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Article

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Use of linguistic signified to support information communication

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ABSTRACT

Introduction: Ferdinand Saussure, linguist, semiologist, philosopher and one of the main founders of semiotics, affirms that "Meaning" (significance) is a representation of something created in the mind, an association that is useful for a "Signifier" that is a psychic impression of sound. Objective: In this context, the objective of this research is to verify the feasibility of generating communication based on images formed in the mind (Signified) and what it can represent cognitively related to the Signifier using a brain-computer interface Method: A computer brain interface has been developed and a user has been tested so that it uses neuro-muscular commands and pure mental commands that invoke Signified (records in the user's mind) that represent a goal of communicating. Result: The results allow to evaluate a relationship between signified and signifier of information drawing from the brain. Psychic images of a communication intent were linked to sound images that are also mental entities, when brain activated, are converted in "speech" (physical sound) computationally. Conclusion: The results demonstrate the feasibility of communication in this modality, which could support the basic communication needs of people who do not communicate orally.

KEYWORDS

Linguistics. Information. Communication. Artificial Intelligence.

Uso do significado linguístico para suporte à comunicação da informação

RESUMO

Introdução: Ferdinand Saussure, linguista, semiólogo, filósofo e um dos principais fundadores da semiótica afirma que o "Significado" é uma representação de algo criado na mente, uma associação que que está relacionada a um "Significante" que é a impressão psíquica do som. Objetivo: Nesse contexto, o objetivo dessa pesquisa é verificar a viabilidade de gerar comunicação baseada em imagens formadas na mente (Significado) e o que ela pode representar cognitivamente relacionado ao Significante utilizando uma interface cérebro-computador. Metodologia: Uma interface cérebro-computador foi desenvolvida e um usuário foi submetido a testes de modo que utilizou comandos neuromusculares e comandos mentais puros invocando Significados (associações na mente do usuário) que representam um propósito de se comunicar. Resultados: Os resultados permitiram avaliar a relação que une o significado ao significante extraindo informações do cérebro. Imagens psíquicas dotadas de intenção de comunicação foram vinculadas a imagens sonoras, que também são entidades mentais, e quando ativadas cerebralmente foram convertidas em "fala" (som físico) computacionalmente. Conclusão: Os resultados demonstram a viabilidade de comunicação nessa modalidade, o que poderia apoiar a

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necessidades básicas de comunicações de pessoas que não se comunicam oralmente.

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1 INTRODUCTION

According to the last census of people with disabilities conducted by the Brazilian Institute of Geography and Statistics - IBGE (IBGE, 2010), about 45.6 million people declared themselves as having disability, this represents 23.9% of the Brazilian population. Of this total, 9,717,318 are hearing impaired, 13,265,599 have motor disabilities, and 2,611,536 have mental or intellectual disabilities. These groups of people with certain types of disabilities such as the deaf, the mute, motor deficiency in the muscle groups that involve speech, as well as people who have undergone tracheostomies, carriers of diseases such as Amyotrophic Lateral Sclerosis (ALS)[1], which in Brazil has an incidence of 1.5 cases/100. 000 inhabitants, totaling 2,500 new cases per year (XEREZ, 2008), the Spinal Muscular Atrophy - SMA [2] that reaches approximately 1 in 10,000 births (ARAÚJO; RAMOS; CABELLO, 2005) and others tend to have difficulties with oral communication and difficulties in interacting with people (SCHALK et al, 2004).

Brain Computer Interfaces (BCI) [3], also called Brain Machine Interface (BMI), or Brain Machine Interfaces (BMC), have emerged as a viable alternative and a hope to improve the quality of life of individuals who have disability. The BCI is a technology that translates brain signals into pre-defined commands that can be used to communicate to control external devices such as turning on/off a television, moving wheelchairs, for example (WOLPAW et al., 2002), and more recently the use of brain signals using electroencephalogram - EEG[4] as a possible communication channel has shown rapid advances, and is presenting itself as a strong contributor in the field of assistive technologies (LEEB et al., 2015).

"Semiotics is the science of signs and meaningful processes (Semiosis) in nature and culture" (NÖTH, 1995, p.19) or even "the science that aims to investigate all possible languages" (SANTAELLA, 1983, p. 15). Charles Sanders Peirce is considered by many scholars as the most influential creator of modern Semiotics" (SANTAELLA, 1983; NÖTH, 2003; ALMEIDA, 2009). Almeida (2009) explains that semiotic activities are not limited to dealing with what is written, since they also deal with images that are manipulated in the imagination, whatever they mean: "A sign is in a joint relation with the thing denoted to the mind. If this relation is not of a degenerate kind, the sign is related to its object only in consequence of a mental association, and depends on a habit" (PEIRCE, 1958, CP 3.360).

