The Relationship Between Reaction Time and Accuracy of Syntactic Judgment by Second Language Learners

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The studies presented in this paper were conducted to find answers to the following questions : 1. Does the time constraint factor influence the speed of processing, the accuracy of judgment, and/or their relationship of second-language learners in a grammaticality judgment task? 2. Does the level of proficiency in a second language influence the speed of processing, the accuracy of judgment and/or their relationship? 3. Does the time constraint factor influence the speed of processing, the accuracy of judgment, and/or their relationship of native speakers? 4. What can be concluded about the use of reaction time measurements in second-language acquisition experiments? The results from the present studies indicate the following : 1. For non-native speakers, the presence or absence of the *time constraint factor* in a grammaticality judgment test produces significant effects on the *speed of processing* but not on the accuracy of judgment or on the relationship between the two variables. 2. *Level of proficiency* in the second language produces significant effects on the *accuracy of judgment* but not on the speed of processing or on the relationship between the two variables. 3. For native speakers, the presence or absence of the time constraint factor did not produce any significant effect on either the speed of processing, the accuracy of judgment or their relationship. 4. Thus it is concluded that the reaction-time measurement is a good indicator of the level of linguistic competence for non-native speakers in second-language acquisition experiments.

1. Introduction

Over the past quarter of a century, the use of reaction time measurements has become quite widespread and thus well known in the field of cognitive science, especially in human information-processing research. As far back as twenty-two years ago, Pachella (1974) had acknowledged that

most of the phenomenon that are of interest to modern cognitive psychologists cannot be quantified or characterized through direct observation. Although science continued to develop in the 80s and new inventions in technology have made it possible for researchers to scan the brain in various ways, it is, more often than not, unethical to look into the brain of a normal person. Thus the most advanced scientific methods are still not available to researchers looking into the information-processing behavior of normal people.

This inaccessibility to the most advanced methods of measurement that can tap into events taking place in the human minds when normal people are processing information have forced many researchers to depend on the use of reaction time measurements in their studies. Cook (1991), E-J Kim (1996), R-H Kim (1993), Mack (1986) and Shim (1991, 1995) are just a few of those researchers who have recently used reaction time measurements in their studies that investigated the performance and/or competence of second language learners in the syntactic processing of their L2 (in all of the above studies, the L2 was English). And they all conclude that the reaction time measurement provides valuable insight into the different patterns of syntactic processing that second language learners manifest.

However, providing the justification and rationale for using a reaction time measurement as a dependent variable in a study is just the first step that a researcher has to take. The next steps, which are to solve the problems of precisely defining the measurement of "reaction time," and clarifying the relationship between a reaction time measurement and any other measurement that may serve as a dependent variable (e.g., accuracy) are perhaps more important. In all of the above mentioned studies, the researchers have indeed discussed the relationship between their two dependent variables, reaction time and accuracy. When there was a significant relationship, it was duly reported.

For example, Shim (1991) reports that there was a significant negative correlation between reaction time and error rate in her native-speaker group data, which suggests a speed-accuracy trade-off effect in the native -speakers' performance. On the other hand, she further reports that the data from the non-native speakers in her study did not show such correlation. However, one needs to take into consideration the fact that all of her data were gathered in a timed experiment. That is, none of her subjects had

the opportunity to perform a non-timed task. Thus, the question still remains as to whether her subjects might have performed differently if they were not constrained for time (or even, *less* constrained for time). A related question would then be, if there was a difference in their performance, how would this have affected the results in terms of reaction time and error rate?

In another study, R-H Kim (1993) used exactly the same procedures as Shim (1991) and added another measure to her study which was the subjects' error rate in a non-time task. In the timed task, she did not find a significant correlation between reaction time and error rate for either the native-speaker group or the non-native speaker group (i.e., there was no speed-accuracy trade-off effect). However, when the results from the non-timed task were compared with the results from the timed task, they showed that all of her subjects made substantially fewer errors in the non-timed task. This was not something that could be expected from the result of her correlational analysis in the timed task.

