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ARTICLE

# Communication of Internal Speech with Communicative Associative Robot via Spectral Neurointerface

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ARTICLE INFO

*Article history*
Received: 19 May 2021
Accepted: 8 June 2021
Published Online: 9 June 2021

*Keywords:*
Spectral neurointerface
Electrocorticography
Internal speech
Communicative robot

ABSTRACT

Thought communications with an associative-communicative robot are carried out through the spectral neurointerface of internal speech. Internal speech is an energy physiological process. Internal speech is vibration from the mental vibration of thought. Mental vibration of thought is a process in the mental ethereal field. The vibrations of thoughts are reflected and observed by the mind in the form of semantic sensual images. Vibrations of semantic sensual images generate vibrations of internal speech action (internal speech) in the form of language communicative and associative stereotypes which are perceived by a touch zone of a brain of Wernicke. Internal speech is a linguistic mental vibration. It is felt and becomes internally audible and drawn to attention. The perception of vibrations of internal speech is carried out through energy channels, such as the internal posterior median canal of the spine. The spectral neurointerface perceives these vibrations. Neocortex makes us a reasonable person - allows us to think and talk. The spectral neurointerface is based on the principles of biosensors, bioenergy detectors, spectral analyzers and electrocorticography for neuroimaging parts of the brain that record vibrations of internal speech, such as the lower frontal gyrus, the upper and middle temporal gyrus, the medial prefrontal cortex, the hind parts of the wedge and precline and the dark temporal region, including the posterior Internal speech activity is associated with the semantic memory of the neocortex.

## 1. Introduction

Neurointerface is a system for the exchange of information between the human brain and an electronic device. The brain processes incoming sensory stimuli, for example - sound, smell, taste, controls the life and movements of the body. He is also responsible for thinking, memory, emotions and the like. It is noteworthy that these powerful but exquisitely subtle abilities arise from electrical and chemical interactions between the approximately 100 billion cells of which it consists. Each such interaction is reflected in the recorded brain activity, and the neurointerface registers this activity in various regions of the brain and transfers it to external device control commands or vice versa transfers external commands to brain electrical activity. A computer with a specialized program always acts as a translator and simultaneously as an information analyzer in the neurointerface. All brains of each person have common anatomical schemes and synoptic interactions, but the exact sample of connections and interactions varies greatly from person to person, so the program should be able to adjust to the pecu-

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DOI: https://doi.org/10.30564/ese.v3i1.3255

liarities of each user's brain. In this case, the program in the computer can process the signal, can be trained, adapting both to the task and to a particular person. For such training, feedback is needed - the program must receive information about whether it correctly interpreted the received signals, whether it "understood" correctly the particular brain with which it works. At the same time, the program can partly manage the patient, orienting him to work with those situations that she recognizes less successfully. We can even say that the brain interface - a computer uses artificial intelligence to recognize the types of brain activity.

Neurointerfaces are unidirectional and bidirectional. The former either receives signals from the brain or sends them to him. The second ones may send and receive signals simultaneously. Neurointerfaces differ in type:

- invasive, sensors are placed directly in the cerebral cortex.

- non-invasive, sensors are placed on the head.

A key feature of the neurointerface is that it allows you to connect to the brain directly. In modern interfaces, brain activity is recorded using electroencephalograms (EEG), magnetoencephalograms (MEG), near infrared spectroscopy (NIRS). MEG allows the measurement of weak magnetic fields generated by ion currents in brain neurons. Superconducting quantum interferometers, or SQUID sensors, are used to detect very weak magnetic fields. Recently, near-infrared spectroscopy (NIRS) has been increasingly used to record brain activity. This is a small device in the form of a hat that is worn on the head. Infrared radiation penetrates through the bones of the skull and adjacent tissues into the frontal and occipital cortex of the brain and allows you to evaluate the oxidation state of hemoglobin, that is, the brain's oxygen consumption. Here, unlike EEG and MEG, a signal of optical nature is recorded - absorption of infrared radiation for recording in the motor and prefrontal cortex signals generated by mental score and logical tasks, musical and visual images.

