Type-token Ratios in One Teacher's Classroom Talk:

An Investigation of Lexical Complexity

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2005

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1. Introduction

Over the past three decades there have been many studies on the manner in which teachers modify their speaking in the foreign language classroom. Study in this area has included analysis of modifications to syntax, grammar, pronunciation, rate of speech and lexis. However, one area that has been relatively neglected is the quantitative study of lexical modification in the form of the type-token ratio (hereafter TTR).

TTR is the ratio obtained by dividing the types (the total number of *different* words) occurring in a text or utterance by its tokens (the total number of words). A high TTR indicates a high degree of lexical variation while a low TTR indicates the opposite. The range falls between a theoretical 0 (infinite repetition of a single type) and 1 (the complete non-repetition found in a concordance). Occasionally, researchers have expressed this TTR as a percentage, multiplying the ratio by 100. However, this is an unnecessary calculation as the ratios are illustrative enough in themselves.

It is also important to note that some studies (Mizon, 1981; Kliefgen, 1985) employ a "token-type" ratio rather than the more common "type-token" ratio. In these studies the number of tokens is divided by the number of types. The results are expressed in a range where a TTR of 1 indicates the highest possible degree of variation and higher ratios indicate lower degrees of variation.

It is the purpose of this paper to investigate the lexical complexity (or more specifically, the lexical variation indicated by TTRs) of one teacher's classroom talk. It will be shown that in this specific classroom situation, there is a direct relationship between the level of the class being addressed and the TTR of the teacher's talk in that class.

Holland and Shortall (1997: 80) state:

> Apart from these studies [Mizon (1981) and Kliefgen (1985)], other research in this area has failed to support the suggested tendency towards higher type-token [ie. "token-type"] ratios with lower level learners.

It is hoped that this action research project, while not in any way generalisable to the greater world outside the small conversation school in which the study was conducted, will add further support in contrast to this claim.

This paper will also address the problems occurring with TTR analysis, insofar as they relate to the current study, and point out, in retrospect of the data collection, the importance of both token-count consideration and of content awareness in TTR analysis of teacher talk.

2. Background

Type-token ratios have been utilized in a great number of different studies ranging from "studies of freshman compositions to childhood acquisition of language" (Youmans, 1990: 4), but only sporadically in the analysis of teacher talk in the classroom. TTR studies of teacher talk may be placed into two broad categories: those that support significant lexical modification relative to level, and those that do not.

2.1 Studies supporting a significant level-TTR relationship

Mizon (in Chaudron, 1988: 72) calculated TTRs (actually token-type ratios) of both a native-speaking teacher addressing native-speaking students in England and a non-native-speaking teacher addressing ESL students in India. Her results (NS teacher: 2.3 for content words, 4.3 for function words; NNS teacher: 7 for content, 7.5 for function) showed lower token-type ratios for the native-speaking teacher, indicating greater lexical variety. This study, as reported by Chaudron, does not clearly state the level of the students apart from the fact that one group is composed of native speakers and the other of ESL students.

Kleifgen (in Chaudron, 1988: 72) calculated TTRs (also token-type ratios) of ESL classroom talk to four kindergarten children. Three were non-native-speaking and one was native-speaking. The TTR of speech directed at the NS child (2.07) showed greater variety than the TTR of speech directed at two of the NNS children (2.73). It seems that the third child was particularly communicative causing the teacher to feel less need to constrain vocabulary (1.69).

Henzl (1979) conducted a study of foreigner talk to students and native speakers. She employed token-type ratios in the analysis of verbs occurring in stories told to listeners in Czech, English and German. Stories were told to beginning learners, advanced learners, and native speakers of the three languages. There was a general tendency towards greater variety (ie. lower token-type ratios) with native-speakers and less variety with beginner non-native-speakers. Chaudron (1988: 73) gives the averages of 1.5, 1.7 and 2.5 for NSs, advanced NNSs and beginner NNSs respectively.

Shortreed (1993) calculated TTRs (type-token ratios) of native-speakers of Japanese talking with native, high, intermediate and low level Japanese speakers. Two tasks were conducted and TTRs were recorded for each. His results show a higher TTR (ie. greater variety) for speech directed at native speakers; the average for the two tasks was 0.53. Average TTRs for speech directed at high, intermediate and low level speakers were 0.46, 0.48 and 0.48 respectively.

2.2 Studies supporting no significant level-TTR relationship

Wesche and Ready (in Chaudron, 1988: 73) conducted a study on professors' classroom talk to both native and non-native speakers. The TTR analysis showed no discernable difference in lexical variation.

Long's study of lexis (in Shortreed, 1993) also failed to illustrate any changes in lexical variation when native-speakers are addressing non-native-speakers.

