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ANALYSIS OF THE EFFECT OF NONVERBAL COMMUNICATION ON ENGLISH PERFORMANCE: CASE STUDY - AIR TRAFFIC CONTROLLER OF TRAINING ENGINEERING

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Abstract- Student air traffic controllers need to acquire a specific level of competence in English, they need to be able to meet the linguistic challenges posed by a complication or unexpected event with particular ease. However, language proficiency does not only involve verbal communication, but also some aspects of nonverbal communication. The aim of the study was to assess nonverbal communication based on the statistical relationship between aspects of nonverbal communication and perceived language performance. In this performance assessment, 12 final year air traffic control students participated in our study. 36 simulations covering three different themes were recorded and observed in detail and a new corpus called the Academy English Conversation Corpus (AECC) was constructed. The results of this research indicate that students' postures and voice can be studied with the same degree of reliability as segmental information and that it is recommended that special attention be paid to the nonverbal communication aspects of student air traffic controllers.

Keywords: Professional Training, Teaching Methods, Air Traffic Controller, Nonverbal Communication.

1. INTRODUCTION

The Air control is considered one of the highest stressful services, which requires a number of cognitive and psychological competencies [1]. Air traffic controllers are required to prevent collisions between aircraft while expediting air traffic [2]. They must also be able to communicate effectively and maintain a high level of language skills in order to perform their duties safely[3]. Language performance is not restricted to vocabulary, pronunciation and knowledge of grammar [4], but is affected by other factors such as nonverbal aspects [5], [6].

Nonverbal communication involves many cueing modalities, such as body language, voice and postures, as well as a number of key themes that cut across psychology and other disciplinary fields [7]. According to Bambaeeroo et al. nonverbal communication is a very valuable part of the communication process, as nonverbal cues are often indicative of the sender's intent and emotional reactions [8].

In addition, Mehrabian and Ferris developed an equation Equation (1) for the verbal and nonverbal aspects of a message in the communication process as shown in Figure 1 [9], [10]:

$$\text{Total Impact}(TI) = 0.07 \text{ spoken words} + \\ + 0.38 \text{ tone of voice} + 0.55 \text{ body movements} \quad (1)$$

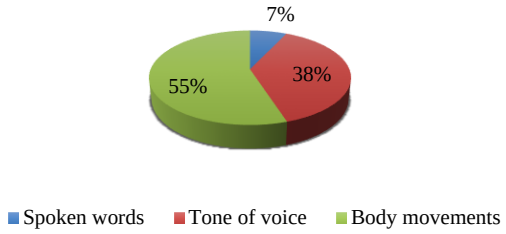

Figure 1. Communication model proposed by Albert Mehrabian [10]

The aim of the study is to assess the nonverbal communication of third year air traffic control students based on the statistical relationship between aspects of nonverbal communication and perceived language performance. In recent years, a series of English corpora have been developed [11], including the Foreign Accented English (FAE) database [12] the Radiotelephony Plain English Corpus (RTPEC) [13] and Database of English Read (ERJ) [14] . However, these corpora do not cover nonverbal aspects and, until now, no study has been conducted to assess nonverbal communication of air traffic controllers - Hence the importance of the present research.

In this research, we focus on the English spoken by Moroccan student air traffic controllers. First step, we collect a corpus of student dialogues. We then conduct a series of analyses to investigate the effect of nonverbal communication on English language performance. Our paper is structured as follows: First, we evaluate the collected data. Secondly, we analyze the concordance and the degree of concentration of the ratings given by the examiners. In section 3, we determine the contribution of three criteria: nonverbal communication aspects, rhythm and segmental to the overall language performance. Finally, we discuss and conclude our work and show the direction of our future studies.