Now the technical problem is measurement accuracy. In non-invasive neurointerfaces - the skull, skin and other layers separating nerve cells from electrodes distort information about the signal. In order to translate electrical activity into understandable commands, the program must be able to: separate the signals it needs and clear them from background noises, adjust to the features of the human brain and translate any information with high accuracy. The brain circuitry is too complex for our analytical and computational capabilities, so at the moment high accuracy is too difficult.

The operation of the interface is based on the analysis of information coming from the patient through four channels. These are the electrical pulses of neurons, their magnetic activity, the flow rate of blood inside the vessels and the change in metabolism.

Many neurointerfaces can be divided into three groups: active, reactive and passive interfaces. The active interface uses changes in brain activity, which is directly and consciously controlled by humans. The reactive interface generates control commands by studying the brain's response to an external signal, such as light or sound. The passive interface analyzes the current activity of the brain, which occurs on its own, in the process of human life. Such interfaces can be useful for creating monitoring systems that monitor the emotional state, detect a decrease in concentration, or a loss of control over the system.

If the neurocomputer interface is connected, for example, with augmented reality glasses, then a person will be able to look at the lighting in the room, switch TV channels and even communicate with a doctor. One of the capabilities of the neurocomputer interface is the transmission of visual information to the brain. Thanks to this, a person can print using a look - however, not very quickly. One of the most famous non-invasive interfaces of this type, it is called R300 speller, allows its owner to dial five characters per minute, the information transfer rate is about 0.5 bits per second. Tianjin University employee Wei Xiwen at the World Robot Conference in China set a record for the speed of typing using neurointerface. Syven's neurointerface spent 0.413 seconds to determine the desired English letter with 100% accuracy. A group of Chinese and American researchers led by Xiaogan Chen of Tsinghua University have developed a non-invasive neurocomputer interface that allows a person to print a look at a rate of 50 to 60 characters per minute.

An international group of scientists has created a system based on functional spectroscopy in the near infrared region, which allows people with "locked man" syndrome to answer yes or no to a question asked. The Australian company Emotiv develops electronics for neurointerfaces based on EEG. In 2017, American scientists in their study used one of the company's products - the EPOC + helmet, which recognizes waves of electrical brain activity and determines the emotional state of a person.

In 2020, engineers at St. Petersburg Polytechnic University developed Russia's first platform for creating neurotrainers and neurointerfaces, which includes a headset that measures brain activity signals and will allow users to learn how to develop robot control systems using brain signals.

Laboratory of Neurophysiology and Neurointerfaces of Lomonosov Moscow State University. The Neurochat technology is based on the achievements of its employees, which allows people with disabilities to communicate normally with each other and with the world in general.


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According to the creators, "the headset registers the neurophysiological indicators of the patient and transforms his mental efforts into certain commands for the keyboard of the computer or other actuators. By translating a mental choice of a character into a real set of these characters on the screen, a person letter by letter can type text without the effort of voice and movement. In February of this year, Neurochat was first used in a transcontinental communication session between patients with severe speech and movement disorders. Moreover, each of them "spoke" in his own language, and the neurointerface translated messages to the interlocutor into his native language.

Ideally, neurointerfaces guide the control of the technique by the power of thought. Neurophysiologists and engineers have not yet been able to read thoughts. Not a single device is yet capable of reading human thoughts. The hope that technology will reach such heights is facilitated by the fact that more projects, developments, scientific research in this area, research groups and commercial companies, including large ones that are engaged in the development and development of neurointerfaces, are emerging. There are more than a hundred research groups alone. The largest companies in this area are Neuralink, Mind Technologies, Covidien, Compumedics, Natus Medical, Nihon Kohden, Integra Life Sciences, CAS Medical Systems and Advanced Brain Monitoring. Even large firms such as Nissan and Facebook have long announced their intentions to create neurointerfaces.