It is possible that the large discrepancy in the error-rates of the timed and non-timed tests was exaggerated by the fact that the non-timed task was administered right after the timed task which could have facilitated the subjects' performance (test-retest effect). Furthermore, considering the fact that the test sentences were made up of pairs of grammatical and ungrammatical sentences it may have been possible for the subjects to compare the sentences and figure out that if one was grammatical then the other must be ungrammatical and vice-versa. While this is difficult to do in a timed, computerized task in which only one sentence is displayed on the screen at a time, it is a definite possibility when the task is non-timed and also administered in the paper and pencil format in which the subjects have access to the whole list of sentences.

This then naturally leads us to the following questions : Does the absence of the time constrain factor indeed play a role in facilitating non-native speakers' accuracy in syntactic processing? How much slower are non-native speakers in their syntactic processing when the time constraint is removed? Do non-native speakers' speed and accuracy show similar relationships when the time constraint factor is present and when it is not? Further, does the subjects' level of proficiency in the second language influence the speed, accuracy, or their relationship in a grammaticality judgment

task? What about native speakers : Do they behave in similar ways as non-native speakers in timed and non-timed tasks of grammaticality judgment? The answers to the above questions are pertinent to the interpretations of studies that investigate second-language leaners' performance since the reaction-time measurement is used in all these studies as an indicator of the subjects' linguistic proficiency (automaticity of linguistic processing). Thus it was in an effort to find the answers to the above questions and provide the basis for the interpretation of reaction-time measurement results in second-language acquisition studies that the following studies were conducted.

2. Experiment A

2.1. Subjects

Subjects were 28 Korean-English bilinguals who were divided into two groups in terms of their level of proficiency diagnosed by the TOEFL. The proficient group consisted of 14 graduate students at the University of Illinois whose TOEFL scores fell between 590 and 633. The non-proficient group consisted of 14 students enrolled in the Intensive English Institute, a language learning program run by the Division of English as an International Language at the University of Illinois. Their TOEFL scores ranged from 477 to 550. All 28 subjects were right handed and their lengths of stay in the US were comparable. The youngest subject was 20 and the oldest was 29 at the time of testing.

2.2. Test Design

The experiment was designed in such a way that for each subject taking a time-constrained test, there would be another subject taking the test under a non-timed condition. Thus the experiment was a 2 × 2 factorial design in which level of proficiency and type of testing condition were the two independent variables. Each independent variable was divided into two levels.

For the timed condition, the subjects were instructed to respond as quickly and as accurately as possible while for the non-timed condition, the subjects were told that time was not a factor in the analysis and that the

researcher was only interested in the accuracy of their performance.

The test sentences were exactly the same as those that were used in a previous study (Shim 1991). There were 52 ungrammatical sentences and 45 grammatical sentences. The sentences were categorized into 13 different syntactic structures which tested the following : the past tense morpheme, the plural morpheme, the third person singular morpheme, the present progressive morpheme, determiners, pronominalization, particle movement in two word verbs, verb subcategorization, auxiliary + verb construction, yes/no questions, Wh-questions, word order and prepositions.

2.3. Procedure

The test sentences were stored in an IBM PC program that randomized the test sentences for each new trial. The program showed the test sentences one at a time and were able to record the reaction time and the accuracy of the subject's response. Reaction time was recorded within a computer accuracy of .01 seconds.

Each subject was tested individually after he/she was interviewed by the experimenter. All the subjects were requested to fill out a language background questionnaire from which their length of stay in the United States, proposed area of study, type of language instruction they had received, and various other relevant information was gathered. The subject was then given the appropriate instruction and the experimenter presented some examples on the computer so the the subject could become familiar with the testing procedure. All subjects were requested to use only their right hand during testing. After the test, which did not last more than 8 minutes, the subjects were paid three dollars each.