3. Research Subjects

3.1 Location and situation

The study was conducted in a small English conversation school in a central urban location in Tokyo, Japan. Classes were relatively informal, utilized a general conversation textbook and encouraged student-teacher and student-student conversation. Classes were 50 minutes in length, held in the afternoons and early evenings.

3.2 Class profiles

While the true and only "subject" of this study is a single teacher, the author of this paper, it is necessary to note some of the aspects relating to the individuals that make this study possible - the students.

Seven classes were included in the study. Class size ranged from one to three people. Proficiency level was determined by the teacher based on general conversation ability relative to each other and other classes both within the school and without. The study included the following classes (Table1), listed in order from least proficient (low) to most proficient (high):

A	Low	male, early 30's, salesman female, early 30's, nurse
B	Low	male, 19, recent high school graduate
C	Low	male, 19, last year high school
D	Mid	female, mid 30's, homemaker female, late 40's, office worker (stationary industry)
E	Mid	male, mid 50's, postal worker female, mid 50's, food processor female, mid 50's, accounting clerk
F	Mid	male, mid 50's, office worker (automotive industry)
G	High	male, early 20's, university student (architecture major)

Table 1: Class Profiles

4. Research Procedure

4.1 Recording Method

A simple cassette recorder was used to record each 50 minute lesson. In order to minimize undue attention to its presence - that is, in an attempt to address the 'observer's paradox' discussed by Spolsky (1998), where the subjects become self-conscious of their speech in the presence of an observer - the recorder was placed in an inconspicuous place in the classroom. This "out of sight, out of mind" technique was particularly helpful to the teacher. Recordings were clear and allowed for easy transcribing.

4.2 Transcribing Method

4.2.1 Defining "teacher talk" or what to transcribe

For the purposes of this study, most of the teacher's utterances were counted as "teacher talk" and transcribed for analysis. There were two main instances when talk was not transcribed: 1) reading from the text or other source material; and 2) instances of language drills or pattern practice.

In the case of the transcribed material, all uttered words were included in the token count. Some researchers prefer to remove small function words, such as articles, conjunctions and prepositions, from their text samples before counting the types and tokens (Heise, 1992). This would be acceptable if one's intent were to investigate, for example, particular native English speaking authors' vocabulary size or competence. Teacher talk, however, can be subject to such a drastic degree of modification - beyond that occurring in natural English writing - that to eliminate

any words from the study could very likely overlook many common modifications. For example, the writer observed the following actual phrase spoken by a native English speaker to a Japanese student of English: “You me, we go store now.” Such "broken English" is, unfortunately, not all that uncommon in English conversation schools when new teachers are addressing low level students. Had the above teacher been the subject of this study, and the token count did not reflect all possible words, his modifications, the omission of articles, conjunctions and prepositions, would have gone unrepresented.

4.2.2 Defining "type"

The main goal of this study was to investigate the teacher's modification of lexis in his classroom talk. In order to reflect these modifications as accurately as possible it was necessary to accept a much narrower definition of type than has been accepted by other TTR researchers. Some researchers have opted to use "lemmas", or word families (Francis and Kucera in Youmans 1990), preferring to group similar words together as a single type. For example, ***cannot*** and ***can't*** would be considered the same type, as would words subject to inflection, such as ***go***, ***goes*** and words related to person, such as ***she***, ***her***. Youmans (1990: 2) states:

> Most people, when speaking of an author's "total vocabulary", probably mean something like 'total number of lemmas' rather than 'total number of graphic/phonetic words'.

This may be true. However, when learning a second language, each distinct morphological, or “graphic”, word must be learned individually by the student, and as such should be treated as an individual word.

Following this morphological point of view, using such a lemma-system in this study would fail to accurately illustrate the modifications of the teacher's lexis. The following example demonstrates this:

> She usually goes to her friend's house every Thursday but this week, she didn't go on Thursday. This week, her friend was sick so she is going to go on Saturday.

If words in the above sentences are grouped into lemmas, 17 types can be counted. If the words are not grouped into lemmas then the type count is 23. Under the lemma system, 5 distinct words are unaccounted for. These are words with a distinct morphology, some even with a distinct semantic meaning that differs from each of the words of the lemma to which they supposedly

belong. For example, ***her*** has a distinctly different meaning from ***she***. ***She*** equals "the girl". ***Her*** is a word that connects some item to the girl; it is not the girl herself. It would seem a mistake to leave these words out of the study of lexical modification.

Furthermore, as in the preceding section on tokens, the use of lemmas would fail to take note of any "telegraphic" or "broken English" used by the teacher. The unnatural but communicative sentence, ***She go to friend house***, has the same lemma-type count as the more natural, ***She goes to her friend's house***.