Elon Musk created Neuralink, with the goal of developing a neurointerface that will allow people to communicate telepathically. In April 2021, Ilona Mask's neurotechnological startup Neuralink published a video with a macaque that plays ping pong on a computer, controlling a virtual racket with the power of thought. Chips were also injected into her brain. According to the developers, using Bluetooth they can be associated with any gadget. First, the monkey was taught to play a video game using a joystick. Her successes were supported by an award in the form of banana puree. At this time, chips recorded macaque brain activity and transmitted data to a computer. There they were processed by a program that learned to recognize the actions of a monkey. After some time, the researchers disconnected the joystick from the computer and watched as the monkey controlled the game with the power of thought, continuing to twist the disconnected controller with his paw. Subsequently, they removed him, and the primate began to play without a single movement of the limbs. Elon Musk said: "We will be able to surpass the power of the human brain by 2030".

Neurointerfaces are used in various spheres of life. The new neuroscience of connecting brains with machines change our lives [1]. Neurointerfaces of interaction [2]. Human brain cloud interface [3]. High resolution passive speech [4]. Technological diagnostics of human condition according to spectral analysis of biofield [5]. Implementation of international telemedicine network with rapid coronavirus registration by resonant technology to neutralize the pandemic [6]. Neuro - processing for the development of neurointerfaces [7]. On-chip $tao_x$-based non-volatile resistive memory for in vitro neurointerfaces [8]. Functional and harmonious self-organization of large intellectual agent ensembles with smart hybrid competencies [9].

Neurointerfaces also find use in robot control. The article discusses the control of an associative-communicative robot through the spectral energy interface of internal speech.

## 2. Aspects of Thinking

The process of cognitive thinking of an individual, characterized by a generalized and mediated reflection of reality. Objects and phenomena of reality have properties and relationships that can be learned directly, through sensations and perceptions. The first feature of thinking is its mediated nature. Directly, he learns what the person can't learn directly indirectly, indirectly: some properties through other, unknown entities through known. Thinking always relies on sensations, perceptions, representations and previously acquired theoretical knowledge. Indirect cognition is mediated cognition. The second feature of thinking is its generality. Generalization as a knowledge of general and essential in reality objects is possible because all the properties of these objects are connected to each other. The general exists and manifests itself only in a separate, specific one. The results of cognitive activity of people are recorded in the form of concepts. The concept is a reflection of the essential features of the subject. The concept of a subject arises from research.

Human thinking proceeds in the form of judgments and conclusions. Judgment is a form of thinking that reflects the objects of reality in their connections and relationships. Each judgment is a separate thought of something. The sequential logical connection of several judgments, necessary to solve any mental problem, to understand something, to find the answer to a question, is called reasoning. Reasoning makes practical sense only when it leads to a certain conclusion, conclusion. The conclusion is a conclusion from several judgments, giving us new knowledge about the objects and phenomena of the objective world. Inferences are inductive, deductive and by analogy.

System forms of judgment are analysis and synthesis, comparison, abstraction, concretization, generalization, classification. Thinking acts mainly as a solution to problems, questions, problems that are constantly put forward to people in life. Solving problems should always give a



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person something new, new knowledge. The search for solutions is sometimes very difficult, so mental activity, as a rule, is an active activity that requires focused attention and patience. The real process of thought is always a process not only cognitive, but also emotionally strong-willed.

For human thinking, the relationship is more significant not with sensual cognition, but with internal speech and language. In a more rigorous sense, internal speech is a language-mediated communication process. If language is an objective, historically established system of codes and the subject of special science - linguistics, then internal speech is a psychological process of formulating and transmitting thought by means of language. Thinking relies on sensations and perceptions. The transition from feeling to thought is a complex process, which consists, first of all, in the isolation and separation of an object or a sign of it, in distraction from a specific, single one and the establishment of a significant common for many objects. Thinking operates with a sense of knowledge. Thinking, as a mental process, models the laws of the surrounding world based on axiomatic positions, establishes connections between objects or phenomena of the surrounding world, reflects the essential properties of objects, which leads to the appearance of ideas about objective reality. Thinking is characterized by the ability of a person to reason, analyze, compare, generalize and draw conclusions.

