structure, the parent word W3 is adjacent to its dependents W1 and W2 on both its sides. The examples of unidirectional structure (8) and (9), on the contrary, have the parent W3 uniquely adjoining W2 which in turn separates the other dependent W1 from its parent W3. Thus, theoretically speaking, (8) and (9) should be syntactically harder to process than (7) thanks to the presence of the intervening word W2 between W1 and W3.

Since Japanese exhibits its predominant syntactic structure as (8), it potentially has more words with unbounded dependencies than English that have to be held in working memory until they are linked with their parents, which would result in the increase of its overall dependency distance. This fact generates a subhypothesis: If Hypothesis 1 is true, then Japanese must have a smaller number of dependents than English in comparable texts in both languages concerned [Hypothesis 2 (preliminary)].

Indeed, one characteristic in Japanese that would allow Hypothesis 2 to be true is that any potential element in a Japanese sentence which would express information shared between the addresser and addressee is optional and therefore omissible. Consider the following example.

(10) [boku [wa]] [Duruurii de] [koohii [o]] [kat ta].[1]
I topic Drury at coffee object buy past
'I bought some coffee at Drury.'

First of all, for (10) to be grammatical, the sole requirement is that the root phrase of the sentence *kat ta* should be placed sentence-finally. Therefore, scrambling the other three items, each of which is formed with a noun followed by a particle, does not affect the well-formedness of the sentence. More importantly, in (10), any item in a bracket might be omitted if it were already understood between the speaker and the hearer. This

[1]Omission of the particle *de* results in ungrammaticality as opposed to that of the topic particle *wa* or the object particle *o*, although deletion of both *ga* and *o* leads to an ambiguous sentence in isolation. (*Paul wani tabe ta* can be interpreted as 'Paul ate a crocodile.' or 'A crocodile ate Paul.')

omissibility makes Japanese quite dissimilar to English in syntactic structure, since in English subcategorisation frames specify the dependents of a verb. For example the English counterpart *buy* of the verb *kau* in (10) requires two dependents, specifically, a subject and an object. Therefore the sentence without them like 'Bought at Drury.' is syntactically illicit, while the Japanese corresponding sentence 'Duruurii de kat ta.' is still well-formed. Observing such syntactic structures in Japanese, we can speculate on syntactic difficulty that omissibility of Japanese is likely to favour Hypothesis 1 because it reduces the number of dependents in a Japanese sentence. This speculation leads us to a more concrete subhypothesis: If Hypothesis 1 is true, then Japanese must have a smaller number of dependents thanks to omission than English does in comparable texts in both languages concerned [Hypothesis 2 (revised and final)].

I shall explore these two hypotheses in the following section through English and Japanese spoken text analyses via dependency distance.

3 Text analyses

3.1 Method and Materials

Materials. There were in total five short texts utilised for analyses: Two English (i.e. ET1 and ET2), and three Japanese (i.e. JT1, JT2 and JT3).[2] All texts are transcriptions of free conversations. ET1, ET2, JT1, and JT3 were transcribed by students at the Phonetics and Linguistic department of University College London originally for the purpose of sociolinguistic research, and JT2 was transcribed by myself. The participants in the conversations were all native speakers of the language concerned. Also all the subjects were university students, with the exception of JT3 for which a Japanese lecturer took part in the conversation. Table 1 below displays the main characteristics of the texts. The data collection procedures were as follows: A free conversation was initially recorded onto a cassette tape, and some continuous section from the entire discourse was transcribed verbatim and as accurately as possible.

[2]I am grateful to Luisa Element, Joanna Conn, and Izumi Nakamura who were responsible for producing the texts ET1, ET2, and JT1 plus JT3, respectively. Thanks also to all the participants in the recording sessions of the conversations.