This process is possible because when we want to express, for example, the word "house", we have a psychic image associated with the materialization of this image, which makes there is an intrinsic relationship between a sign and what it represents, so that its meaning can go beyond a limited context of the object, what Peirce (PEIRCE, 1958, CP 5.470) calls "logical interpretant":

> The symbol is a sign that establishes a relation with its object by means of mediation, that is, the ideas present in the symbol and in its object are related in such a way as to make the symbol be interpreted as referring to that object, that is, making the symbol represent something that is different from it. Thus, the symbol is related to its object due to an idea present in the user's mind, an associative habit, a law, called by Peirce a "logical interpretant". This, as Santaella shows, "corresponds to the law or

[1] ALS - Amyotrophic lateral sclerosis is a neurodegenerative disease of unknown cause, which affects mainly the motor neurons of the spinal cord, brainstem, and encephalon (PALERMO; LIMA; ALVARENGA, 2009).

[2] SMA - Spinal muscular atrophy is a neurodegenerative disease with autosomal recessive genetic inheritance (BAIONE; AMBIEL, 2010).

[3] BCI - Brain Computer Interface is a computer system capable of establishing communication between human neurophysiological activity and a computer (SCHUH, 2017).

[4] EEG - Electroencephalograms are equipment that records the synchronization of thousands of signals emitted by neurons (WOLPAW, 2007).

interpretative rule that guides the association of ideas linking the symbol to its object" (RIBEIRO, 2010, p. 51).

The concept corroborates with Fiorin (2002) who explains that both concepts and sound images are mental entities. The acoustic (or sound) image "is not the material, physical sound, but the psychic impression of sounds, perceptible when we think of a word but do not speak it" (FIORIN, 2002, p.58).

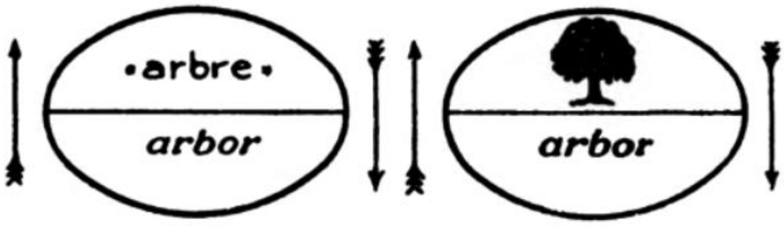
Based on Saussure's semiology (1916), the brain signal pattern generated by an image formed in a person's mind (meaning or concept) can represent anything, object or need to be expressed, since this relationship is implicit to the user's cognitive and is linked to the signifier.

Figure 1. Signifier and signified by Ferdinand Saussure.

Source: Cours de linguistique générale (SAUSSURE, 1916, p. 111).

Saussure (1916) uses "tree" as an example, in Latin "arbor". Saussure's theory states that the sound image, 'arbor' is arbitrary. This holds true when looking at different languages; to non-Latin speakers, 'arbor' means nothing. Combined with the concept, the image of a tree or a tree in front of you, becomes a sign. What he is arguing is that language itself is arbitrary; it is the associations or concepts that we attach to words that hold meaning and form the signs. Without these meanings, words would represent nothing, according to Saussure (1916):

Figure 2. Sign, by Ferdinand Saussure.



Source: Cours de linguistique générale (SAUSSURE, 1916, p. 112).

As this psychic image represents something, it becomes possible to attribute this brain signal pattern to a signifier (sound image), allowing to make a communication subsidized by a brain-computer interface, and enabling a user to communicate even by synthesized speech (computer-generated speech).

This study, therefore, applies concepts of semiology by Saussure (1916) to provide a person with the possibility of communicating basic needs.

For such an evaluation, a BCI was developed that uses wave patterns generated by a non-invasive EEG. The data generated by the hardware are classified by an Artificial Intelligence - AI machine that can identify patterns. This pattern allows the generation of an artificial voice communication (synthesized).

2 DEVELOPMENT

2.1 Neural signals and the electroencephalogram

Hans Berger, a German, was the precursor of the scientific development of the electroencephalograph, achieving the first registers of brain signals (BERGER, 1929). In 1934, Hans had already detected that the electrical activity was produced by neurons, and not by other intracranial structures. Hans Berger coined the word electroencephalogram - EEG, described the bioelectricity, in the form of alpha, beta, theta and delta waves, which is used worldwide by modern science (NIEDERMEYER; SILVA, 1982).

According to Teplan (2002), biological signals, also called bio signals, are signals that can be measured and monitored from biological beings. Bio signals in general are acquired by reading the variations in electrical currents produced by specialized tissues, organs or systems, which can be captured by electrodes placed in previously mapped regions. In general, the signals that the EEG captures come from electrical currents from the activity of the cerebral cortex[5] rich in neural tissue (neurons).