2. RESEARCH METHOD

2.1. Data Collected

During the three years that student air traffic controllers spend at the Mohammed VI International Civil Aviation Academy (AIAC), practical training is an important part of their initial training [15]. This practical training is done in the form of simulations allowing the student controllers to develop the skills necessary for air traffic management. In March 2021, 12 final year air traffic control students (five male and seven female) participated in the experiment. Each student was asked to participate in three separate 30-minute scenarios. As a result, 36 simulations of different levels of difficulty were recorded and then observed in detail. As a result, we constructed a new corpus called the Academy English Conversation Corpus (AECC). Despite the limitations of the current database, the corpus already provides a basis for conducting a preliminary language analysis, such as presented in this research.

In the three different scenarios, the content is briefly as follows: Case 1: loss of separation between two aircraft during initial climb, Case 2: failure of ground-to-air communication, Case 3: overflying a prohibited area. The whole Pseudo-pilot / Controller communication process and the associated devices are illustrated in Figure 2 [16].

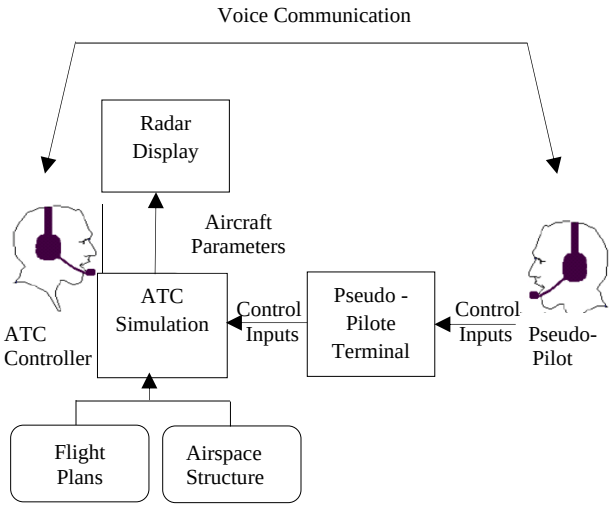

Figure 2. Pseudo-pilot/Controller communication [16]

The exercises are conducted in the presence of an examiner, who acts as an assistant to the students. Due to the variety of circumstances and situations , students were asked to use the ASSIST principle [17] as shown in Figure 3. This technique is designed to help student air traffic controllers respond to abnormal situations[18] by creating step-by-step plans to assist aircraft without compromising the safety of other traffic. The examiner will then know what the student is doing.

2.2. Evaluation of Collected Data

Three qualified examiners with good teaching experience and language proficiency joined the annotation experiment [19]. The letters EX1, EX2 and EX3 refer to the three respective examiners. They were asked to give a segmented score on a scale of 1 to 5 for all the data in the dialogue, as shown in the Table 1 [20], for each of these four criteria:

1. Nonverbal communication: assessment of speaker postures and voice.
2. Rhythm: assessment of the cadence of words used.
3. Segmental: assessment of fluency and structure.
4. Language performance: overall assessment of student's English.

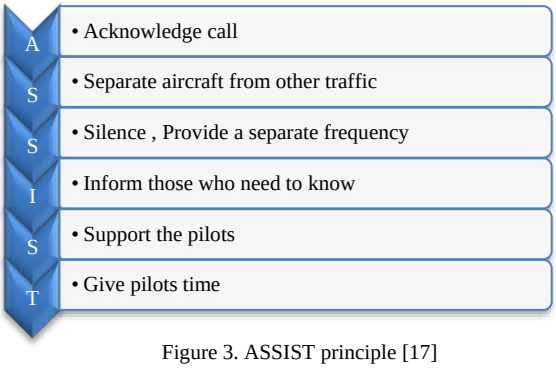

Figure 3. ASSIST principle [17]

Table 1. Assessment criteria [20]

1 Very poor	Imprecise
2 Poor	Considerable practice is required
3 Fair	Common
4 Good	Accurate
5 Excellent	Close to the level of a qualified person

Figures 4 to 7 respectively show the histograms of the ratings given by the examiners for each criterion: nonverbal communication, rhythm, segmental and language performance. As shown in the figures, examiner ratings of two (Poor), three (Fair) are the most frequent.