In order to reflect detailed variation in teacher talk, and also to facilitate computer analysis of the data, it was convenient to utilize a more "morphological" definition of type. For this study, Kucera and Francis' early definition (1967) of distinct word type has been adopted (Kucera and Francis in Youmans, 1990:3):

> a word (type) is any distinctive, continuous string of alphanumeric characters (including hyphens and apostrophes but excluding other punctuation) that is preceded and followed by a space.

4.3 Type and token counting method

4.3.1 Technical procedures

1) The recordings were transcribed using MS Word and saved as a *.txt* file.
2) The transcripts were double-checked for spelling and accuracy.
3) A simple type-token counter program (written by the author using the C++ programming language; see Appendix 1) was used to analyze each *.txt* file. The analyzed data were output in the form of another *.txt* file listing the type and token count at each word (see Appendix 2 for a sample).
4) The resulting *.txt* files were imported into MS Excel for graphic analysis.

4.3.2 Type-token ratios and type-token curves

TTRs were first calculated for each class. The ratios were calculated by dividing the total number of types by the total number of tokens for each class. The results were displayed graphically (see below, section 5.1.1).

Following Youmans's (1990) model, a type-token curve (hereafter TTC) was then constructed for each class. A TTC is the line formed on a graph by plotting the running type-count against each token for the entire text. A TTC displays the type-token information very comprehensively. The TTCs for all classes were displayed on a single graph for easy comparison (section 5.1.3).

5. Results and Discussion

5.1 TTR Analysis of the data

5.1.1 Initial analysis: Calculations of TTR at total token count

The following TTRs were calculated for total type and token counts of each class (Table 2):

Class	Level	TTR
A	Low	0.219
B	Low	0.277
C	Low	0.261
D	Mid	0.238
E	Mid	0.236
F	Mid	0.278
G	High	0.283

Table 2:
TTR at total token count

When these classes are arranged in relative order from lowest proficiency level to highest and their TTRs are plotted on a graph from left to right, any correlation between the teacher's TTR and level of the class should be apparent. That is, if low-level correlates with low TTR (and high with high) then one would expect the graph line to slope gradually up and to the right. However, as the graph in figure 1 illustrates, this is not the case:

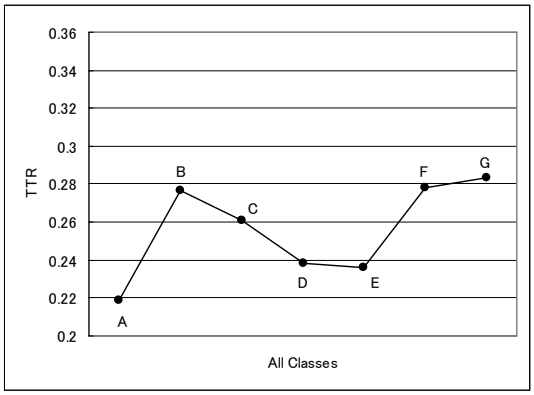


Figure 1: TTR at total token count

Based solely on TTRs calculated using the classes' *total* type and token counts, one would be inclined to assert that there is no correlation between class level and teacher TTR. This would, however, be an inaccurate assertion. The reason for this is very clear: the total token count for each class has not been taken into account. The above graph is comparing TTRs calculated with different token counts. In effect, it is "comparing apples and oranges".

5.1.2 Addressing the problem of text size: Calculations of TTR at specific token counts

The importance of considering the total token count can be seen in the following examination of the data. The class with the lowest token count (ie. the least amount of teacher talk) is class B. It has a total token count of 1343. If TTRs are calculated for each class but at 1343 tokens rather than using the total token count, a different set of results is obtained (Table 3):

Class	Level	TTR
A	Low	0.259
B	Low	0.277
C	Low	0.300
D	Mid	0.301
E	Mid	0.318
F	Mid	0.315
G	High	0.351

Table 3: TTR at 1343 tokens

If these data are plotted in a similar manner to the first set then the result is a line with a relatively uniform slope up and to the right (Figure 2) - a result clearly indicating a correlation between the teacher's TTR and class level.