Table 1

Text	Subjects		
	Number	Native tongue	Type
ET1	4	English	University students
ET2	4	English	University students
JT1	6	Japanese	University students
JT2	3	Japanese	University students
JT3	3	Japanese	University students plus a lecturer

Method. The first stage of analysis was calculating the mean dependency distance for each text. Firstly, speech error in the texts such as repeated words, hesitation words or sounds, and ungrammatical phrases were bracketed in order not to be analysed subsequently. Secondly, the dialogues in the texts were separated into independent syntactic groups. I shall simply use the term 'phrase' to refer to a separated unit. Thirdly, surface dependency analysis was applied to each phrase and the dependency distance for every word in the phrase was measured. Fourthly, the total dependency distance for a text was counted by adding up all the distances in the text. Finally, the value of the mean distance for the text was computed by means of dividing its total distance by the number of words analysed in the whole text.

With regard to the segmentation and classification of words, the English analyses were primarily based on the Word Grammar Encyclopedia 2 (Hudson, 1997b). In addition, the following particulars should be noted concerning the taxonomy of full and auxiliary verbs: *need* and *had* followed by *to* and the infinitive of a verb were treated as auxiliary verbs; *got* in the string of *have got to* and *gotta* were dealt with as full verbs. I handled gerunds as single words belonging to both word-classes 'full verb' and 'noun'.

As to how the Japanese utterances were separated into words and classified, the following word-classes were recognised: 'particle', 'adverb', 'auxiliary verb' 'full verb' 'adjective' and 'noun', in which 'classifier' and 'numeral noun' were included. It is however noted that while *iru*, its super-polite equivalent *irassharu*, their diminutive forms *ru*, and *rassharu*, plus their respective inflectional forms, were all treated as full verbs, the copula *da* and its polite counterpart *desu* along with their inflectional forms were considered as auxiliary verbs.

In determining dependency distance, the weighted measuring system developed by Hiranuma (1998) was not used in order to maintain consistency between English and Japanese; weighted distance is applicable only to Japanese, and no comparable weighted measure for English has been developed yet. Thus, any single word in the texts therefore

counted equally, as one, which also means that Japanese particles (e.g. *wa*, *ga*, and *o*) and auxiliary verbs (e.g. *desu* and *masu*) were treated as separate words, hence counted as one too.

The syntactically analysed texts were examined quantitatively to produce a number of measures. In addition to the mean distance for each text, I calculated the proportion of parent words that had more than one dependent, and the average number of dependents per full verb. The reasons for these measures will be explained below.

3.2 Results and Discussion

3.2.1 Analyses 1: Hypothesis 1

Results. I shall report the results of the analyses at two stages: First, the results of the mean dependency distances, then the quantitative results of the dependents in the texts. Table 2 represents the texts' mean dependency distances.

Table 2

English text	Distance		Number of words	Japanese text	Distance		Number of words
	Mean	Gross			Mean	Gross	
ET1	0.340	169	496	JT1	0.380	198	521
ET2	0.428	231	539	JT2	0.342	183	535
Subtotal	0.386	400	1035	Subtotal	0.360	381	1056
-	-	-	-	JT3	0.500	531	1061
Total	0.386	400	1035	Total	0.430	912	2117

Focusing on the data for ET1, ET2, JT1 and JT2 which were homogeneous in the status of their participants, we can notice that the mean distances of the four texts are very similar. The subtotal values of the mean distance reveal that the Japanese texts (= .360) are even less difficult to process than the English ones (= .386), contrary to our expectations.

Chisquare tests confirm the non-significance of the difference in the values for these four texts. A test on ET1 and ET2 shows that the two English texts are not significantly different in terms of distance ($p > .05$), and a test on JT1 and JT2 shows the same for the two Japanese texts ($p > .35$). Two tests on the above four individual texts and on ET1+ET2 and JT1+JT2 show that there is even less difference between the English texts and the Japanese texts ($p > .15$, $p > 0.40$).

