

# Auditory Processing of Information as a Significant Factor in Improving Communication Competence in Children with ADHD

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**Abstract:** *In modern society, we encounter the need to redefine the existing communication models to harmonize them with the dynamic changes of the sophisticated world. In most definitions, the previous communication models are extremely simplified and homogenized. Such models are only possible in a sterile communication situation when the distractions from the environment are closed, with the presence of uniformity of the individual characteristics of a person, which is less and less possible to achieve in the modern world full of diversity. This paper aims to look at the influence of auditory processing on children's communication competence, which is manifested in the reduction of loss that can occur due to individual characteristics of a person, such as the perceptual attributes of the auditory stimulus or errors that can occur during the transmission of information from the sender to the recipient. The scientific contribution at the cognitive level is manifested in a more precisely defined auditory specificity in detection, discrimination and interpretation during the communication process. At the methodological level, the development of an original methodology for the qualitative comparison of subjects was achieved using statistical parameter analysis. On a practical level, the inventiveness of the application of the obtained results is manifested in their usage with the aim of improving communication competence.*

**Keywords:** communication process, auditory input, information transfer, attention variability, sound

## 1. Introduction

Observing communication competence as a complex concept that is interpreted in different ways by many authors, it is important at the beginning to determine what defines the concept of communication competence for children with ADHD (attention deficit hyperactivity disorder) within the framework of this paper. Accordingly, when it comes to defining communication competence, quality evaluation includes, on the one hand, analysing crucial theoretical concepts about the communication process, and on the other, understanding the specifics of the functioning of people with ADHD. Given that communication is a process, the outcome of the communication process can be influenced by various factors such as auditory and stimulus modulation and by reducing noise in the communication channel with the purpose of increasing the probability that the message will be correctly interpreted, and thus the child's communication competence will be more successful. Erina (2019) connects the basic characteristics of ADHD with difficulties in communication and socialization, but the measurable determinants of these difficulties have not been determined methodologically. Therefore, methodological uncertainty makes it difficult to define and measure communication competence in children with ADHD. The definitions of communication competence state that it consists of several dimensions, with the most frequently researched dimensions or criteria for evaluating communication competence: success and appropriateness (Greene 2003: 15–29). The mentioned dimensions can be observed during the communication process of children with ADHD in the form of as little noise as possible during the transmission of information from the receiver to the sender (or vice versa), which in the analysis of this paper are defined as errors of commission and errors of omission.

The concept of communicative competence, which is seen as a significant factor in improving the abilities of children with developmental disabilities, was introduced by Hymes (1972), who presented the phrase communicative competence for the first time at the Research Planning Conference on Language Development among Disadvantaged Children. From the very name of the conference, it is evident that communication competence is the subject of the author's research in the field of children with developmental disabilities, which has been recognized since the last century. A very important feature of Hymes's theory of communicative competence refers to the four parameters that underlie communicative behaviour, and they refer to the possibility (Does the behaviour conform to a formal system of rules?), feasibility (To what extent is something feasible?), social appropriateness considering the social context and realisation. Other authors supplement the initial definition by placing more emphasis on the aspect of the individual's abilities. In fact, Savignon (1972) defined communicative competence as "the ability to act in the right communicative environment, i.e. as a dynamic exchange in which linguistic competence should be adapted to the entire informational input, linguistic and paralinguistic, provided by one or more interlocutors".

The prevalence of ADHD based on scientific research indicates a percentage of 0.2% to 27% in school-aged children (Polaczyk and Jensen 2008: 434–442). The global prevalence of ADHD combined in a systematic meta-regression analysis is 6.48% (Zorlu 2020: 1237–1245). The prevalence of the mentioned disorder, which tends to increase annually, represents a significant factor in redefining existing communication models. The specifics manifested in children as part of the aforementioned disorder are an integral part of a dynamic and reversible communication process, which needs to be observed from a

modern point of view, which focuses on the individual characteristics of a person. If we look at communication as a perceptual process, the outcome of which is influenced by the individual's different thresholds of excitability, the ability to deal with distractors from the environment and the variability of the individual's attention, there is a need to analyse and study aforementioned categories more thoroughly within the framework of the communication process itself.