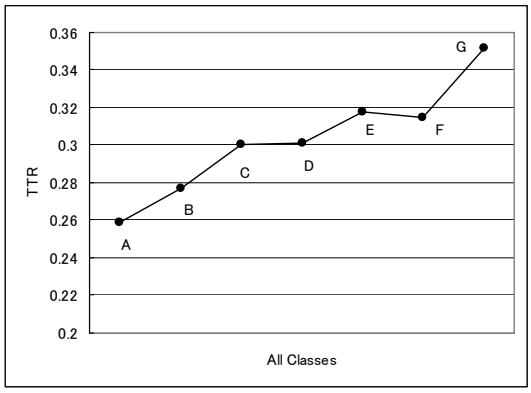


Figure 2: TTR at 1343 tokens

This correlation can be further confirmed by examining additional graphs calculated at the "terminal" (ie. maximum) token-count of each class (see Appendix 3 for full data and additional graphs). However, with each successive "step up" in token count one class must be removed from the study. Class B, for example, can not be included in a TTR comparison at 1896 tokens, and a comparison at 2380 tokens would only include 2 classes. This is a very inefficient method for examining TTR.

5.1.3 TTCs: A more accurate means of analysing the data

This problem of token consideration has been addressed by various TTR researchers (Youmans, 1990; Richards, 1986; Malvern and Richards, 1997). Richards for example, in his study of childhood language acquisition (1986), elected to plot terminal TTRs against token counts in an attempt to present the data more accurately. A more convenient, and accurate, method of representing the data can be seen in Youmans's TTCs (1990). A TTC graph (Figure 3; a full-page version of the graph can also be found in Appendix 4) was constructed for the entire data set of this study. As can be seen, the corresponding type count at any token can be easily located and compared to those of other classes. Generally speaking the steeper the curve is, the higher the TTR.

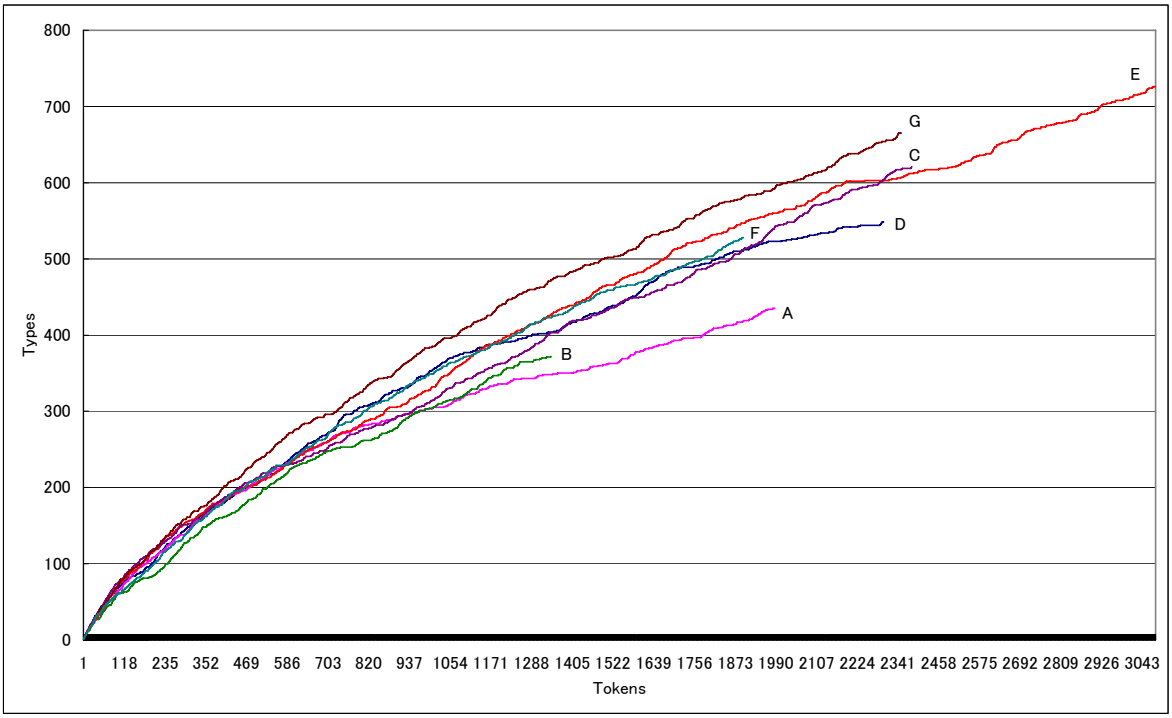


Figure 3: Type-token curves for all classes

The above graph shows that the TTRs of the teacher's talk were generally lower in low level classes, the TTCs were less steep. In some places "cross-over" of the TTCs does occur. All of these instances, with the exception of one particularly drastic case, that of class C, are reasonably insignificant as they occur between classes of similar proficiency. The unexpected results for class C, a low level class whose TTC crosses over the TTCs of all mid-level classes, will be examined in more detail below.