2.4. Data Analysis

Two separate two-way ANOVAs were run in order to test the significance of differences among the groups for the effect of the two independent variables (level of proficiency and testing condition) on the two dependent variables (reaction time and error rate). Then, planned pairwise comparisons between the groups in each testing-condition and proficiency level were done for all factors regardless of the significance of main effect. Since this meant 4 comparisons when the degree of freedom was 3, the alpha

level was adjusted using the modified Bonferroni test (Keppel 1982). The planned pairwise comparison was done in order to further investigate the significance of difference within each of the pair of groups. Also, correlational analyses were done between the two dependent variables in order to find out if there were any significant relationship between them. Finally, an analysis of the data in terms of the error rates was conducted for each syntactic category. The main purpose of this analysis was to find out if the groups in different testing conditions and levels of proficiency were experiencing difficulty in similar categories. If this was true, I also wanted to find out if the order of difficulty was the same for all groups.

For each subject, all reaction time measurements that were above 2.5 standard deviation from their mean and measurements for incorrect responses were excluded from the analyses. On the whole, from a total of 2716 reaction time measurements, 46 were excluded because they were beyond the cut-off of 2.5 standard deviations above the mean and 200 measurements were excluded because they were from incorrect responses. Thus 2470 reaction time measurements were used in the final analyses.

As discussed in Shim (1991), reaction time measurements that are beyond a certain amount from the mean need to be excluded from the analysis because they may not represent the normal processing time of the given sentence. The cut-off point is decided upon before the study is conducted and it is set at an appropriate level depending on the type of testing that is involved in the study. Following Shim (1991), it was deemed appropriate to set the cut-off at 2.5 standard deviations above the mean. The reason for excluding reaction time measurements for incorrect responses is due to the fact that these measurements do not represent the reaction time needed for accurate and successful processing of the given sentence.

In the case of error rates, errors on grammatical sentences were not included in the analysis. For errors made on ungrammatical sentences, one can assume that the subject was not successful in recognizing the ungrammaticality of the sentences. However, for errors on grammatical sentences, one cannot judge as to the specific reasons behind such errors and thus counting those errors in the analysis might mis-represent the subjects' level of accuracy.

3. Experiment B

3.1. Subjects

Subjects were 37 native speakers of English who did not speak any other language beyond a beginner's level. They were divided into two groups in terms of the condition of task : timed and non-timed. The youngest subject was 18 and the oldest was 22 at the time of testing. All subjects that participated in this experiment were students enrolled in introductory linguistics courses at the University of Illinois. They were encouraged to participate in the experiment as a means of getting hands-on experience in psycholinguistic experiments. The design and purpose of the study were later explained to the subjects in a regular lecture and discussion session.

3.2. Test Design

As in the experiment for non-native speakers, for the timed condition, the subjects were instructed to respond as quickly and as accurately as possible while for the non-timed condition, the subjects were told that time was not a factor in the analysis and that I was only interested in the accuracy of their performance.

The test sentences were exactly the same as those that were used in my recent study (Shim 1995). There were 90 ungrammatical sentences, in which the ungrammaticality was either directly due to violation of the Subjacency Principle, Binding Principle A, or due to the violation of another related parameter of English (e.g., Pro-drop Parameter). There were also an equal number of grammatical sentences that were similar in construction with the ungrammatical sentences which did not violate any principle of UG.

3.3. Procedure

The test sentences were typed and stored in a text file for the Turbo Pascal used with a Macintosh computer. A Turbo Pascal program was developed that randomized the order of presentation of the test sentences for each subject. The program showed the test sentences one at a time and recorded the reaction time and the accuracy of each response by the subject.

Reaction time was recorded within a computer accuracy of .01 seconds.

Subjects were tested in groups in the LinguaCenter Computer Laboratory in the Division of English as an International Language, University of Illinois at Urbana-Champaign. All testing sessions were conducted in the afternoon, between 2:00 p.m. and 4:00 p.m., on either a Wednesday or a Friday. There were 21 seats available in the computer room, but no more than 16 people were tested at the same time. The temperature of the lab was maintained at a comfortable level for all sessions. The experimenter was present throughout the duration of the test and conducted all of the testing sessions herself.