JT3 was dissimilar to the other Japanese texts in that its discourse was in formal style thanks to the presence of the lecturer. The formality in style seems to have increased the syntactic difficulty of the texts to give the highest mean distance (= .50). A chisquare test on JT1, JT2 and JT3 supports the statistic disparity among the three Japanese texts (p = .00), and also the significant difference in the group of all the five texts is statistically borne out (p = .00).

Discussion. The above results, that the four comparable texts were statistically similar in terms of mean dependency distance, provide good evidence for Hypothesis 1: Japanese is no more syntactically difficult than English. Furthermore, the actual values of the mean distance indicated that the Japanese texts should be easier to process than the English ones, which might seem surprising from a perspective of dependency direction since Japanese as a unidirectional language ought to have a higher mean distance than a bidirectional language such as English. Yet, as I have postulated in Hypothesis 2, if Japanese speakers keep dependency distance as low as English speakers do, they must presumably achieve it by using fewer dependents during their syntactic processing. To verify this claim, we need to explore further the data by analysing the quantity and distribution of dependents in the texts, which is reported in subsection 3.2.2.

JT3, whose mean distance was the highest in the data, was statistically different from the other Japanese texts. It was allegedly due to their stylistic difference in speech. The result of JT3 does not provide conclusive evidence against Hypothesis 1, however, because of the lack of English data comparable to JT3. Moreover, it is tempting to speculate that English may not show as much stylistic variation according to the speakers' social status. I shall leave this issue for further research.

3.2.2 Analyses 2: Hypothesis 2

Results. Table 3 below demonstrates (i) the number of words possessing more than one dependent, (ii) the number of words, (iii) the ratio between (i) and (ii), (iv) the number of dependents depending on full verb, (v) the number of full verbs, and (vi) the proportion between (iv) and (v).

Table 3

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Text	No. of words with > 1 dep.	Total no. of words	Ratio (i)/(ii)	No. of.deps. on full verbs	Total no. of full verbs	Ratio (iv)/(v)
ET1	105	496	0.211	126	76	1.657
ET2	118	539	0.218	114	66	1.727
ET1+2	223	1035	0.215	240	142	1.690
JT1	64	521	0.122	107	75	1.426
JT2	73	535	0.136	107	80	1.337
JT1+2	137	1056	0.129	214	155	1.380
JT3	157	1061	0.147	179	102	1.754
JT1+2+3	294	2117	0.138	393	257	1.529

Initially, chisquare tests are applied to the texts of the same language to see if there is a relationship between (i) and (ii), and (iv) and (v). The homogeneity of each group of the comparable English ($p > .80$ for both tests) and Japanese data ($p > .55$ for both tests) on Table 7 are borne out. Contrary to the results in Analyses 1, there was no statistic differences found in the data for dependents among the three Japanese texts, either ($p > .30$ for both tests).

On the one hand, it can be seen from the ratio (iii) on Table 3 that the number of words having more than one dependent is in the entire English texts 21.5 per cent, which strikingly differs from the equivalent figure, namely 12.9 per cent, for the integral Japanese texts JT1 and JT2; the proportion of words with more than one dependent in the Japanese texts is less approximately by 10 per cent in comparison with the English texts. This dissimilarity between the two groups is statistically proved by a chisquare test ($p = .00$). The same result ($p = .00$) was confirmed by tests for the data of the four texts, of all the five texts, and the total values for ET1+ET2 and JT1+JT2+JT3.

On the other hand, the ratio (vi) displays that the ratios of the number of dependents depending on full verbs to the number of full verbs for both comparable English and Japanese texts are rather similar, viz. 1.690 and 1.380, respectively. Another chisquare test confirms the association between the English and Japanese data ($p > .15$) and amongst the four texts in question ($p > .55$). It is also proved by tests that the statistic differences are insignificant between the total figures for the whole English and Japanese texts and among the data for the five texts ($p > .55$ for both tests).