5.2 Correlating TTR with content

5.2.1 Lexical "complexity": lexical "variation" and "sophistication"

The calculating of TTRs illustrates well the lexical "variation" in a text or utterance. However, TTRs alone cannot show the complete lexical complexity. Laufer and Nation (1995: 309-310) discuss several measures of "lexical richness": Lexical Originality (number of tokens unique to one writer divided by total number of tokens); Lexical Density (number of lexical tokens divided by total number of tokens); Lexical Variation (number of types divided by number of tokens – ie. TTR); and Lexical Sophistication (number of advanced tokens divided by number of

lexical tokens). It is this last measure that is of interest here. Laufer and Nation state the following (1995:309-310):

> What is labelled as 'advanced' would depend on the researcher's definition. To decide what vocabulary is advanced, it is necessary to take the learner's level into consideration. Thus, the lexis in the lexical syllabus of the last two school grades could be considered advanced for school students, but not necessarily for university students. The lexis of the two last school years may not be the same in different countries with different educational objectives and different amounts of instruction. Here lies the weakness of the LS measure. The same piece of writing may be analysed differently in terms of LS, depending on how 'advanced' vocabulary is defined. This makes the measure unstable.

Despite the fact that LS may indeed be an unstable measure, it does justice to the notion that content is an important factor in analysing lexical complexity. And while a complete analysis of the teacher's lexical sophistication is beyond the scope of this paper, it is necessary to make some brief comments on the content of the teacher's talk. This content, as it relates to both token and type counts, will be discussed in the next two sections.

5.2.2 Comparing teacher talk in beginning and advanced classes: Factors affecting token count

When the number of tokens in a text or utterance increases disproportionately to the number of types, the TTR for that text or utterance decreases. This is realized directly through repetition. There are several main instances when repetition occurs in teacher talk: 1) for aid in retention; 2) for clarification; 3) for emphasis; and 4) for praise/confirmation. These are all cases of repetition that seem to have occurred more frequently in the lower level classes, classes in which discourse is much less similar to that of natural native speaking. For illustrative purposes, samples from transcripts of Class A (low proficiency) and Class G (high proficiency) are examined below. These samples show that repetition was used much more actively in the lower level class, thus helping to explain the greater number of tokens per type.

5.2.2.1 Repetition for aid in retention (recycling vocabulary)

Recycling vocabulary is a well-used technique for helping ESL students retain target vocabulary. Repetition of a word can occur in direct sequence, repeating the word two or more times in a row, or it can occur spaced throughout the lesson to "remind" students of the target vocabulary. Teacher talk in Class A made much greater use of repetition for retention, especially in direct sequence. Unsure words and target language are repeated slowly with clear enunciation to reinforce retention:

Sample 1 (discussing the purchase of a new computer mouse)

T: A pet?...
A mouse. ...
Right. The day before yesterday. Day. Before. Yesterday.

Sample 2 (demonstration of target language leading to subsequent practice)

T: How much? Five cents. How much? Ten cents. How much? How much? Twenty-five.

In Class G teacher talk, rightly or wrongly, there seems to be very little repetition for retention of new vocabulary. Definitions were quickly given and class proceeded with rarely more than one example:

Sample 1 (giving a definition of apply for)

T: Hope to belong to. Apply for means to send in your resume, for example.

Sample 2 (giving a definition of advertise)

T:... you know "advertise", right? In the weekly newspaper. For example, Asahi Weekly is a newspaper. If you have a company and you want to advertise your company in the weekly newspaper every week you would send in a design for your company, a phone number and address, and they would print it.

5.2.2.2 Repetition for clarification

When a student fails to understand what has been said by the teacher, the word or phrase must be repeated. Here this is referring to situations where students are familiar with the vocabulary but for some reason were unable to understand it on first hearing. In the case of Class A, exact repetitions were very common:

Sample 1 (identifying value of coins)

T: Ok. What's next? Is this ten? Ten yen?...
Is this ten? Ten yen?

Sample 2 (introducing a topic)

T: What's in here?...
Yes. Coins. Money…
Coins. That's right. Today we're going to look at money and coins.

However, it appears that with the more proficient Class G, when clarification was needed at all, the teacher was more likely to paraphrase the expression:

Sample (describing picture quality)

T: Yeah, when I tried to send an email, i-shot, to my home computer and it came up this little, fuzzy, gray, light brown, terrible…
Yeah, almost. Really bad quality.

5.2.2.3 Repetition for emphasis

In both classes repetition was sometimes used to emphasize points. In Class A the repetition was usually exact:

Sample 1 (strengthening an opinion)

T: That's a good one, that's a good one.

Sample 2 (setting the rules)

T: Don't read it. Main point, key point: don't read. One dollar. It's too slow. Don't read.