When subjects arrived at the testing site, a description of the experiment, the consent form and written instructions were given, and all instructions were repeated orally. All subjects were requested to fill out a language-background questionnaire and to use only their right hand during testing. Practice sentences were presented before the actual test began. Subjects were also told to remain in their seats quietly after finishing the test so that other subjects would not be distracted.

3.4. Data Analysis

Although 37 subjects participated in the experiment, the results from 7 subjects were not included in the analysis because the information from the language background questionnaire revealed that these subjects were left handers. ANOVAs were conducted in order to test the significance of differences between the two groups (timed and non-timed) on the two dependent variables (reaction time and accuracy). Correlational analyses were also done between the two dependent variables in order to find out if there were any significant relationship between them. Finally, the results were observed in view of the speed and accuracy rates for sentences with different syntactic construction. The purpose of this analysis was to find out if the relationships between speed or accuracy for certain syntactic constructions were different from others.

As in experiment A, all reaction time measurements that were above 2.5 standard deviation from their mean and measurements for incorrect responses were excluded from the analyses. Likewise, in the case of error rates, errors on grammatical sentences were not included in the analysis.

4. Results

4.1. Non-native Speakers' Reaction Time

Non-native speakers' reaction time was affected by the different types of testing condition but not by level of proficiency. Table 1 shows the mean reaction time of each group in seconds and Figure 1 is a graphic illustration of the findings.

Statistical analysis (ANOVA for multifactor randomized design) revealed

Table 1. Mean RT for Non-native Speaker Groups

	Level of Proficiency	
Testing Condition	Non-Proficient	Proficient
Timed	5.03 (0.92) secs.	3.94 (1.01) secs.
Non-Timed	7.12 (0.83) secs.	6.95 (1.64) secs.

Numbers in parentheses show standard deviations.

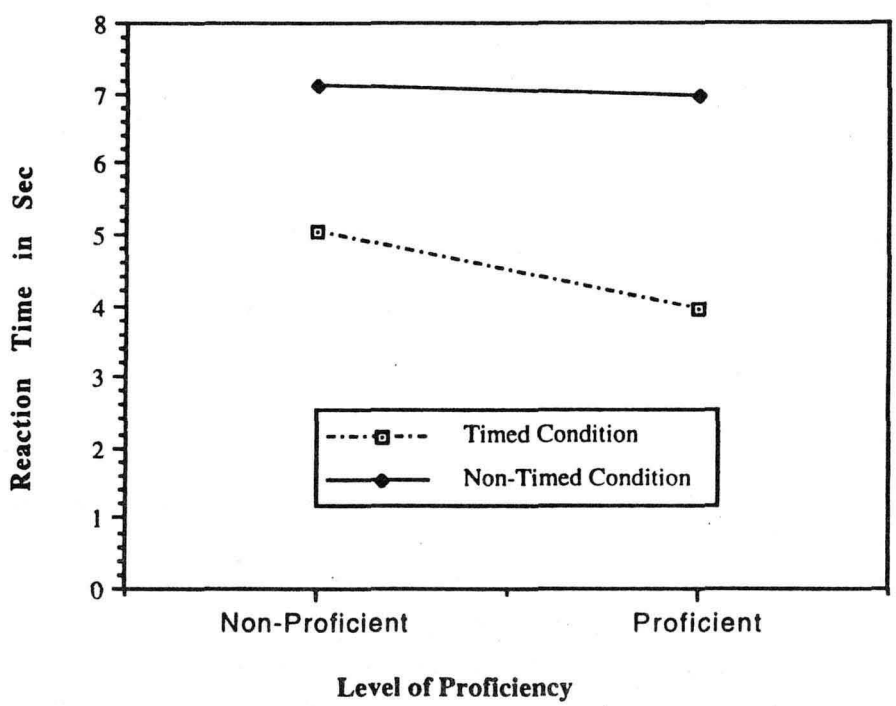

Figure 1. Mean RT for Non-native Speaker Groups.

significant main effect [$F(1,24)=34.404$, $p<.0001$] for testing condition (Timed and Non-Timed). However, the effect for level of proficiency was not significant and there was no testing-condition × level-of-proficiency interaction.