Discussion. The ratio (iii) on Table 3 provides clear evidence that the Japanese texts have fewer dependents; approximately 87 per cent of the words in the entire texts were linked in a one-to-one fashion with their parents, which was less by about 10 per cent than the English texts. There was however, no evidence for fewer dependents on the full verbs in the Japanese texts according to the ratio (vi). Rather, it provides evidence for on average roughly the same number of dependents depending on the full verbs in both the English and Japanese texts.

Thus, the results of Analyses 2 provides confirmatory evidence for Hypothesis 2. In addition, they reveal that the difference in dependency relations is not located at full verbs, but rather is distributed equally throughout the entire Japanese sentences, which should consequently yield a simpler syntactic structure for the sentences, i.e. extensively singly-linked dependency structure.

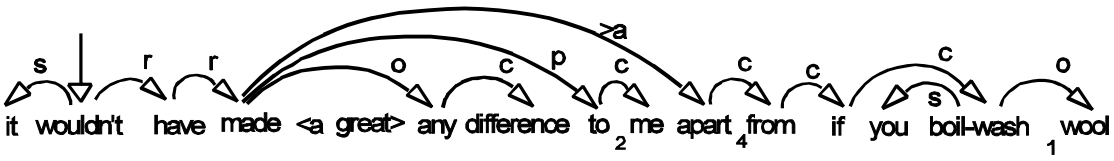
The data for JT3 may seem surprising because they were statistically indistinguishable from the data for the other Japanese texts in Analyses 2 as opposed to the first set of analyses. The results regarding JT3 in Analyses 2 still support the claim that Japanese has simpler syntactic structures containing fewer dependents, and also bring closer to home that this should be the case irrespective of stylistic differences. Yet on the other hand, Analyses 1 showed that the meandependency distance of JT3 was the highest, therefore the most difficult to process syntactically. An implication of these facts would be that so far as Japanese is concerned, formality in style would increase overall dependency distance by allowing a few very long dependencies rather than by creating more multiple dependents overall.

Our findings suggest that in general, functional pressure in syntactic processing should force working memory to create and hold as simple syntactic structure as possible. This seems to be attained in English by structuring dependencies in two directions, and in Japanese by multiple omission of dependents.

Finally, although the whole analysed texts must be sacrificed for the sake of brevity, a sample of three phrases is demonstrated below: (11) and (12) from the comparable texts of English and Japanese, respectively, and (13) selected from the formal style Japanese text.[3]

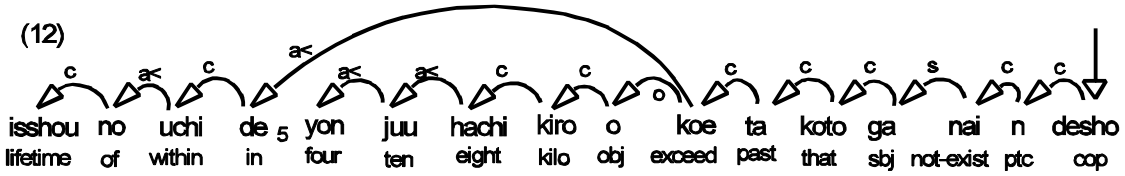
[3]The five full texts and their dependency analyses will be available in my forthcoming thesis.

(11)



(taken from ET1) mean distance = 0.500 (7/14)

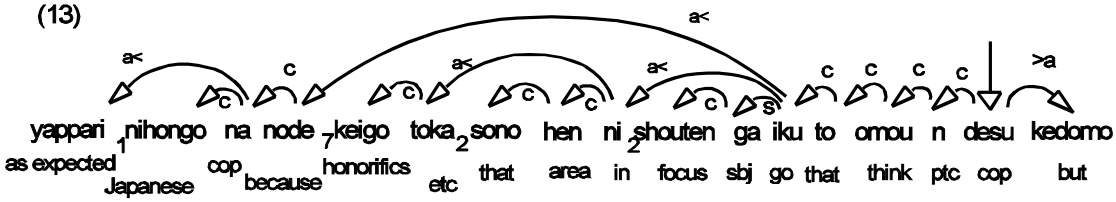
(12)



(taken from JT1) mean distance = 0.312 (5/16)

'Your weight has never exceeded 48 kilos in your whole life, has it?'