Research dealing with the analysis of the communication process mainly focus on variable and distractible attention, which hinders memory and planning processes, consequently reflecting on academic success and affecting children's communication competence. Deviations in the communication competence of children with ADHD are manifested as difficulties when maintaining the topic of conversation and difficulties in creating and maintaining a coherent, well-planned and appropriate conversation (Green 2014: 51–91; Tannock et al. 1996: 237–252; Martin and et al. 2003: 451–466). Excessive talking and struggle with taking turns during conversation are also observed (Martin 2003: 451–466; Green 2014: 78; Hawking 2016: 50). Numerous scientific studies show communication difficulties in children with ADHD, with the greatest emphasis on children's communication competence, where deviations compared to the regular population have been observed (Bignell 2007; Geurts 2008; Green 2014). The aforementioned authors link weaker communication skills with the basic symptoms of ADHD, such as attention variability, impulsivity and increased motor restlessness. Research aimed at analysing the influence of environmental distractors, primarily auditory stimuli, on the communication competence of children with ADHD is almost not represented.

## 2. Methods

Accepting the specifics in the reception, processing and interpretation of auditory stimuli in the communication process in children with ADHD, the specifics of the perceptual attributes of auditory stimuli (primarily the volume and frequency of the auditory stimulus) that can affect the individual's communication competence will be methodologically determined. Knowledge integration from different scientific fields will make an attempt at the methodological level to determine a way to reduce distractions during the communication process so that the outcome of the communication is as successful as possible. In the research, emphasis is placed on analysing the characteristics of auditory distractors during the communication process, through which it is possible to influence the improvement of the communication competence of children with ADHD. If we consider communication competence as a set of skills that can be improved and practised, it is extremely important to determine errors that occur due to inattention or errors that occur due to impulsivity in the communication process in children with ADHD. The sample of respondents included 20 children aged 8–10 from the area of the city of Varaždin, with average intelligence.

Following the stated goals, hypotheses are set that will be confirmed or refuted by the results of the research using scientific research methods.

*H1: Using the T.O.V.A. test, it is possible to determine the characteristics of auditory distractors during the communication process*

*H2: By determining the characteristics of auditory distractors in the communication process, it is possible to improve the communication competence of children*

To determine the variability of attention and the way of reacting to auditory stimuli, the T.O.V.A test was used in the research, (Greenberg 2018) its auditory part precisely. Tests were performed for the auditory stimulus according to the following variables:

- Commission errors
- Omission errors

In the first phase of auditory research, a stimulus frequency of 390.0 hertz (Hz) and 261.6 Hz was used, set at 100 ms in intervals of 2000 ms. The stimulus was presented to 22.5% (n = 72) during the first half of the research and 77.5% (n = 252) during the second half. The subject is instructed to respond to the target as quickly as possible. Different ratios of targets to non-targets allow examination of the effects of different response requirements on given variables (Greenberg, 2018). The strength of the stimulus was set to 50 decibels (db), and the difference in the time required to respond to the auditory stimulus of the group of subjects was examined.

During the research, the influence of the perceptual attributes of auditory stimuli on the creation of noise in the communication channel between sender and receiver was examined, and auditory stimuli of frequencies 390.0 Hz and 261.6 Hz were used, set at 200 ms in intervals of 2000 ms. The examination of the influence of auditory stimuli was carried out in such a way that the same group of subjects participated in the experiment twice. The simplest stimuli for measuring hearing are pure tones because they are relatively easy to define with only two dimensions - intensity and frequency. The stimulus was presented to 22.5% (n = 72) during the first half of the research and 77.5% (n = 252) during the second half. The subject is instructed to respond to the target as quickly as possible. The intensity of the stimulus was set to 70 decibels (db), and the group of subjects with ADHD, that is, the experimental group of subjects, was investigated. Determining the hearing threshold is a way to describe the sensitivity of the hearing mechanism. The hearing threshold and sensitivity are reciprocal in magnitude, which can be interpreted in a way that a lower hearing threshold means higher sensitivity.