Planned pairwise comparisons with an adjusted alpha-level of 0.375 (modified Bonferroni test) showed significant difference of RT within each proficiency group for the testing-condition factor : [$F(1,12) = 19.667$, $p<.01$] for the Non-proficient group and [$F(1,12) = 16.957$, $p<.01$] for the Proficient group. The differences due to level of proficiency were not statistically significant.

4.2. Non-native Speakers' Accuracy

Unlike reaction time, non-native speakers' error rate was mainly affected by the level-of-proficiency factor rather than the testing condition factor. Table 2 shows the mean error rate of each group in percent (in parentheses are the standard deviations of the respective groups). Figure 2 is a graphic representation of the findings.

A two-way analysis of variance revealed a significant main effect [$F(1, 24) = 32.607$, $p<.0001$] for level of proficiency (Proficient and Non-proficient). However, there was a non-significant main effect for testing condition and there was no testing-condition × level-of-proficiency interaction.

Table 2. Mean Error Rates for Non-native Speaker Groups

	Level of Proficiency	
Testing Condition	Non-Proficient	Proficient
Timed	28.3%(10.6)	12.4% (3.6)
Non-Timed	24.6% (7.8)	9.8% (4.0)

Planned pairwise comparisons with an adjusted alpha level of 0.375 (modified Bonferroni test) showed a significant difference of error rate within each testing condition group for the level-of-proficiency factor : [$F(1,12) = 21.232$, $p<.01$] for the group in the non-timed condition and [$F(1,12) = 13.972$, $p<.01$] for the group in the timed condition. The differences due to testing condition were not statistically significant for either of the group pairs.

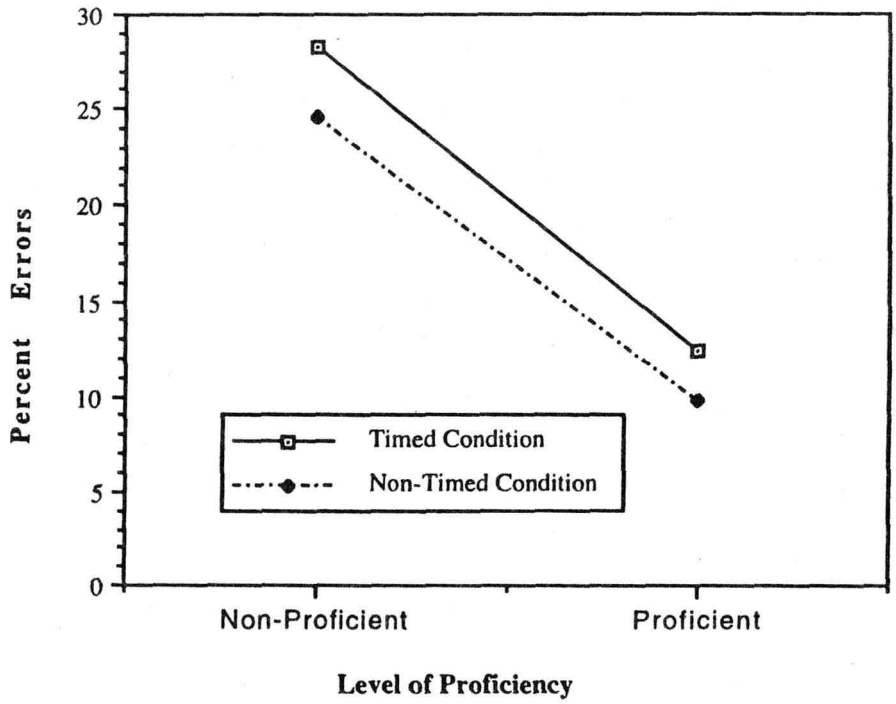

Figure 2. Mean Error Rates for Non-native Speaker Groups

4.3. Correlation Between NNSs' Reaction Time and Accuracy

Correlational analysis (person-product moment correlation) showed that there was no significant relationship between the two variables when each of the groups was taken separately as well as when all the subjects were taken together as a single group.