The EEG uses a method of recording the electrical activities of the brain, capturing the signals that relate to the flow of information processed by the cerebral cortex. The signals are detected by electrodes placed on parts of the skull and measure the differences in potentials between two specific points in the brain. EEG signal capture techniques are divided into two types, invasive and non-invasive (WARD, 2010).

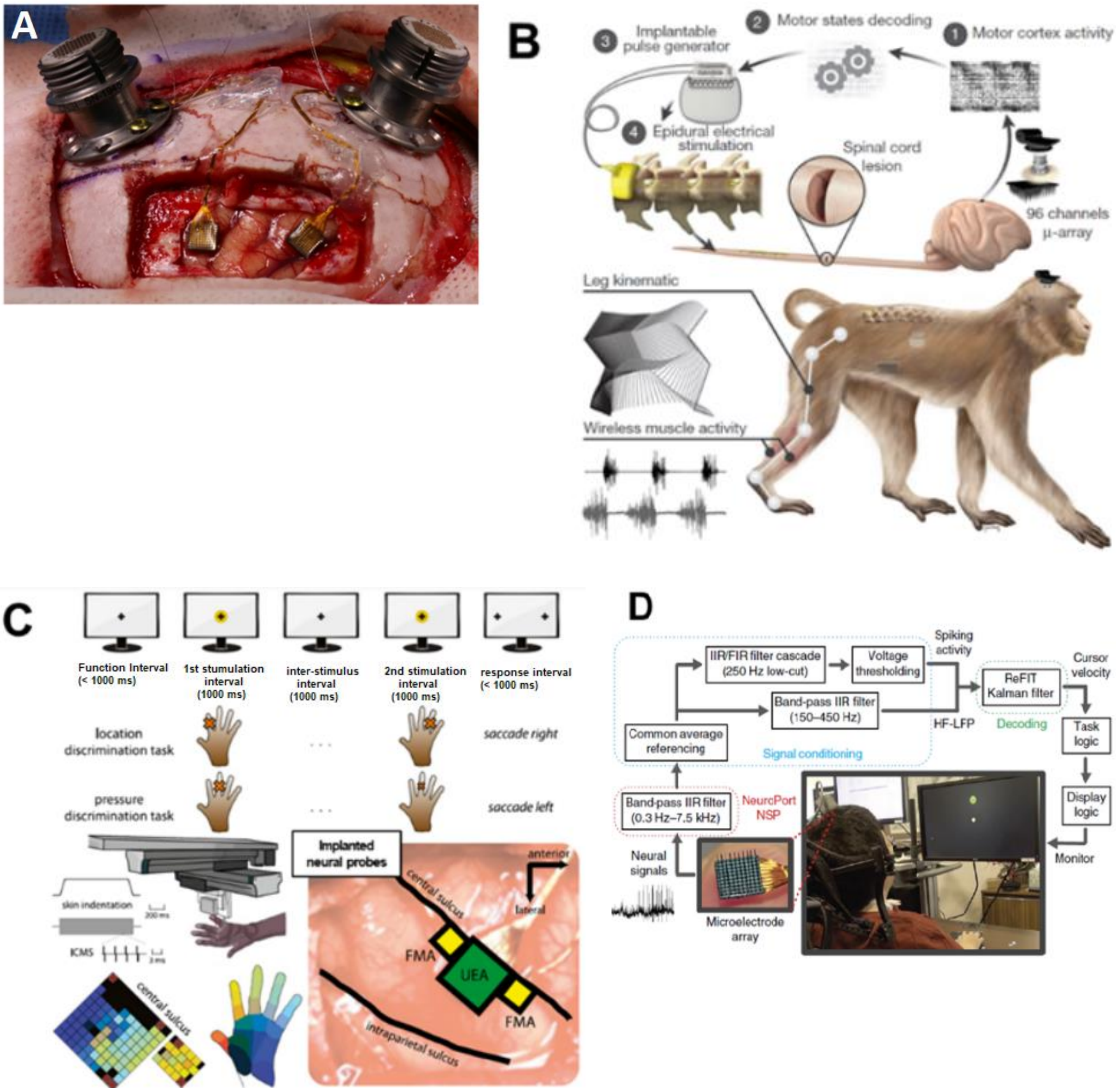
2.1.1 EEG's invasivas

According to Wolpaw (2007), EEG had the first records of studies using the invasive EEG technique in the mid-1960s. The precursor of this technique was the German scientist Eberhard Fetz. By accessing the cerebral cortex, it was possible to analyze neurons located in the cerebral cortex and associate them with primary motor movements of the body. The goal was to capture brain commands and send them to electronic devices. Monkeys were trained to react with specific movements to certain visual stimuli, and it was possible to identify the interval between the beginning of the activities of the cortex cells and the muscles involved in the reaction. Furthermore, the studies also made it possible to analyze the relationship of the brain regions with the areas of the body related to the positions of the body members that reacted with motor force.