When an Englishman or an Indian thinks about the same object, the figurative vibration of thought is the same, caused by the object itself or the pronunciation of its name. For this reason, a mind reader whose brain center is in connection with a person's su center can read a hidden figurative. The thought of whose spoken speech he cannot understand. The figurative mental vibration of thought is the same in all people, and its expression as a mental sound vibration is the same in people who speak the same language. If the mental language vibrations that encircle thought in the form of speech were the same for all people, then the language would be the same.

Consciousness takes a general undifferentiated movement of figurative thought, and continues as a differentiated movement, manifested further in the form of internal speech of the process of thinking. Thinking manifests itself, firstly, as a subject in the subtle form of the mind and its contents, generated by figurative vibrations of thought and, secondly, in the form of linguistic internal speech, as an expression of thought that projects into the world of sensual experience so that they are the source of the impressions of individual experience within it. The mental language vibrations of internal speech are the same for people who speak the same language. This allows you to solve the problem of recognizing the internal speech of any specialist through the spectral neurointerface.

## 3. Spectral Neurointerface

Different parts of the brain consisting of neurons are responsible for different physiological functions (Figure 1). Neuronal activity can be traced by electrocorticography.

In the context of neurointerfaces, we will understand them as an external high-tech device connected to our brain and designed to study its abilities, in our case internal speech.

Spectral neurointerface translates brain activity in internal speech into text. Its functioning is based on the work of neural networks with long short-term memory and an open decoder. It is trained and controlled on spectral electrocorticography data obtained from the internal speech of participating professionals. First, the spectral electrocorticogram data obtained when reading the text are taken: the temporal, spatial and frequency characteristics of vibrations are distinguished. The internal speech vibrations are decoded into text using an open deep learning algorithm. The encoder, which recreates the characteristics of the text from the activity of the brain of internal speech, in turn, is based on the work of two bidirectional recurved neural networks with long short-term memory.

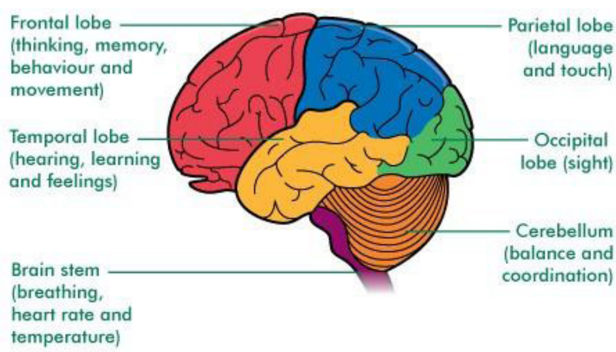


**Figure 1.** Brain functions.

It is advisable to supply the spectral neurointerface with a regulatory network that allows cleaning the spectral electrocorticogram based on internal speech data of various professionals. This saves the spectral electrocorticogram from artifacts.

Thus, it is possible to achieve high-quality work of the spectral neurointerface in translating the brain activity of internal speech into language speech. At the same time, sufficient performance of the spectral neurointerface is achieved for dialogue in sonorless speech production. Spectral neurointerface can be used for silent people, as well as for telepathic dialogue by internal speech of various specialists.

Spectral neurointerfaces can be widely used for dialogue and control with communicative associative robots over long distances using high-tech wireless communication means for receiving and transmitting messages.

## 4. Robot with Communicative Associative Thinking

Mental communication with a communicative associative robot is carried out through its intelligent communicator agent. A team of professionals with different voices communicate with a communicative associative robot using a spectral energy interface. The communicative robot receives the mental language thoughts of each professional by his internal speech through the spectral energy interface.

The system of communicative associative robot of recognition of internal speech vibrations based on syllable resonators automatically converts syllables into words, and words into messages (Figure 2).