4.4. NNSs' Performance in Grammatical Categories

Only error rates were calculated for this analysis. Table 3 shows the results.

The results were consistent with previous results from Shim (1991) in that all subjects, regardless of level of proficiency and/or testing condition seemed to be experiencing difficulty in the categories determiner, verb-classification and prepositions. The order of difficulty in terms of greater to lesser error rate for the 13 syntactic categories were also similar all across

Table 3. Mean Non-native Speaker Error Rates for Grammatical Category

Grammatical Categories	Testing Condition			
	Non-Proficient		Proficient	
	Timed	Non-Timed	Timed	Non-Timed
Determiners	83.30%	58.25%	45.75%	50.00%
Verb classification	66.66%	71.00%	33.25%	25.00%
Prepositions	45.83%	37.50%	29.17%	16.75%
Particle Movement	37.50%	16.75%	12.50%	0.00%
Wh-Questions	29.16%	29.25%	12.50%	8.25%
Past-Tense Morpheme	20.83%	12.50%	4.17%	8.25%
Aux+V. Construction	20.83%	12.50%	4.17%	0.00%
Pronominalization	20.83%	37.50%	4.17%	0.00%
3rd Person Singular	20.83%	16.75%	8.25%	12.50%
Yes/No Questions	20.83%	12.50%	0.00%	0.00%
Plural Morpheme	8.25%	16.75%	12.50%	8.25%
Present Progressive	4.17%	4.25%	0.00%	0.00%
Word Order	0.00%	8.25%	4.17%	0.00%

the four groups.

4.5. Native Speakers' Reaction Time

The testing condition factor (timed and non-timed) did not have an effect on native speakers' reaction time. Mean reaction time for the group in the timed condition was 3.428 second (standard deviation, 1.723) and the mean reaction time for the group in the non-timed condition was 3.121 seconds (standard deviation, 1.952). As these means show that the two groups processed the sentences in much the same amount of time in the two testing conditions.

4.6. Native Speakers' Accuracy

The testing condition factor did not have an effect on native speakers' accuracy rate either. Mean accuracy rates for the group in the timed condition was 88. percent (standard deviation, 13.7 percent) and the mean reaction time for the group in the non-timed condition was 91 percent (standard deviation, 11.8 percent). Again, these rates show that the two groups processed the sentences at about the same level of accuracy in the two test-

ing conditions.

4.7. Correlation Between Native Speakers' Reaction Time and Accuracy

No significant correlation was found between the two variables for the groups in either of the conditions.

4.8. Native Speaker's Performance in Syntactic Constructions

Both reaction time and accuracy rates were taken into consideration for this analysis and Table 4. shows the summary of the results.

Table 4. Mean Native Speaker RT and AR for Syntactic Constructions[1]

Syntactic Constructions	Testing Condition			
	Reaction Time		Accuracy	
	Timed	Non-Timed	Timed	Non-Timed
Pro-drop (G)	1.42	1.34	96%	100%
Pro-drop (U)	2.15	2.20	65%	69%
Movement (G)	4.48	4.24	61%	69%
Wh-question (U)	2.52	2.29	97%	97%
Subjacency-base (G)	3.69	3.53	92%	93%
Subjacency (U)	4.40	4.24	94%	95%
Pronoun subject (G)	2.80	2.23	99%	99%
Anaphor subject (U)	2.18	1.88	96%	97%
Anaphor binding (G)	4.96	4.44	94%	95%
Anaphor binding (U)	5.68	4.82	91%	96%

Although no significant effects were found for either the reaction time variable or the accuracy rate variable, there was a consistent tendency for the group in the timed condition to respond more slowly than the group in the non-timed condition. The group in the timed condition also showed a consistently lower rate of accuracy than the group in the non-timed condition. There was no significant correlation between the reaction time variable and the accuracy rate variable for any of the syntactic constructions used in the test.

[1] See Shim (1995) for a detailed description of the various syntactic constructions used in this experiment.