This technique has enabled the evolution of science regarding health, technology, and communication in numerous works (O'DOHERTY et al., 2009; FONG et al., 2012; TABOT et al., 2013; ARYA et al., 2013; BUSCH et al., 2015; PANDARINATH et al., 2015; JAROSIEWICZ, 2015; WALDERT, 2016; OPIE et al., 2016; BOUTTE et al., 2017; CHOI et al., 2018; HASSAN et al., 2019).

[5] The cerebral cortex represents the outer layer of neural tissue of the brain in humans and other mammals. It is also the largest site of neural integration in the central nervous system and plays a key role in attention, perception, awareness, thinking, memory, language, and consciousness (SALADIN, 2011).

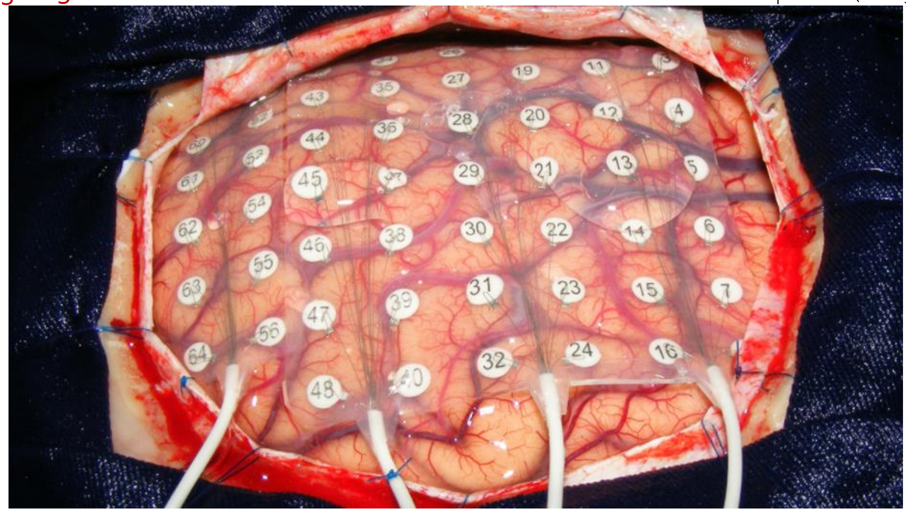
Figure 3. invasive EEG (2018).



Source: (CHOI et al., 2018, p.456).

The state of the art regarding the process of communication and speech synthesis using invasive BCIs, was recently published in the journal Science:

Figure 3. the state of the art in invasive BCIs for communication and speech (2019).



Source: (SERVICK, 2019, online).

Mesgarani's[6] team relied on data from five people with epilepsy. His network analyzed recordings of the auditory cortex (which is active during speaking and listening) as these patients listened to recordings of stories and people naming digits from zero to nine. The computer then reconstructed the spoken numbers from neural data alone; when the computer "spoke" the numbers, a group of listeners called them with 75% accuracy[7] , (SERVICK, 2019).

Another team, led by computer scientist Tanja Schultz[8] , from the University of Bremen in Germany, relied on data from six people undergoing brain tumor surgery. A microphone captured their voices as they read monosyllabic words aloud. Meanwhile, electrodes recorded from the speech planning areas of the brain and motor areas, which send commands to the vocal tract to articulate words. Computer scientists Miguel Angrick[9] and Christian Herff[10] , now at Maastricht University, trained a network that mapped electrode readings to audio recordings and then reconstructed words from unpublished brain data. According to a computerized scoring system, about 40% of the computer-generated words were understandable [11] , (SERVICK, 2019).

2.1.2 Non-invasive EEG's

Choi et al. (2018), explains that electroencephalography is widely used in non-invasive BCI systems because it is very useful for mapping associations between EEG signals and cognitive function (CHOI et al., 2018). However, noninvasive neural methods are limited because neural signals from noninvasive probes are typically insufficient for complicated tasks that require a high degree of accuracy, such as robot control. For this reason, implantable neural probes are preferred for BCI systems that require precise controls and adjustments, such as neuro prosthetic devices.