## 3. Results / Discussion

To determine the specificity of the subjects' communication competence, statistical processing of the data of the experimental group of subjects observed through two phases of the research, characterized by different stimulus modulation, was made. A group of respondents was analysed in the presence of auditory distractors, and the

number of errors that occurred during the communication process was observed. The obtained data are quantitative data collected through primary testing, and according to their size, they belong to small samples. Therefore, statistical methods of small independent samples and data science methods using Stat::Fit and Statistica applications are used for data processing. Impulsivity errors occur when the subject fails to control their response and responds incorrectly to a visual or auditory stimulus. Errors of inattention occur when the subject fails to respond to the specified target, which means that the subject fails to press the T.O.V.A. button for the micro-switch when the target (stimulus) is applied.

Analysing the data obtained from the experimental test, one notices the difference in communication competences observed by recording errors that occur due to commission or omission during the communication process. In the descriptive analysis, it can be seen that more errors occur when testing auditory stimuli in the first phase of the test compared to the second phase of the test. Observing the errors that occur due to commission during the first phase of the test for the auditory stimulus, they range from 7 to 46,

with an arithmetic mean of 33.4 errors, the median of 37 and a range of 39. For comparison, in the second phase of research for the auditory stimulus there are 12 to 59 errors, with a range of 47, an arithmetic mean of 27.17; and the median of 16.50 errors. It is evident that more errors due to commission occur in the first phase of the examination, which is also reflected in the weaker communication competence of the examinee.

Summarizing the results of the examinees during the first and second test phases for the auditory stimulus observed through descriptive analysis for the variable Errors of omission, it is evident that there is a difference in the number of errors between the two test phases. Results during the first phase of the test show much more errors compared to the second phase of the test, which is determined by different perceptual attributes for the auditory stimulus. The range of results during the first phase of the test for the auditory stimulus amounts from 23 to 34 errors, with a range of 11, an arithmetic mean of 28.80, while the median is 29.

To obtain more precise results, theoretical distributions of values are made (Tables 1 and 2).

**Table 1:** The theoretical probability distribution for the variable "Errors of commission"

	Theoretical probability distribution	Rank	Kolmogorov- Smirnov test	Andreson- Darling test
First phase auditory stimulus	Loglogistic (0, 2.85, 33.20)	37	ks <sub>stat</sub> = 0.33 α = 0.05 ks <sub>stat</sub> (10,0.05) = 0.40 p = 0.16 result = ACCEPTED	ad <sub>stat</sub> = 1.7 α = 0.05 ad <sub>stat</sub> (0.05) = 2.4 p = 0.13 result = ACCEPTED
Second phase auditory stimulus	Pearson 5 (10.9, 0.836, 3.11)	95.7	ks <sub>stat</sub> = 0.19 α = 0.05 ks <sub>stat</sub> (12,0.05) = 0.375 p = 0.67 result = ACCEPTED	ad <sub>stat</sub> = 0.54 α = 0.05 ad <sub>stat</sub> (0.05) = 2.49 p = 0.70 result = ACCEPTED

**Table 2:** The theoretical probability distribution for the variable "Errors of omission"

	Theoretical probability distribution	Rank	Kolmogorov- Smirnov test	Andreson- Darling test
First phase auditory stimulus	Weibullova (0, 9.09, 30.40)	100	ks <sub>stat</sub> = 0.13 α = 0.05 ks <sub>stat</sub> (10,0.05) = 0.40 p = 0.98 result = ACCEPTED	ad <sub>stat</sub> = 0.31 α = 0.05 ad <sub>stat</sub> (0.05) = 2.49 p = 0.92 result = ACCEPTED
Second phase auditory stimulus	Loglogistic (0, 2.17, 8.58)	45.80	ks <sub>stat</sub> = 0.26 α = 0.05 ks <sub>stat</sub> (12,0.05) = 0.37 p = 0.32 result = ACCEPTED	ad <sub>stat</sub> = 0.54 α = 0.05 ad <sub>stat</sub> (0.05) = 2.49 p = 0.70 result = ACCEPTED

Observing the theoretical probability distributions in Tables 1 and 2, it is evident that they depend more on the variables than on the set to which the group of respondents belongs. All distributions have a left limit, which in some cases is the minimum value, and in others, the limit is set to 0, due to the type of the variable itself (no variable can take on negative values). The most common theoretical probability distribution is the Loglogistic distribution (50%), and the second is the Pearson 5 distribution (37.5%).