In class G, however, again the repetition, when it occurred, was more of a paraphrase, restating the idea in a slightly different way:

Sample (commenting on clothing)

T: That's good. Very stylish. Nice style.

5.2.2.4 Repetition of praise/confirmation words

Another interesting comparison to be made between Class A and G is the teacher's use of praise and confirmation words. Table 4 lists three common praise/confirmation words and the frequency with which they occur in each class:

Word	Class A	Class G
"Good!"	25	2
"Nice!"	4	3
"Right!"	15	0
Total	44	5

Table 4: Frequency of praise/confirmation words

As the above table shows, these words are much more common in the lower level class and, after the initial occurrence of each, contribute only to the token count, thus driving the TTR down. It would seem that the teacher felt less inclined to praise the high level student. This could be due to the more natural, conversation-like discourse of the lesson.

5.2.3 Explaining anomalies in the type-token curves: Factors affecting type count

While token counts are pushed higher by repetition, type counts are pushed higher by lack of repetition. Some main factors that can influence the type count are: 1) degree of vocabulary restraint for simplification purposes; 2) complexity of topic; 3) frequency of topic change; and 4) degree of telegraphic speech. In the TTC graph above, it was noted that Class C seemed to fall out of the general pattern of "low-level equals shallow TTC, high-level equals steep TTC". An examination of some of the factors that affect type count may help explain this. Samples will be examined from Class C below.

5.2.3.1 Degree of vocabulary restraint for simplification

Several researchers have commented on vocabulary simplification. Chaudron (1988: 72), for example, cites an excellent example of a teacher practicing vocabulary restraint: "What do you think is happening in this picture, what's it supposed to depic- to show?" Henzl (1979: 161) also comments: "… in English samples the expression *young gal* was substituted by the word *woman*…" In the case of Class C, there are no apparent examples of this kind of simplification. In fact, the opposite occasionally occurs. Difficult or new vocabulary, rather than being simplified, was often augmented with more complex vocabulary, thus adding to the type count. This may have been due to an unconscious attempt to satisfy the student's apparent desire to acquire new and interesting vocabulary:

Sample (discussing computer language)

T: That's right. It's called binary…
…It's called machine code.

5.2.3.2 Complexity of topic

The complexity of subject matter can also affect the type count in the teacher's talk. Generally, more complex topics require a more complex and diverse lexis. Some of the topics[*] that were covered in Class C include: chemistry, computer programming, artificial intelligence, metaphysics, cosmology, movies, and political parties. This could help explain the unusually steep TTC. In contrast, topics addressed in Class A, another low-level class, included much simpler content: games, rafting, money, menus, and food. This is reflected in Class A's TTC.

5.2.3.3 Frequency of topic change (topic count)

In addition to complexity of topic, the actual frequency of topic change may also have an effect on type count. Table 5 illustrates the topic count of each class.

Class	**Topic Count**
G	16
C	15
E	13
D	12
F	10
A	10
B	9

Table 5: Topic count

As can be seen, Class C has a relatively high topic count, only slightly less than that of the highest level class, while the other low level classes, A and B, have lower counts. Using topic counts to help explain the unexpectedly steep TTC of Class C seems reasonable. However, it should be kept in mind that, much like Laufer and Nation's Lexcial Sophistication measure,

[*] It should be noted that most of these topics were initiated by the student, a particularly inquisitive and technologically-minded high school male, and not by the teacher.

determining what constitutes “topic” is somewhat subjective. Nevertheless, there does seem to be a general correlation between topic count and TTR.

5.2.3.4 Degree of telegraphic speech or “broken English”

While there were no particularly clear examples of telegraphic speech present in this study it is worth taking note of it here as it relates to type count. According to Bates, Bretherton and Snyder (1988: 164) in their study of early childhood lexical development, telegraphic speech can actually raise the TTR:

> The other way [to raise the number of types] is to speak telegraphically, an option elected by many of the least advanced children in our 28-month sample. If this interpretation is correct, it would explain why high type-token ratios are negative indicators of language development at 28 months, even though the same measure is a positive indicator of language ability in later years.

This would be an issue in, for example, the "broken English" of the new teacher mentioned in section 4.2.1. It is conceivable that had a similar study been conducted of the above teacher's classroom talk, many of his TTCs would have been steeper than those presented here.

6. Conclusion

The purpose of this paper was to examine the lexical complexity of one teacher's classroom talk and to point out some of the concerns relating to TTR analysis as they occur in this study.

Initial analysis of the data proved to be unreliable, showing no correlation between student level and the TTR of the teacher’s talk. However, after the consideration of two important factors, token count and content, more reliable results could be calculated.