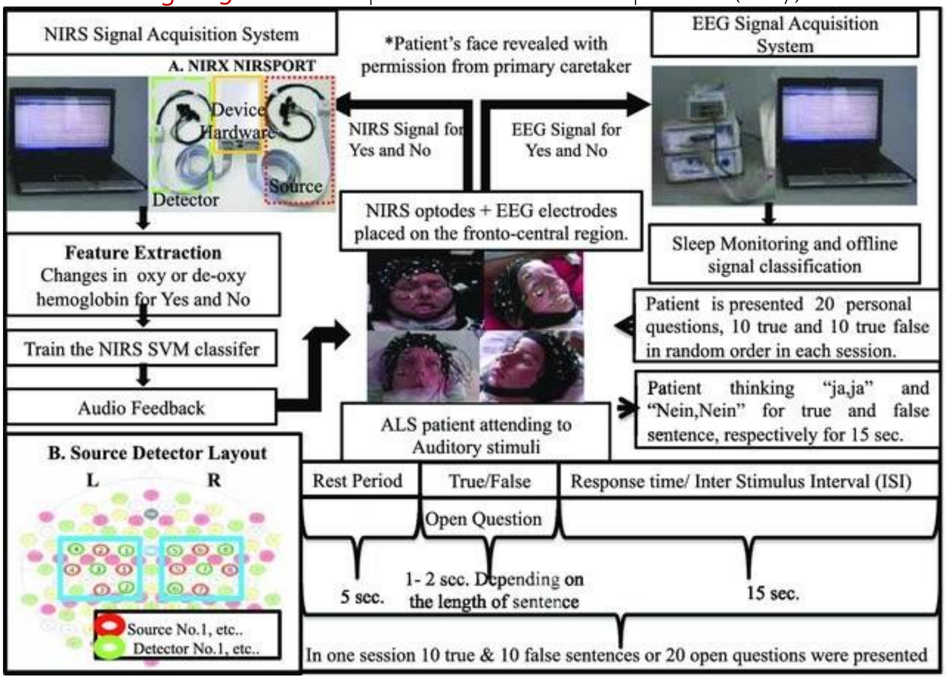
The commonly used non-invasive modality for recording brain signals is electroencephalography. EEG signals are deciphered to control commands in order to re-establish communication between the brain and the output device (WALDERT, 2016). Where non-invasive EEG recordings obtained from electrodes attached to the surface of the scalp.

The most recent studies regarding communication using non-invasive BCI are directed towards the research of with complete locked-in state - CLIS or completely paralyzed users

6 Nima Mesgarani, computer scientist at Columbia University.
7 Audio available at: https://www.sciencemag.org/sites/default/files/audio/Mesgarani-1.mp3
8 Tanja Schultz, computer scientist at the University of Bremen, Germany.
9 Miguel Angrick, computer scientist at Maastricht University in the Netherlands.
10 Christian Herff, computer scientist at Maastricht University in the Netherlands.
11 Audio available at: https://www.sciencemag.org/sites/default/files/audio/Herff-1.mp3

(CHAUDHARY et al, 2018; GUGER et al., 2017; SHEHIEB; ALANSARI; JADALLAH, 2017; HAN; IM, 2018) and directed towards speech/text generation (SPÜLER, 2017; NGUYEN; KARAVAS; ARTEMIADIS, 2017) and speech processing (SAKTHI, DESAI, HAMILTON, and TEWFIK, 2021).

Figure 5. Brain-computer interface in CLIS patients (2017).



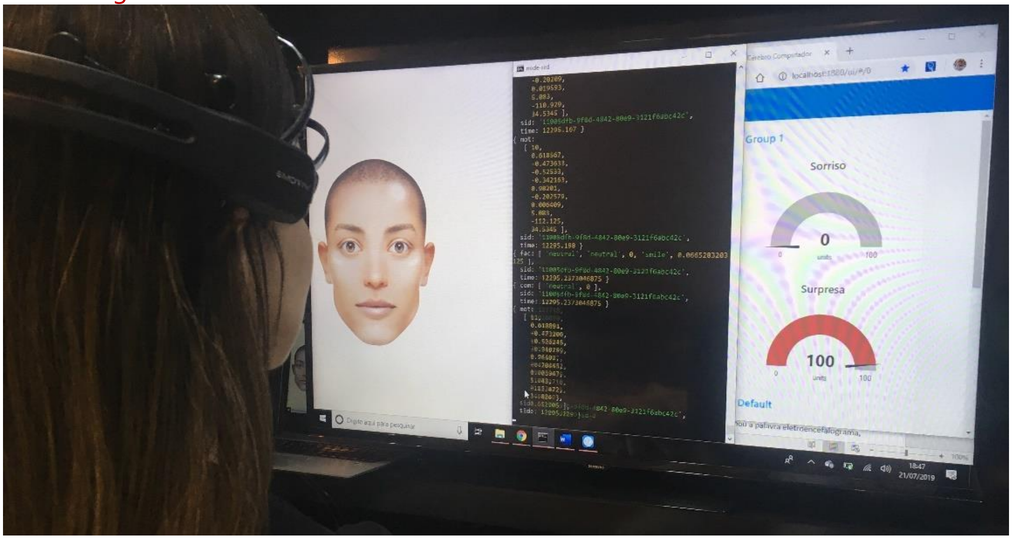
Source: (CHAUDHARY et al., 2018, online).