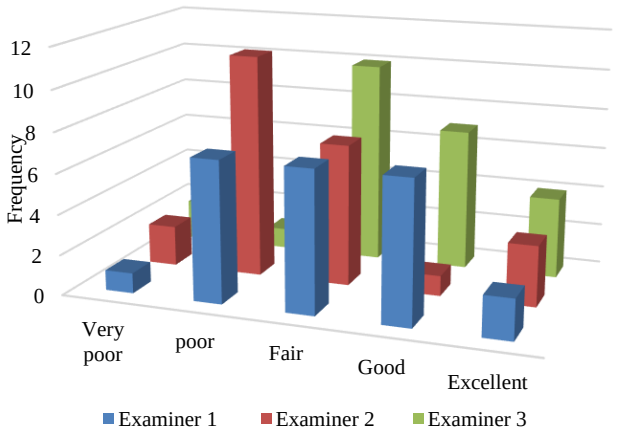

Figure 4. Histograms of the ratings given by the examiners for nonverbal communication

3. RESULTS AND DISCUSSIONS

3.1. Concordance of Ratings

The scatter plots between the ratings of the three examiners are shown in Figures 8 to 11. The graphs for nonverbal communication, segmental and language performance show that the points are distributed on a diagonal. These results indicate that the concordance of language performance, segmental and nonverbal communication is high.

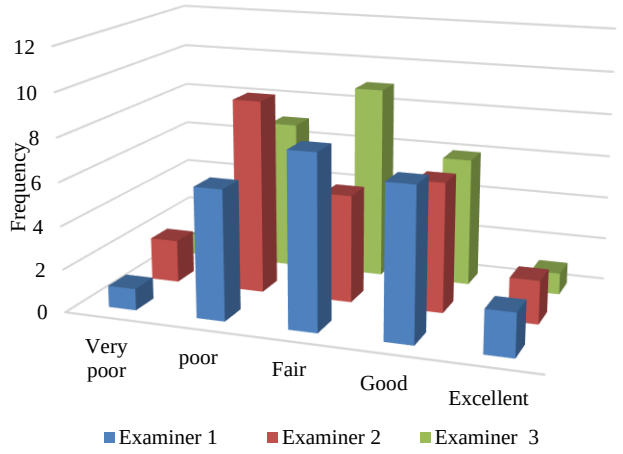

Figure 5. Histograms of the ratings given by the examiners for rhythm

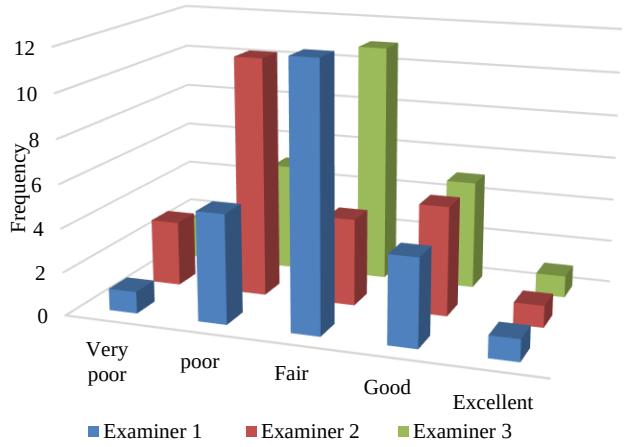

Figure 6. Histograms of the ratings given by the examiners for segmental

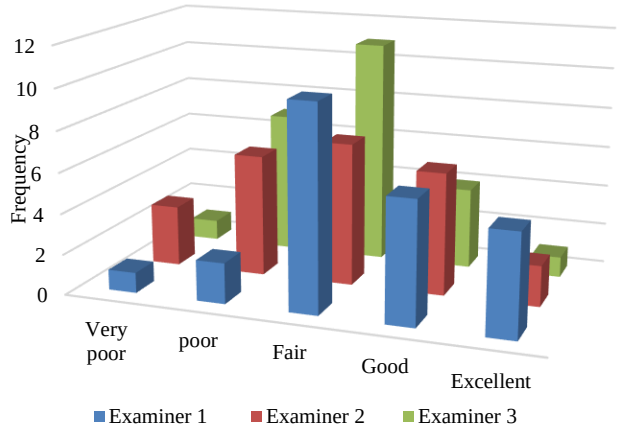

Figure 7. Histograms of the ratings given by the examiners for language performance