A communicative associative robot perceives words by syllables. It has resonated filters for each syllable and recognizers of syllable morphemes by communicative vibration signals by analogy with the auditory snail. The communication robot has a syllable and punctuation decryptor which sequentially puts text codes of the current syllable or punctuation mark from its memory into the common memory and dampens the resonating filter or recognizer of the previous syllable. The communication robot recognizes syllables and punctuation marks by the decoder and through the neural network structure formats the message, in accordance with the sign markup, and transmits it to the control intelligent system of the robot.

**Figure 2.** Communicative associative robot

The use of robots with communicative associative technologically intelligent thinking logic through spectral neurointerfaces is in demand in various spheres of life. Cognitive robots with imitative thinking for digital libraries, banks, universities and smart factories [10]. Robots with artificial intelligence and spectroscopic sight in hi-tech labor market [11]. Robots for communication in public in high-tech industry life and space [12]. System retraining to professional competences of cognitive robots on basis of communicative associative logic of technological thinking [13]. Increase of safety use robots in industry 4.0 by developing sensitivity and professional behavioral skills [14]. Robotization of service with goods and products via automatic cabinet [15].

## 5. Communicative Associative Logic of Technological Intellectual Thinking

Human thoughts are the essence of reason. The mind knows everything in comparison. He compares heard and written thoughts, opinions and worldviews of other people. If your own thoughts, opinions, images and worldviews coincide with other people, then consent comes. If the mind does not agree with the thoughts, opinions, images and worldviews of other people, then the mind forms its own thoughts, opinions, images and worldviews.

Technological intelligent artificial intelligence can compare thoughts, opinions, images and worldviews according to utility criteria. Technological intelligent artificial intelligence can choose thoughts, opinions, images and worldviews according to the criterion of preference. Technological smart artificial intelligence can detect novelty on the principle of opposite (optimal - not optimal; effective - not effective; dangerous - safe, etc.) method from nasty based on objective conditions.

The semantic basis of communicative associative logic is an essential dictionary of lexical meanings of representatives of reality.

### 5.1 Entity Dictionary

Let S be a spelling dictionary, where S = {Si}, Si is a morphological word. The word Si refers to the Qij feature of the Mij representative from the Mi set, where Mi = {Mij}. Denote the lexical meaning of the word Si via {Mij, Qij, Si}. The relationship of the lexical values of words {Si} with elements of the set Mi is given by the set of feature relations Qi, where Qi = {Qij, (Mi, Mij)}.

A set of lexical values associated with a set of characteristic relations with representatives is an essential dictionary. Words in the dictionary are supplied with characteristic indexes according to their characteristic relationships with representatives. The entity dictionary captures the characteristic entities of representatives. The dictionary helps to use words with its lexical meaning and distinguish between representatives whom they call on a symbolic level.

Words are used based on characteristic indices. Each feature has three indexes. One index indicates the subject area of knowledge, the second indicates the situation, the third

  DOI: https://doi.org/10.30564/ese.v3i1.3255

indicates the situational moment. Words with multiple lexical meanings have multiple sets of indexes. For example, torment (muka) and muka (flour). The word field is used in various subject areas. Each set of indexes defines a lexical word value.

## 5.2 Information Needs Technology

The information demand implementation system uses a knowledge base and a skill base. The implementation of the information demand is taken either from the knowledge base, or is developed by a typical procedure for implementing the skills base according to the current information demand, or a network of element-by-element implementation according to the combined information demand is formed. Schemes for implementing information needs are obtained from a study of educational practices in the formation of imitative thinking. The diagrams are shown in Figures 3-4.

After implementation, the new information need is entered into the knowledge base and associated with the knowledge element, which is its implementation. The variation of such information need is carried out in a variable part, which are implemented by standard procedures common to them.

The realization of combined information need is developed by the investment, variation and combination of implementations of information need, which are located in the knowledge base of the system. New information need is built either by sequentially merging existing need from implementations, by investing one in another, or by merging and investing at the same time.