The Study by Han and Im (2018) was evaluated on a female patient in CLIS who had not even communicated with her family for over a year. An average online classification accuracy of 87.5% was obtained using EEG data recorded for only 5 seconds. According to the authors, this is the first report of successful application of EEG-based BCI to online yes/no communication of CLIS patients (HAN; IM, 2018). Researchers Shehieb, Alansari, and Jadallah in 2017 used 14-channel portable commercial EEG devices (SHEHIEB; ALANSARI; JADALLAH, 2017) and Spüler, letter generation and imagined speech (SPÜLER, 2017), presented as studied by Nguyen, Karavas, and Artemiadis (2017).

More recently the state of the art using non-invasive BCI SINGH & GUMASTE (2021) could decode the Imagined Speech -IS signal with an average classification accuracy of 85% when classifying a long vs. short word. Our proposed approach can also differentiate between brain signals in resting state and IS with an average classification accuracy of 94%.

The study presented in this paper, following the example of SHEHIEB, ALANSARI, AND JADALLAH (2017) also uses commercial portable 14-channel EEG with communication and online following the example of CHAUDHARY et al., (2018), but using voice and text interface for the receiver using portable 14-channel hardware, and BCI user with normal cognitive and communication skills.

Figure 6. BCI in non-invasive EEG - Record of user submitted to BCI test.



Source: Produced by the authors;

Studies state that although non-invasive EEG is less accurate compared to invasive EEG, it still contains enough real-time information to be used as a source for different applications and even in real-time BCI machines and that non-invasive EEG brain signal capture methods can serve as a basis for communication and control devices (WOLPAW; MCFARLAND, 2004; MÜLLER; BLANKERTZ, 2006; CITI et al, 2008; AHMADIAN; CAGNOCI; ASCARI, 2013; SHARMA, JAIN, KAUR, and SINGHOBTEVE, 2020).

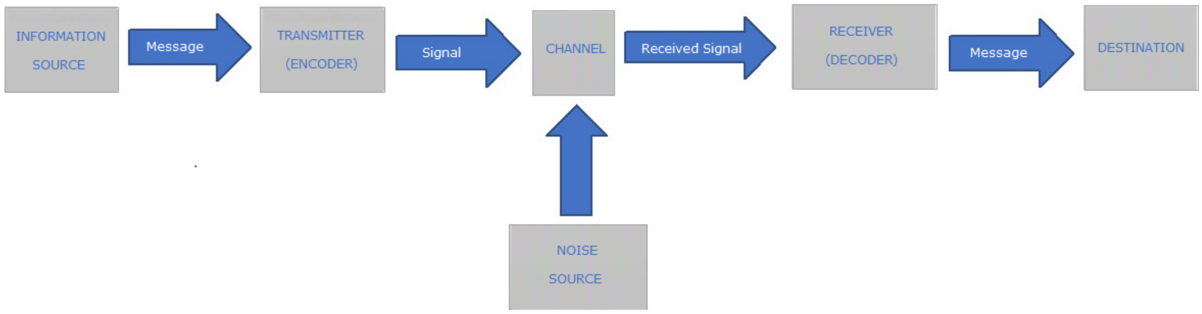
Non-invasive EEG electrodes require some level of skill in the person placing them in identifying the correct position, as well as in periodic maintenance to ensure sufficiently good skin contact. Improved methods for extracting key EEG features and converting them to device control, as well as training the user using the interface, help improve BCI performance (MCFARLAND; WOLPAW, 2011).

2.2 The communication process and synthesized speech

This study has no intention of creating definitions, but it is important to point out that there is some vagueness, or even some confusion in defining the term communication for Information Science. Inazawa and Baptista (2012) explain that just as Capurro and Hjorland (2005) stated that Information Science is in conceptual chaos, perhaps a study on the term "communication" would result in the same chaos. Still, according to Inazawa and Baptista (2012), the model of the Mathematical Theory of Communication of Shannon and Weaver (1949), seems to be the most uniform scheme among the authors who deal with the epistemological bases involving information science (INAZAWA; BAPTISTA, 2012). "As an example of some works that mention the Mathematical Theory of Communication, there is Buckland (1991), Ingwersen (1992), Pinheiro and Loureiro (1995), Bates (1999), Capurro (2003), Araújo (2003), Matheus (2005) and Zins (2007)" (INAZAWA; BAPTISTA, 2012, p.172).

For this work, the model of the Mathematical Theory of Communication conceptually guides the definition of communication. According to Eco (1972) apud Wolf (1999) Shannon and Weaver's model is very flexible, meeting the needs of communication processes between two machines, between two human beings, and between a machine and a human being.

Figure 7. Model of the Mathematical Theory of Communication (1949).



Source: (Adapted by the authors from Shannon and Weaver, 1949, p.7).

According to Santos (2013), it is realized that man has long had the desire to interact with machines in a natural way and it is known that speech is the main way of communication between people, and that speech synthesis (automatic generation of speech by the computer) has received attention from the academic and professional community for several decades.