To confirm the hypothesis, the functions of each parameter, each set, were examined. To test the functions, the application Statistica was used. The functions of each set variable were determined and are shown in Tables 3 and 4, respectively in Figures 1 – 4.

**Table 3:** Functions of the variable "Errors due to commission"

	Function	Figures
First phase auditory stimulus	f (x) = 24,65*exp (0,20*x)	1
Second phase auditory stimulus	f (x) = 4,41*exp (0,18*x)	2

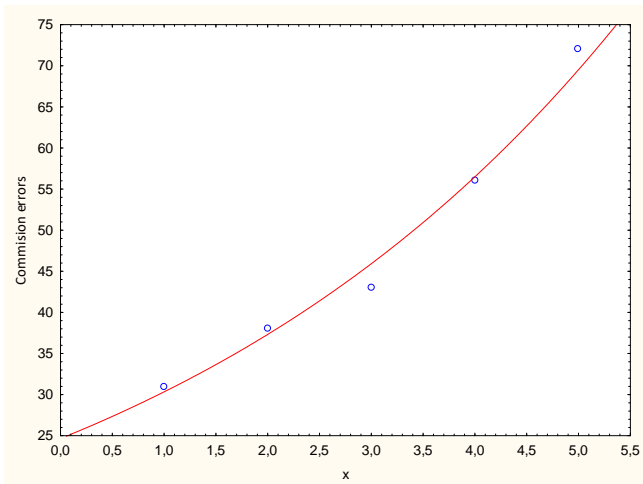


Figure 1: Function of the variable "Errors due to commission" first phase

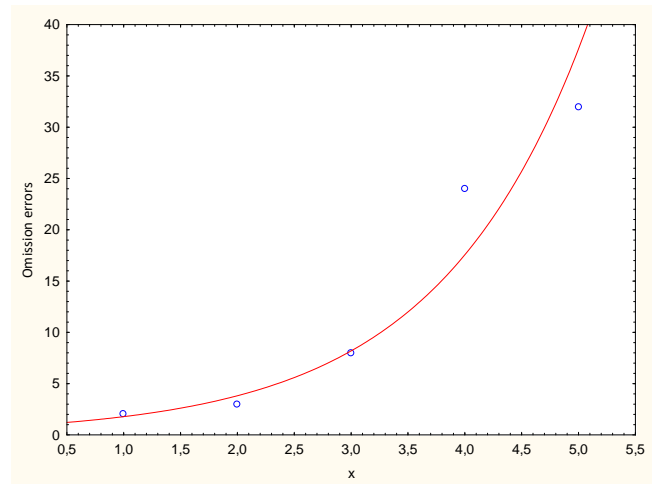


Figure 4: Function of the variable "Errors due to omission" second phase

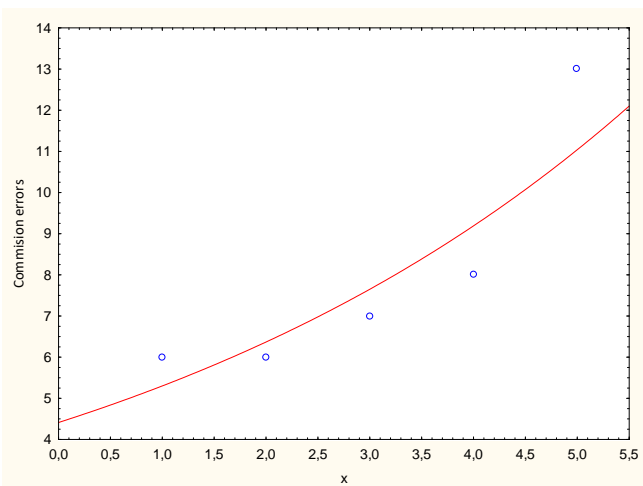


Figure 2: Function of the variable "Errors due to commission" second phase

Table 4: Functions of the variable "Errors due to omission"