It has been shown that, in this teacher's classroom talk, there is generally a direct correlation between type-token ratios, when expressed as type-token curves, and the proficiency level of the students in the class. The most significant divergence from this tendency, a steep TTC for the teacher talk encountered in a single low-level class, was explained by an examination of the actual content of the teacher's talk. The teacher talk in this particular class exhibited traits common to those of higher level classes: lack of vocabulary restraint, more complex topics and a higher topic count. This, however, is an exceptional case. It is the result of a particular individual, in a one-on-one class, who was given the freedom to initiate discussions on any topic he wished and who welcomed a diversity of topics and the introduction of new and interesting vocabulary.

Appendix 1:
Brief description of the type-token counting program

The program was written in C++ as a simple console application and runs through the following steps when analysing the data:

1. The user is prompted for the filename of the text to be analysed. The file must be in *.txt* format and located in the same directory/folder as the counting program.

2. The text is read into the program.

3. All words are converted to lower case.

4. The text is "tokenized". That is, the text is dissected into individual words (delineated by spaces) and each word is stored separately but in a sequenced list (called a 'vector'). During this process, all punctuation external to each word is removed. Tokens are also counted at this stage.

5. For each token the program searches back through the tokens occurring previously in the token list for matches. If there are no matches then the token is a new type and the type count is advanced by one.

6. The final tokenized list and running type and token counts are written into a new *.txt* file. The label "tokenized" is prefixed to the original filename.

A sample of the program's output can be seen in Appendix 2. The *.txt* file is extremely versatile as it can be edited, printed or imported into spreadsheet software for further analysis.

Appendix 2:

Sample of TTR program output *.txt* file

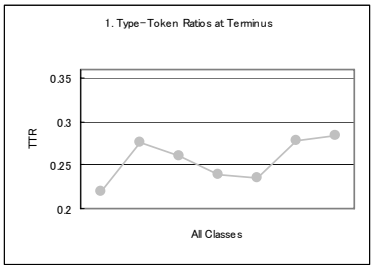
Class D

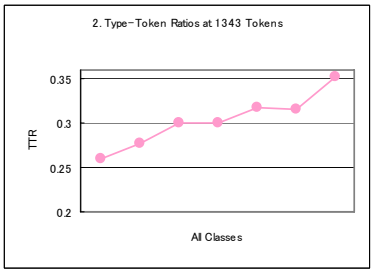
(Token)	(Type)	(Word)
1	1	how
2	2	are
3	3	you
4	4	guys
5	5	today
6	6	good
7	6	today
8	7	yesterday
9	8	it’s
10	9	beautiful
11	10	isn’t
12	11	it
13	12	what’s
14	13	new
15	13	how
16	14	was
17	15	everyone’s
18	16	week
19	17	do
20	17	you
21	18	have
22	19	any
23	20	comments
24	21	or
25	22	questions
26	23	for
27	24	her
28	25	play
29	26	some
30	27	sports
31	28	track
32	29	and
33	30	field
34	31	running
35	31	and
36	32	high-jump
37	32	and
38	33	under
39	34	i
40	35	understand
41	35	i
42	36	think
43	36	it’s
44	37	called
45	38	steeplechase
46	39	so

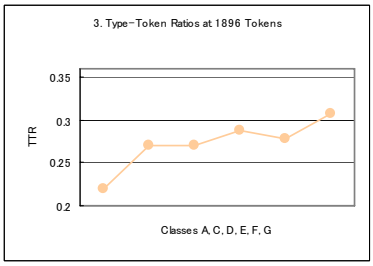
Appendix 3:

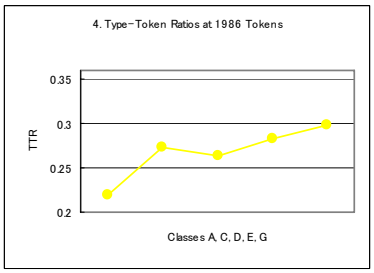
TTR data at token intervals

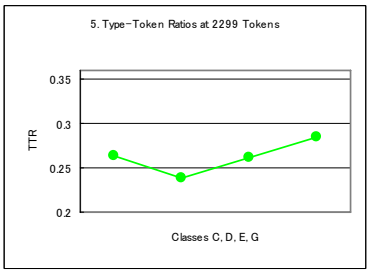
TTR Calculated		at terminus	at	1343	at	1896	at	1986	at	2299	at	2349	at	2380	at	3080
Class	**Level**	TTR	Types	TTR	Types	TTR	Types	TTR	Types	TTR	Types	TTR	Types	TTR	Types	TTR
A	Low	0.219	348	0.259	418	0.22	435	0.219	*	*	*	*	*	*	*	*
B	Low	0.277	372	0.277	*	*	*	*	*	*	*	*	*	*	*	*
C	Low	0.261	403	0.3	512	0.27	541	0.272	604	0.263	617	0.263	621	0.261	*	*
D	Mid	0.238	404	0.301	511	0.27	523	0.263	548	0.238	*	*	*	*	*	*
E	Mid	0.236	427	0.318	547	0.289	560	0.282	603	0.262	607	0.258	612	0.257	726	0.236
F	Mid	0.278	423	0.315	528	0.278	*	*	*	*	*	*	*	*	*	*
G	High	0.283	472	0.351	581	0.306	592	0.298	654	0.284	665	0.283	*	*	*	*