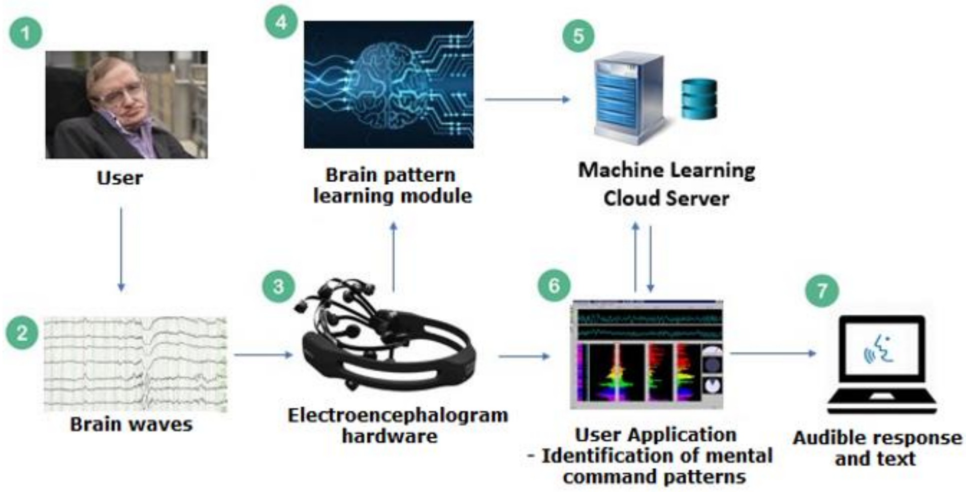
Santos and Duque (2011), in a study on multimodal computer interfaces, address many benefits in this mode of interaction with information. Santos (2013) demonstrated that 94% of the tested sample universe understood the text narrated by artificial voice (human voice synthesizer) and Santos and Duque (2011) conclude in their experiment that 100% of users claimed to have understood the text in its entirety and 87% of users rated the use of computer voice narration as great, very good, and good.

3 METHODOLOGY

3.1 The software

For the execution of the research, a functional prototype software was developed, a Brain-Computer Interface that works with brainwave pattern recognition using electroencephalograms, learning modules for pattern recognition using Artificial Intelligence, and that can issue audible messages to mobile devices based on a communication intention in the sender's mind, in order to enable audible communication.

Figure 8. Software architecture.



Source: Produced by the authors.

Detailing Figure 8:

Nº 1- User with communication needs. E.g.: carriers of Amyotrophic Lateral Sclerosis - ALS, Spinal Muscular Atrophy - SMA, stroke or brain injury sufferers, incarceration syndrome, among others.

Nº 2- Primordial that the user has the capacity to generate cortical activity based on facial movements and/or mental commands.

Nº 3 - Emotive Epoc+ 14-channel electroencephalogram hardware sends brain signals to training module.

N° 4 - Recognizes patterns and performs conversion of brainwave modality to command pattern. Analyzes all brainwave data generated in the brain for any pattern already learned and sends it for storage.

Nº 5 - Server that stores the user's brainwave pattern learning data in a cloud.

Nº 6 - Receives cortical activity, i.e., brain commands (waves) (e.g., "Push an object") and/or facial gestures (e.g., "Smile"), generated by neuromuscular activity and activity generated by mental command and searches for patterns to identify already learned command.

The commands are transcribed into intelligible information, returned by the artificial intelligence database, making it possible to assign meaning in a configurable way according to the communication need (e.g.: "Yes", "No", "I am thirsty", "I am hungry", "I am in pain", etc.).

N° 7 -Application that does the Natural Language Processing - PLN and to generate the output of the processing of mental signals in the form of synthesized voice and works as an application server.

3.2 Relation Between Meaning and Signifier

Five commands were mapped, being 2 neuromuscular (expressions of "Smile" and "Surprise") and 3 pure mental commands ("Pull an object", "Lift an object", "Push an object"). Each command represents a communication intention since what is imagined is merely a representation of something concrete by a mental association. What is created is a relation with an idea present in the user's mind linked to a signifier. The mental commands and the previously mapped communication intentions are represented in the table below:

Table 1. Command/ Intent Mapping.

MIND COMMANDS	COMMUNICATION INTENT
Smile	Yes
Surprised	No
Pull object	I am Thirsty
Lift object	I am Hungry
Push object	I am in pain

Source: Produced by the authors.

3.3 User training

To conduct the experiment, the criteria for user selection were as follows: a person with full (i) communication; (ii) intellectual; (iii) motor; and (iv) visual capabilities. In this context, a woman 37 years old, with a complete undergraduate degree and endowed with all the prerequisites listed, was selected.

a) a) Mental commands and mental associations were passed and evaluated to ensure that they were understood by the user.

b) b) The user answered all the associations answered with 100% accuracy..

To generate learning from the artificial intelligence model for recognizing brain patterns that are individual, the user was subjected to repeat each neuromuscular command 5 times and each pure mental command 5 times.