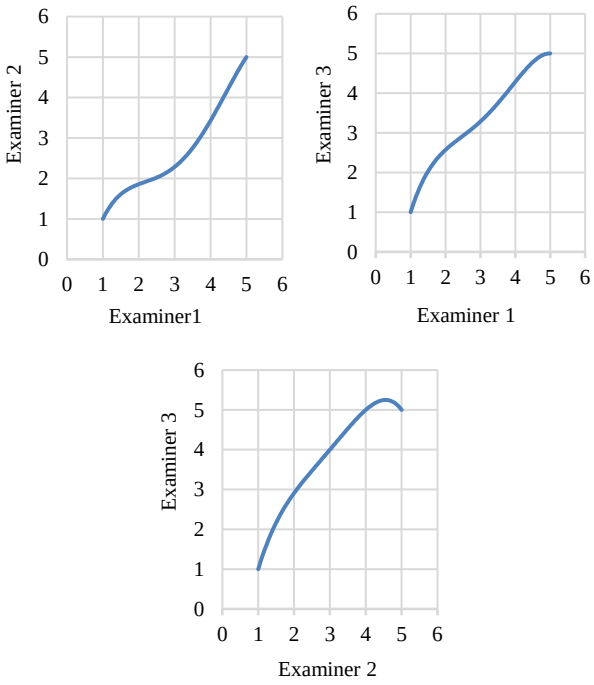

Figure 8. Bubble graphs of ratings of Nonverbal communication between examiners

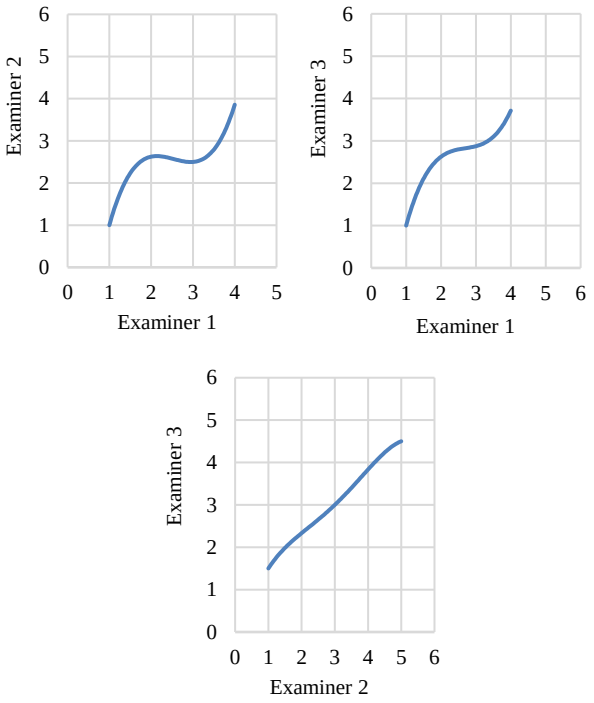

Figure 9. Bubble graphs of ratings of Rhythm between examiners

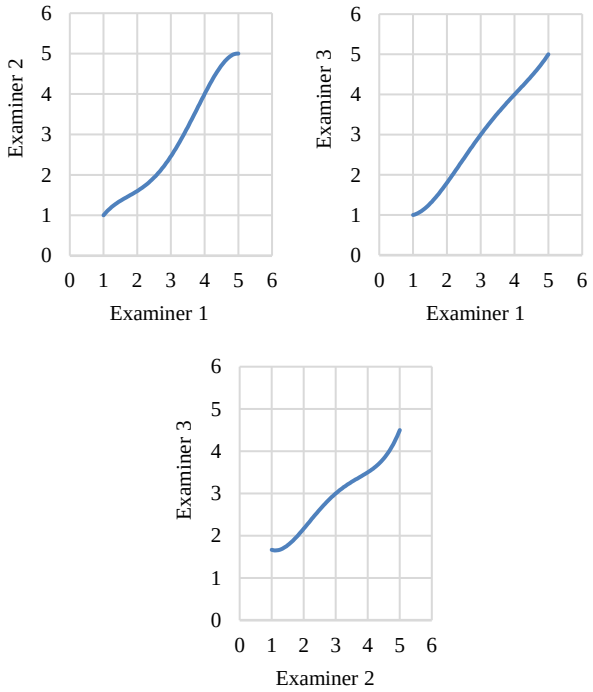

Figure 10. Bubble graphs of ratings of Segmental between examiners

On the other hand, the scatter plot for the rhythm criterion is more scattered than the other criteria, suggesting that the perception of this criterion is different from one examiner to another. In order to compare the concordance with other data sets, the degree of rating concentration [21] has to be calculated.

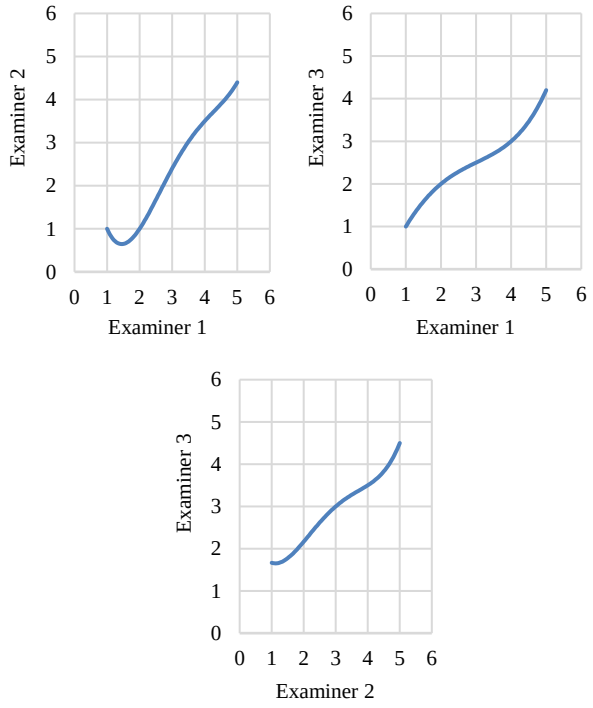

Figure 11. Bubble graphs of ratings of Language performance between examiners

The degree of concentration of the ratings was calculated by using the following Equations [21]:

$$C_s = \frac{2}{K(k-1)} \sum_{i=1}^{K-1} \sum_{j=i+1}^{K} C_s(i,j) \tag{2}$$

$$C_s(i,j) = \frac{1}{N} \sum_{n=1}^{N} d_s^{(n)}(i,j) \times 100 \tag{3}$$

where,

N : Number of samples;

K : Number of examiner;

$C_s(i,j)$: Ratio of samples that are similarly rated by examiners b i and j.

We assume two conditions: matched samples C_A, and allowing ± 1 gaps C_B; s is condition of the calculation, and $s \in \{A, B\}$ is number of samples. Therefore,

$$d_A^{(n)}(i,j) = \begin{cases} 1 & r_i^{(n)} = r_j^{(n)} \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

$$d_B^{(n)}(i,j) = \begin{cases} 1 & \left| r_j^{(n)} - r_j^{(n)} \right| \le 1 \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

where, $r_i^{(n)}$ denotes the rating of the sample n annotated by the examiner.