	Function	Figure
First phase auditory stimulus	$f(x) = 21,66 * \exp(0,09 * x)$	3
Second phase auditory stimulus	$f(x) = 0,83 * \exp(0,76 * x)$	4

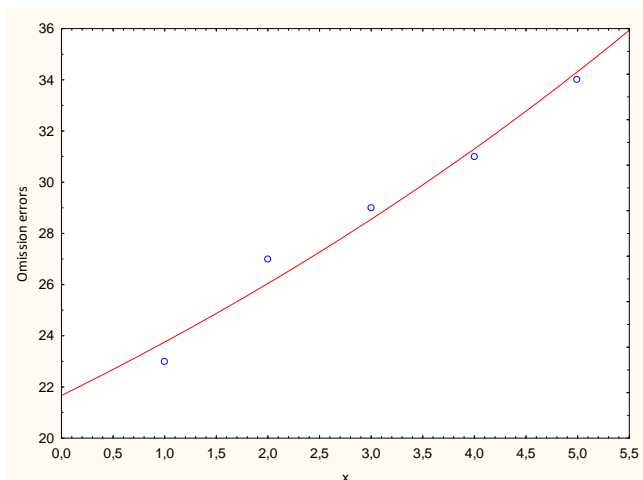


Figure 3: Function of the variable "Errors due to omission" first phase

Observing the obtained results, we conclude that these results agree with the results of other researchers who talk about the specifics of the communication process in children with ADHD. Specifics that occur during the communication in children with ADHD are manifested in louder speech, excessive talking that is observed during the communication process and there is a need for a louder way of communication during the game. The mentioned results can be connected with the results of recent research in the field (Bignell and Cain 2007: 499–512; Green 2014: 15–29) which speak in favour of the specificities that can be observed during the communication process in children with ADHD, which are manifested in the form of excessive talking, difficulties in following the conversation, difficulties in answering questions or following the interlocutor's topic. The results of this research build on previous studies of communication in children with ADHD, where difficulties with paying attention to the flow of the conversation, difficulties with waiting for the turn or agreeing with the topic of the conversation were recorded (Bignell and Cain 2007: 499–512; Perkins 2010: 227–246; Green 2014: 15–29), also speaking during the conversation, difficulties with following the conversation and difficult focusing on the interlocutor, reduced attention and concentration and motor agitation. The mentioned specifics support the fact that the sensory processing of auditory information from the environment in the group of subjects with ADHD is different from the regular population. Such difficulties in interpersonal communication are observed as the more difficult direction of attention to the conversation, faster saturation with the topic of conversation and difficulties in ignoring irrelevant information and focusing on important ones (Barkley 1997; DSM V. 2013).

The results obtained from this research indicate more errors during the communication process in the form of reception, processing and interpretation of information in the first phase of the research, which is determined by the specific perceptual characteristics of auditory stimuli examined in children with ADHD. The research showed that there is a significant difference between the first and second phase of the research and confirms that in the subjects with ADHD, errors in the reception, processing and interpretation of auditory stimuli occur to a greater extent in the first phase of

the research. The study of communication competence and its connection with psychophysiological mechanisms can be found in Bachman (1990). In his theoretical model, the aforementioned author emphasizes the influence of the auditory channel but does not provide detailed guidelines when determining the characteristics of stimuli that can improve communication competence, therefore there is a need for a more precise determination of distractors that can influence the outcome of the communication process.