4 TEST APPLICATION AND RESULTS

4.1 Testing with neuromuscular signals

With the interface configured and the EEG installed with precision quality measured in the user's head, we began the tests.

The user was instructed not to talk to the experiment interlocutor during the test application and to answer "yes" or "no" using the commands according to table 1.

The first test was performed after training the communication intentions related to the audible "Yes" and "No" answers.

Six questions were asked and the respective answers for each question were recorded:

Table 2. Results with YES / NO answers.

QUESTIONS	AUDIBLE RESPONSE
Do human beings need water to live?	Yes
Is the capital of Brazil Brasilia?	Yes
Are you sitting on a chair?	Yes
Is the color of the sky green?	No
Are you running in the street at this moment?	No
Do you live in Italy?	No

Source: Produced by the authors.

The questions were asked one at a time in order to decrease the false positives generated by the interface. Even so, it was possible to detect the occurrence of some false positives generated by the BCI when the user's facial movement is neutral. Therefore, the registers started to be computed immediately after the user was asked the question.

4.2 Testing with pure neural signals

In the second part of the test, the user had to communicate 3 distinct needs, in the following order: 1) I'm thirsty; 2) I'm hungry; 3) I'm in pain. Repeating the process for 3 consecutive times, for a total of 3 series.

Table 3. Results of the mental commands by grade.

AUDIBLE MESSAGE	SERIES 1	SERIES 2	SERIES 3
I am thirsty	OK	OK	OK
I am hungry	OK	OK	OK
I am in pain	OK	OK	OK

Source: Produced by the author.

The user in this study presented an excellent ability with the BCI, but there are cases in which users cannot repeat a pattern of brain activation several times in a row for the same activity, which influences the algorithm that works with pattern recognition for learning. According to Vidaurre and Blankertz (2010) this number varies, between 15% to 30% of users may present this behavior. Maskeliunas et al. (2016) state that these numbers can reach 50% of users when using low-cost equipment.

4.3 Questionnaire

After applying the test in the BCI, the user answered the following questions by issuing the respective answers:

Table 4. Structured questionnaire.

QUESTIONS	USER RESPONSES
What do you think about to generate the answer "Yes" (Smile)?	"First I see myself smiling, then I execute the gesture of smiling."
What do you think about to generate the answer "No" (Surprise)?	"I imagine myself startled and perform the gesture of surprise with my face."
What do you think about to generate the command "I'm thirsty" (Pull object)?	"I imagine a glass with water far away. And I concentrate to bring it close to me, using the power of the mind, as if reaching for the glass to drink the water from it."
What do you think about to generate the command "I'm hungry" (Lift object)?	"I think of a plate of food, and I go about lifting the plate (with my mind) as if I could make the plate float in the air."
What do you think about to generate the comand "I'm in pain" (Push object)?	"I see the image of a bad thing! It's something that exists only in my head. I don't know what it is, but it's like a kind of black cloud, and it contains some red and green dots. I see pain as a bad thing, so I think this thing ("cloud") that I see in my head is bad. So with my mind I push it away.

Source: Produced by the authors.

4.4 Discussion and Conclusions

The results indicate that it is possible to establish a relationship of meaning and signifier to generate communication. By capturing brain signals using an EEG, it is possible to conclude that psychic images are formed in the user's mind, and it is really a cognitive association, an imaginary representation whose meaning can be anything and related to its signifier. It simply depends on the association that the user makes in his mind. In the reported in table 4, when attributing the mental image of raising a plate of food to the meaning "I'm hungry", it is clear that it is purely an association created by the user, because in place of the plate of food it could have been anything that represents "I'm hungry with hunger" in the user's mind, such as a fruit, a fork, a hamburger, an animal, or even a stone. The same happens with neuromuscular actions, where the positive gesture that we normally do by moving our head from top to bottom and vice versa, now has a new action, smiling. As well as the negative movement, moving the head from left to right and vice versa, becomes used as an expression of surprise.

In general, these mental representations can be anything, because absolutely everything in some way can be represented by meaning, if there is some relationship in a person's mind. It is an equivalence created in the user's mind that replaces something concrete, a process of signification. Interesting to note about the theory is the fact that the study demonstrates that from a concept formed in the brain, it is possible to attribute any meaning, even if it makes no sense to people outside the context. As is the case of the communication "I'm in pain" in Table 4, represented by a kind of cloud, as reported by the user. It is an association in which it is possible to perceive the representation of an object that is not the thing itself but aims to be a representation of that thing.

The study points out that it is possible to use the relationship of the signified with the signifiers as a form of communication. Apparently both signals generated by neuromuscular movements and pure mental commands have a great potential for communication.

Regarding the technology employed, the commands on the interface tend to generate false positives as the number of available commands increases, which may limit, in a way, its use of multiple communication intensions.

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