The degree of concentration for the collected data are presented in Table 2. In contrast, Table 3 shows the degree of concentration calculated by Minematsu et al. for the ERJ database [21]. They also calculated the degree of the concentration for the FAE corpus and found $C_A = 46.5\%$ and $C_B = 80.3\%$ for the overall performance. Thus, the degree of concentration of our dataset is almost similar than that of these corpora. These findings imply that the data collected are reliable enough to be used. Additionally, the aspects of nonverbal communication analyzed in this research indicated that the degree of concentration is practically the same as segmental. This result therefore indicates that the aspects of nonverbal communication can be studied with the same degree of reliability as the segmental information.

Table 2. Degree of concentration

	C_A	C_B
Nonverbal communication	36.6%	80.6%
Rhythm	28.7%	73.3%
Segmental	40.7%	82.6%
Language performance	42.5%	85.4%

Table 3. Degree of concentration calculated by Minematsu et al. [21]

	C_A	C_B
Rhythm	28.7%	73.3%
Segmental	40.7%	82.6%

3.2. Contribution of Each Three Criteria

The contribution of each criterion to the overall performance was studied by calculating the standardized partial regression. The standardized partial regression represents the objective variable as a linear combination of the explanatory variables and is expressed as follows:

$$y = a_1 x_1 + a_2 x_2 + a_3 x_3 + a_0 \tag{6}$$

where,

y: Objective variable which is considered as overall performance;

x_1, x_2, x_3: Standardized explanatory variables which are considered as the ratings of the three criteria nonverbal, rhythm and segmental respectively.

a_1 a_2, a_3: Standardised partial regression coefficients which are considered as the contribution of each explanatory variable.

Table 4. Standardized regression coefficients

	EX1	EX2	EX2	Overall performance
Nonverbal communication	0.974	0.711	0.554	0.598
Segmental	0.813	0.94	0.914	0.517
Rhythm	0.215	0.178	0.333	0.221

We can see that, according to the table 4, the nonverbal communication of examiners EX1 and EX2 contribute significantly to their overall performance. In the case of examiner EX3, although the value of the standardized partial regression coefficient of nonverbal communication is lower than that of the examiners EX1 and EX2, it has a relatively significant influence on the overall performance. In a second step, the standardized partial regression coefficient was calculated considering all data. The result is shown in the overall performance column of the table 4. Indeed, the contribution of nonverbal communication is the second most important after segmental, and much higher than that of rhythm. This result suggests that nonverbal communication significantly affects perceived performance in English.

At the end of our study, it is recommended that nonverbal communication skills training be added to traditional aviation training programs, this approach will enable student air traffic controllers to communicate effectively even in the most stressful operational situations.

4. CONCLUSION

Despite the wealth of accumulated knowledge on language performance, most studies have focused only on aspects of verbal communication. In this study, we examined the verbal and nonverbal aspects of communication observed among student air traffic controllers during practical work. Three scenarios of abnormal situations were created. We constructed a new corpus called the Academy English Conversation Corpus (AECC) by recording the students' voices and postures during the exercise.

The results of our statistical analysis concluded that aspects of nonverbal communication have a positive and profound effect on the perceived English language performance of student air traffic controllers, and that students' postures and voices can be studied with the same degree of reliability as segmental information. As the research is still in a developmental phase, future work aims to enrich the corpus by creating new scenarios and by involving other student air traffic controllers.

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BIOGRAPHIES

Youssef Mnaoui was born in Mohammedia, Morocco in 1980. He is a Ph.D. student at ENSET Institute, University of Hassan II Casablanca, Morocco since 2018. Since 2004, he is an air traffic controller at the National Airports Office in Casablanca, Morocco. Since 2018, he is an Air Traffic Control Simulator Instructor and also teaches the course of Air Investigation and Accidents at Mohammed VI International Civil Aviation Academy, Casablanca, Morocco. His research is focused on simulation, technology teaching systems, training system air traffic control communication, air investigation and accidents.

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