5. Discussion

5.1. The Reaction Time Variable

From the results presented above, it has become evident that the subjects' reaction time measurements are related to the testing condition given in the experiment in the case of the non-native speakers but not for the native speakers. This, however, is to be expected since the subjects in the Non-timed condition were not under any time constraint and thus were free to take all the time they *wanted*. When a subject is not sure about the grammaticality of a sentence, the subject is likely to take more time to think about the structure of the sentence. However, this duration of time is probably not identical to the minimum duration of time that is *needed* to accurately process the sentences.

The important question here is whether this effect was also found in the subjects' error rate. In other words, did subjects who were able to perform at their own speed without the burden of having to make quick decisions perform more accurately than those subjects who were required to work as quickly as possible? The results indicated otherwise. Although the subjects who were not constrained for time did take longer time to process the test sentences, their judgments on the grammaticality of the test sentences did not get better. There was no significant difference in the groups' error rates.

The results from the non-native speaker experiment are even more revealing when considered in view of the results from the native speaker experiment. No effect of any kind was observed in the native speaker experiment for either the reaction time variable or the accuracy rate variable. Thus a strong suggestion that emerges from these results is that the time contraint factor in a syntactic judgment study (and perhaps other kinds of language processing studies) neither inhibits nor facilitates the subjects accuracy judgment as long as the subjects' level of proficiency is similar. Rather, they give additional information about the subjects' speed (or automaticity) of syntactic processing.

Thus as researchers, we are able to get a more accurate description of the subjects capability in grammaticality judgment tasks since they provide the researcher with a set of measurements that must have a direct relationship with the actual time that is needed to process the given sentences. In other words, if certain groups of subjects whose level of language proficien-

cy have been rated at essentially the same level show that they require different amounts of reaction time, this would be an indication that there must be another factor (e.g., age of onset, length of exposure) which may be the cause for the difference.

However, one important aspect of reaction time measurement that all researchers need to remember is that the underlying assumption in the use of the reaction time variable is that the subjects will cooperate and perform at maximum speed and maximum accuracy. Moreover, it is perhaps just as important that the type of instruction given to the subjects does not emphasizes one measurement over the other (i.e. accuracy and speed should be treated with equal importance by the experimenter). This is the approach in giving instructions that Pachella (1974) defines as 'normal'.

In the present study, the comparison was made between the 'normal instruction' approach and the 'extreme accuracy emphasis' approach. Thus although testing conditions of these two types were not found to affect level of performance, this does not mean that accuracy rate (or error rate) will not be affected by other types of testing conditions (e.g moderate to extreme speed emphasis). Pachella (1974) gives a nice illustration of the

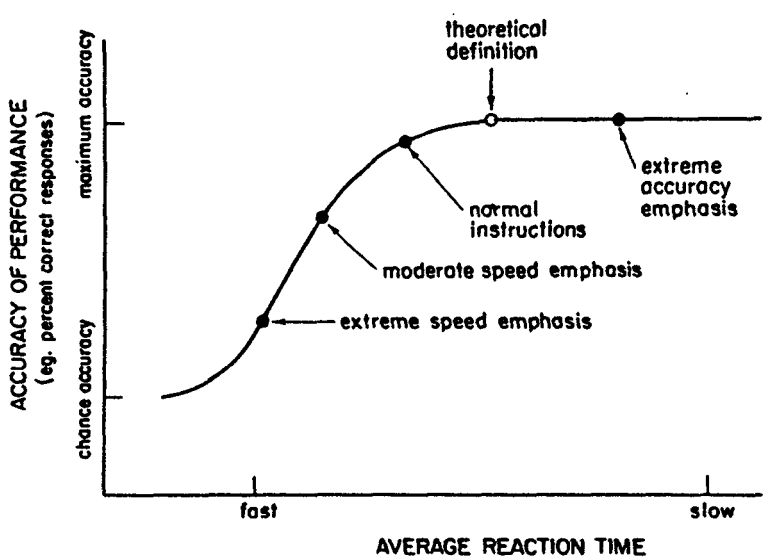

Figure 3. An Idealized Speed-accuracy Operating Characteristic.[2]

[2] Taken from Pachella (1974), p. 59.

different types of testing conditions that are possible due to the effects on instructional emphasis. (See Pew, 1969 for a more detailed discussion about testing conditions), and refers to it as a *speed-accuracy operating characteristic* (see Figure 3).