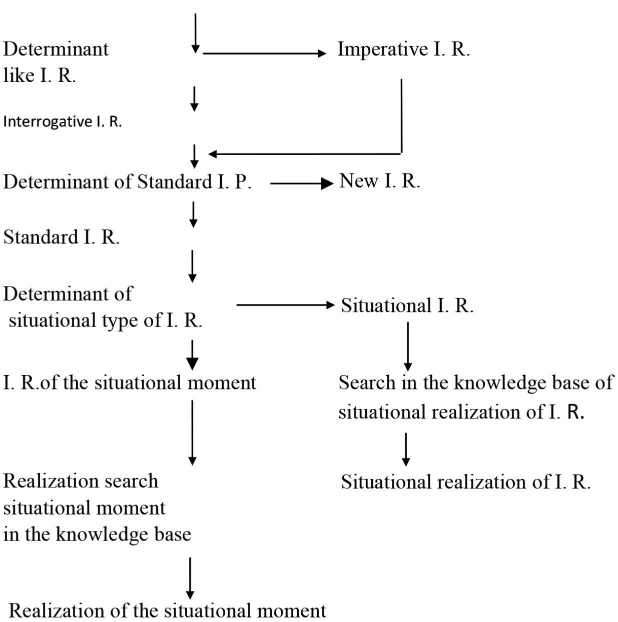


**Figure 3.** Realization of standard information requirement (I. R.)

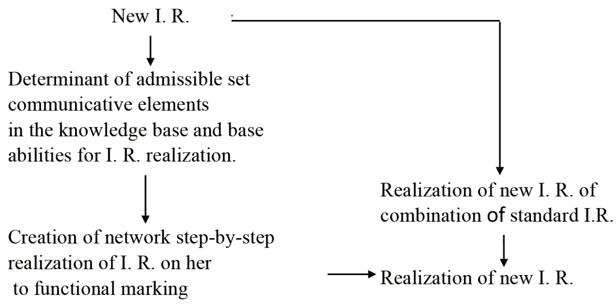


**Figure 4.** Realization of new information requirement (I. R.)

Retraining system is used to work with the new concepts (Figure 5).

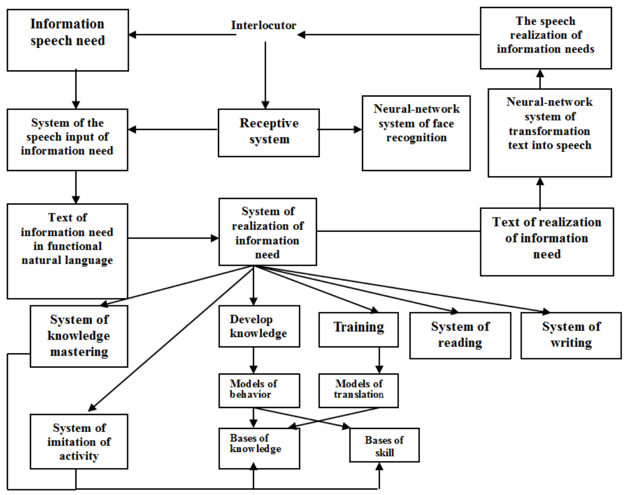


**Figure 5.** Retraining system.

## 6. Conclusions

On the way to create an ideal neurointerface that can convey and translate thoughts with high accuracy between the brain and computer, and will also have many areas of use and huge distribution among the population, there are several obstacles. Basically, these obstacles represent a number of modern technical, ethical and legal restrictions. Already, large corporations own our personal information, and with the development of neurointerfaces they will be able to read our thoughts, few will like it, but this is not the worst. The scary thing is that using the brain-computer interface, if necessary, it will be possible to change a person's personality or completely intercept control over his body. No matter how high the hacking protection is. Neurointerfaces will be susceptible to computer viruses and attackers. For this reason, developers will have to provide an appropriate level of security.

Neurointerfaces are progressing, not stopping it. Attracting intellectual resources greatly contributes to the development of technology, and once again convinces that


DOI: https://doi.org/10.30564/ese.v3i1.3255

neurointerfaces are approaching at incredible speed and people should be ready to meet them.

The use of robots with communicative associative technologically intelligent thinking logic through spectral neurointerfaces is already in demand in various spheres of life.

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