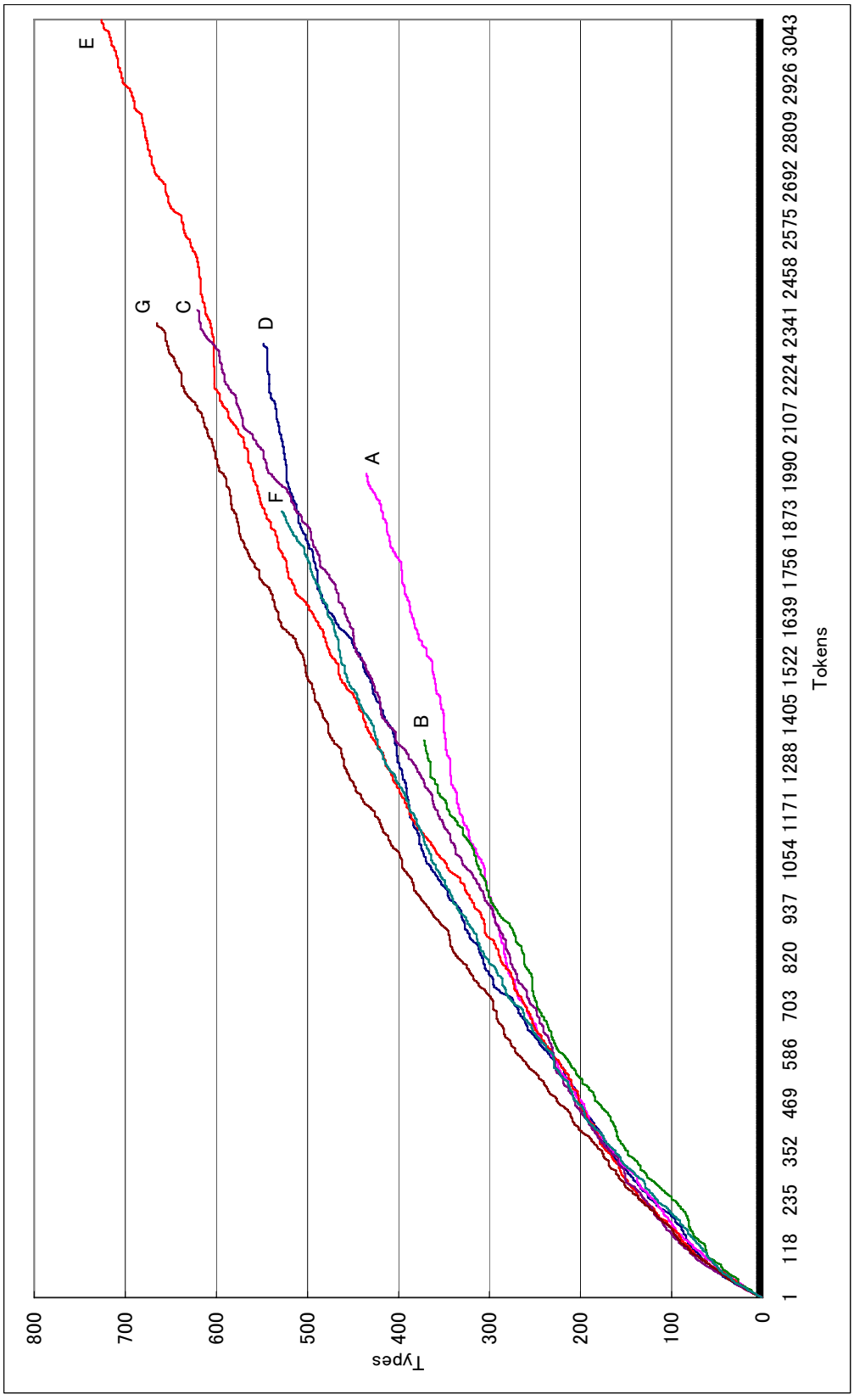








Appendix 4: Full-size TTC Graph



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