Taking a radical stance, one could bring up the point that in the non-native speaker experiment, there is a tendency for non-timed groups to have fewer errors than the timed groups even though the differences were not statistically significant. The point here is that this tendency is expected since there cannot actually be an idealized situation where the theoretical definition of reaction time is achieved even with the 'normal instruction' approach. Thus if the subjects know in advance that both accuracy and speed is required of their performance they will inevitably sacrifice maximum accuracy for speedier reaction. Nevertheless, considering the small within-group variances found in this study, it seems unlikely that the differences would emerge as significant even if one were to test a very large number of subjects (that is, assuming that 'normal instructions' are given).

Moreover, the results from the native speaker experiment are exactly the opposite of the the results from the non-native speaker experiment. The phenomenon in the native speaker experiment can be explained if one considers the fact that the native speakers' level of linguistic competence is uniform and thus their accuracy judgment cannot get better when they are given more time to think about the structure. Thus instead of getting better, their accuracy rate may fall when they are given the opportunity to make judgments against their native speaker intuition.

Why is it then, that R-H Kim (1993) found a significant difference in error rates obtained from her timed-test condition and her non-timed-test condition? As I indicated in the introduction, it is very likely that there was a test-retest effect compounded by the fact that the presentation of the test sentences was neither random nor one at a time.

5.2. Level of Proficiency Effect

If testing condition is not a factor that affects the error (accuracy) rates, is there no factor affecting the subjects level of accuracy? Yes, there is. It was found in this study that the subjects' level of proficiency determined by the widely accepted TOEFL score was a variable that could accurately pre-

dict the significant difference in error rates. The proficient subjects had a lower mean group error rate than the non-proficient subjects.

Thus a researcher needs to keep in mind that unless the number of subjects in a given group is fairly large, it is difficult to say that any group of subjects truly represent the whole spectrum of variation that exists in the level of proficiency possessed by learners of English as a second language. Any interpretation of results from such a study should therefore take into consideration, and if possible, report, the subjects' level of proficiency as indicated by other types of standardized and well-recognized test measurements.

A related question to the effect of level of proficiency on error rates is whether this variable also affects reaction time measurements. The present study did not find this to be the case. In other words, reaction time measurements did not differ in relation to the level of proficiency of the subjects. This is, again, a very strong indication that the reaction time variable is a stable and reliable indicator of the actual processing time of syntactic structures.

Some opponents of the use of reaction time measurements might argue that there was a tendency for proficient groups to require lesser reaction time than the non-proficient groups in both testing conditions even though the differences were not statistically significant. Would the difference turn out to be significant when a large number of subjects are tested? This may be a question that should be answered by further studies. However, considering the small amount of within group variation as represented by the standard deviations, this seems a remote possibility.

6. Conclusions

In conclusion, this study has showed the following :

1. Non-native speakers' speed of processing is affected by the presence or absence of the time constraint factor in a grammaticality judgment test, but their accuracy of judgment or the relationship between reaction time and accuracy variables do not change with or without the time constraint factor.

2. Non-native speakers' accuracy of judgment is affected by their level

of proficiency in the target language, but their speed of processing and the relationship between the two variables are not affected by their level of proficiency.

3. In the case of Native speakers, neither reaction time nor accuracy rate is affected by the presence or absence of the time constraint factor. Further, the time constraint factor did not produce any significant differences in the relationship between the two variables.

4. Thus the reaction-time variable can be considered a good indicator of the level of linguistic competence of non-native speakers in second-language acquisition experiments if researchers do their best to give normal instructions that would elicit performance that is closest to Pachella's theoretical definition of reaction time.

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