Accordingly, in this part of the experiment, the researcher's scientific interest is focused on studying errors that occur due to impulsivity and errors that occur due to inattention during the communication process in children with ADHD. Based on the assumption that a greater amount of errors that occur as a result of the communication process acts as noise in the communication channel between the receiver and the sender, and thus can adversely affect the communication process, an analysis of the errors that occur during the communication process was made with an emphasis on different perceptual attributes of the stimulus to obtain more exact results.

Errors of commission are defined as the inability to inhibit, that is, the inability to control responding to a stimulus in a visual and auditory test situation, which results in an incorrect response (Greenberg 2018). The research confirmed that errors due to impulsivity occur to a greater extent in the first phase of research in children with ADHD. The results obtained from the implementation of two phases of the research show that difficulties with the inhibition of stimuli from the environment occur during the first phase of the research where the respondents make an average of 33, while in the second phase they make 27 errors.

Errors of omission are defined as not reacting to the stimulus that is when the subject fails to detect a given auditory or visual stimulus (Greenberg 2018). The research confirmed that there is a statistically significant difference between the two phases of the research in relation to the investigated variables. Errors due to inattention occur to a greater extent during the first phase of research in children with ADHD. The results of the research can be shown by the arithmetic mean, which is 28.8 errors during the first phase of the research compared to 9.17 errors during the second phase of the research for the auditory stimulus.

Evaluating the results of the research and integrating the results obtained from previous experiments in which the attributional characteristics of stimuli were defined, it can be concluded that the characteristics of distractors can be determined in the group of subjects with ADHD which can contribute to the improvement of communication competence. The analysis of the characteristics of the auditory stimulus determined that the stimulus with a frequency of 390 Hz and 261.60 Hz set at 200 milliseconds is less distracting in the examined group of children with ADHD, and there are fewer errors that are manifested through the communication process such as excessive talking, difficulties with following the topic of the conversation or not reacting to the verbal instructions of the interlocutor, as well as maintaining concentration on the topic of the conversation.

Errors due to omission were reduced by 42.43% using a stronger auditory stimulus (70 db), while errors due to commission were reduced by 67.43%, which gives us significant results for the formation of newer communication paradigms. The total number of correct answers when analysing all variables is 17.31% higher in the second test, with a reference to stronger tones. Based on these findings, it is possible to conclude that by modulating the stimulus, it is possible to influence the improvement of the communication competence of children with ADHD, thereby reducing the variability of the individual's attention. The listed results confirmed the given hypotheses.

#### **4. Conclusion**

In modern society, the art of communication becomes the premise of the communication process. The art of communication, transmitting and receiving messages, and reducing the noise in the communication channel are increasingly important in modern education curricula, which place more and more emphasis on communication competence as one of the fundamental skills. The modern approach to understanding communication competence is based on definitions adapted to the analysis of recent research with an emphasis on diversity, individuality and specificities that occur during the communication process contrary to the existing uniformed definitions. The degree of openness towards sensory multimodal concepts is a determinant of the introduction of contemporary and diversity in communication processes. Considering the competitiveness, dynamic and diversity of communication processes, it is extremely important to include the significance of stimuli, as well as the individual characteristics of a person and their excitability threshold depending on the difficulties they face, so that communication is truly an interaction process, taking into account "noises" as well and all their specificities, especially in the population of children with ADHD, which has a prediction of growth in the coming years. Under the increasing growth of various difficulties in development, the need to analyse and find new communication models will be more and more important in the coming years. Facing such opportunities should result not only in the creation and analysis of models but also in providing support to researchers, teachers, parents and children in order to create advanced models for analysing the impact of environmental stimuli that would enable the reduction of the impact of noise in the communication process. Since the environment in which children exist is constantly changing, the constructs of communication models must necessarily adapt to these changes.

#### **5. Future Scope**

Careful selection of methodology of this research tends to reduce the limitations of the research, but they are, as well as in other research, impossible to completely eliminate. Guidelines for further scientific research should cover a larger number of subjects, as well as the greater territorial range, which in this research covers only the area of Varaždin. Additionally, the sample included exclusively male subjects, and it would be interesting to see the formation of results when males and females are included.

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## Author Profile



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