(13)



(taken from JT3) mean distance = 0.705 (12/17)

'I think that it is Japanese, as you can see, so I will focus on the area like honorifics.'

KEY: s = subject; r = sharer; c = complement; o = object; a< = pre-adjunct;
>a = post-adjunct; sbj = subject marker; obj = object marker; ptc = particle;
cop = copula; past = aux (past)

We can observe especially from (12) that singly-bounded dependencies occur to a great extent in comparison to the English example (11), and several subjects are omitted from both the Japanese examples (12) and (13): the subjects of *koe* in (12), the copula *na* and the main verb *omou* in (13).

4 Conclusions

In conclusion, Hypotheses 1 and 2 are borne out by the results of the text analyses above. We conclude therefore, that despite its general uniformity in dependency direction, Japanese is in fact no more difficult for syntactic processing than English. The most parsimonious explanation for this conclusion is that Japanese can keep, or rather may be forced by functional pressure on working memory to keep its dependency distance as low as English by employing fewer dependents in its syntactic structure, taking advantage of optionality.

References

Baddeley, A. D. (1986). *Working Memory*. Oxford: Oxford University Press.

Baddeley, A. D. & Lewis, V. J. (1981). Inner active processes in reading: The inner voice, the inner ear, and the inner eye. In A. M. Lesgold and C. A. Perfetti (Eds.), *Interactive processes in reading* (pp. 107-129). Hillsdale, NJ: Erlbaum.

Baddeley, A. D., Thomson, N. & Buchanan, M. (1975). Word length and the structure of short-term memory. *Journal of Verbal Learning and Verbal Behavior*, *14*, 575-589.

Coltheart, M. (1983). Iconic memory. *Philosophical Transactions of the Royal Society, London B, 302*, 283-294

Darwin, C. J., Turvey, M. T. & Crowder, R. G. (1972). The auditory analogue of the sperling partial report procedure: Evidence for brief auditory storage. *Cognitive Psychology 3*, 255-267.

Gibson, E. (1991). *A Computational Theory of Human Linguistics Processing: Memory Limitations and Processing Breakdown*. Ph.D. dissertation, Carnegie Mellon University, Pittsburgh, PA.

Gibson, E. (1997). Linguistic complexity: Locality of syntactic dependencies.

Hiranuma, S. (1998). Measuring the Processing Load of Japanese Words. *UCL Working Papers in Linguistics 10*, 415-439.

Hudson, R. A. (1984). *Word Grammar*. Oxford: Blackwell.

Hudson, R. A. (1990). *English Word Grammar*. Oxford: Blackwell.

Hudson, R. A. (1995). Measuring Syntactic Difficulty. London.

Hudson, R. A. (1998). Lecture note for Word Grammar 1998: 8 Processing.

Lakoff, G. (1987). *Women, Fire and Dangerous Things. What Categories Reveal about the Mind*. Chicago: University of Chicago Press.

Langacker, R. (1987). *Foundations of Cognitive Grammar, I. Theoretical Prerequisites*. Stanford: Stanford University Press.

Langacker, R. (1990). *Concept, Image and Symbol. The Cognitive Basis of Grammar*. Berlin: Mouton de Gruyter.

Moray, N., Bates, A., & Barnett, T. (1965). Experiments on the four-eared man. *Journal of the Acoustical Society of America*, *38*, 196-201.

Neisser, U. (1967). *Cognitive psychology*. New York: Appleton.

Sakitt, B. (1976). Iconic memory. *Psychological Review*, 83, 257-276.

Taylor, J. (1989). *Linguistic Categorisation: An Essay in Cognitive Linguistics*. Oxford: Oxford University Press.