Preface

Why Biocommunication in Plants?

If we speak of biocommunication in plants, we first must clarify the terms of communication and signalling which are based on systems we define as languages and codes. We should rely on the recent results of the pragmatic turn in the philosophy of science of the last century, which clarify the conditions for generating correct sentences in science.

Biocommunication is defined as meaningful interaction between at least two living agents, which share a repertoire of signs (representing a kind of natural language) that are combined (according to syntactic rules) in varying contexts (according to pragmatic rules) to transfer content (according to semantic rules).

Contrary to all former concepts, these three levels of semiotic rules are complementary parts of any natural language or code-based system. According to Charles Morris, we cannot speak of language or signal-mediated communication if one of these three levels is missing. So the most recent definition of biocommunication is this: sign-mediated and rule-governed meaningful interactions that depend on a communally shared repertoire of signs, codes and rules. Importantly, these features are lacking in any abiotic physical interaction.

Additionally, we know that mathematical and mechanistic theories of language are not helpful in investigations on natural languages and real-life communication processes because such theories cannot explain typical features of living agents that communicate. These aspects are not formalizable as no algorithm is available for de novo-generation (innovation) of coherent/correct sentences/sequences. This means that no natural language or code speaks or codes by itself but needs living and experiencing agents (biological systems) that are competent in using such languages or codes.

In the biology of the twentieth century, the physiology of cells, tissues, organs, and organisms of all kingdoms was the mainstream direction in biological research. In the 1970s, an increasing use of "communication" as a metaphor also occurred in biology. During the last decade of this period, interest in communication (no longer being used as a metaphor) within and between organisms overtook that of the pure physiological understanding of organisms. Cell-to-cell communication now dominates contemporary cell biology, resulting in enormous knowledge about a great variety of signalling systems serving for organization / coordination of production, release, uptake, and processing of "information" within and between cells.

In parallel, the use of "language" as a metaphor increased from the middle of the twentieth century with growing knowledge about the genetic code. Most of the processes that evolve, constitute, preserve, store, and rearrange the genetic storage medium DNA are terms that were originally used in linguistics, such as nucleic acid language, genetic code, "codes without commas" (Francis Crick), coding, copying, translation, transcription, sequence homology. Meanwhile, the linguistic approach lost its metaphorical character and the similarity between natural languages/codes, and the genetic storage medium DNA are not only accepted but are adapted in epigenetics, bioinformatics, biolinguistics, protein linguistics, and biosemiotics.

The advantage of methodical adaptation of communication and linguistic terminology is in having appropriate tools for differentiation at specific levels, which is otherwise difficult to describe non-reductively by pure physiology. This means that language-like systems and communication processes occur at the bottom of living nature. Language and communication are not inventions of humans, nor are they (as often claimed) anthropomorphous adaptations to describe the non-human living nature. It is becoming obvious that every coordination and organization within and between cells, tissues, organs, and organisms needs meaningful signs: chemical molecules that serve as signals, symbols and codes for conveying essential messages that serve as vital indicators of environmental (both abiotic and biotic) conditions. Because no code codes itself, as no language speaks itself, these signs need to be sensed and interpreted in a correct context by biological agents, i.e., there must be subjects/ representatives of sign production and sign interpretation. This means that if sensing and contextual interpretation fails, this will then result in non-appropriate (non-adaptive) behaviour and can have even fatal consequences for cells, tissues, organs, and organisms.

The method of analyzing any part of a machine in detail to get a picture of its whole functional blueprint, which can then be used to reproduce or manipulate it, or to produce an even more perfect one (taking genetic engineering as an example); is still useful if we are dealing with machines. However, growing evidence of biological processes makes it doubtful whether investigating organisms with this mechanistic attitude will be useful in the future. Communication between cellular parts, cells, tissues, organs, and organisms is far from being a procedure which can be reduced to mechanistic input/output or cause/reaction descriptions. It is evident that communication processes within and between living organisms include a variety of circumstances and competences that must be fulfilled in parallel if communicative acts are to have successful consequences, such as common coordination.

First of all, no single organism is able to communicate as an emerging property. It must be a community, a society, or a swarm of organisms that each share an identity (group) and a competence to sense others as being part of their biological identity (self/nonself competence, kin recognition), even if this competence is shared genetically solely. To biocommunicate, it is necessary that an organism has some skills that serve as signs (signals, symbols), such as chemical molecules either produced directly by itself or as secondary metabolites or even molecules in the surroundings that are not produced by the organism but can still be manipulated, according to the organismal needs.

Secondly, organisms must share a competence to use these signs in a coherent manner, which means using these signs in a strict temporal and spatial context. In most cases, it is not just one signalling molecule but complex networks of signalling molecules and channels that are dynamically combined in a certain manner to transport messages (information) effectively. This represents a common feature of sign-use in biocommunication processes, which is called their correct combination or syntax.

Thirdly, organisms are part of ecological habitat in which they live together with other organisms of the same or related species, as well as with an abundance of nonrelated organisms of other kingdoms. This context exactly represents the natural history of organismic swarms or communities in which they – and this is only a recently experienced feature – evolved and developed certain abilities to appropriate response behaviours according to their survival. These include sensing, learning, and memory, which are the preconditions for faster adaptations.

Finally, the signalling molecules, which serve as signs, transfer messages with meanings (semantics). The informational (semantic) content, which is transported, triggers certain response behaviours by the same or related, or even unrelated, organisms. Interestingly, the signal sequence or signal content does not necessarily depict a single meaning, i.e., function can vary according to different situational contexts. This means that even identical signs can transport a variety of different messages according to different contextual needs and scenarios. This is important in very dense ecological habitats, for example, in the rhizosphere biology. The different uses of identical signs (sequences) enable the generation of dialects within same species that can transport messages, which are microecosphere-specific. These include sensitive self/nonself recognition between slightly differently adapted populations of the same species in the same ecological habitat.

Although sign-mediated interactions (i.e., communication processes) are very reliable in most cases, they do not function mechanistically in a strict sense. Syntax (combination), pragmatics (context), and semantics (content) must function in parallel to ensure and optimize coordination and thus survival of group members.

These semiotic rules do not function mechanistically but may be varied, deleted, or, in certain circumstances, generated de novo. Additionally, biosemiotic rules do not function by themselves but need semiotic subjects, i.e., living organisms that use and understand such rules. If no living organism is present, semiotic rules, signs, and communication are absent. Although highly conserved semiotic rules are modifiable, environmental circumstances, such as stress, trigger adaptive responses. In such cases, signals may transport new messages, which previously did not exist, broadening the communicative competences of organisms and their evolutionary capabilities. This is different in the case of abiotic (purely physical) processes, where semiotic (syntactic, pragmatic, semantic) rules of sign-use are not relevant as natural laws are sufficient alone. No biosemiotic rules are used or are necessary for water molecules to freeze into ice.

To give an answer to the question "Why biocommunication in plants": biocommunication in plants integrates both biology of plants and communicative competences of plants. It allows more coherent explanation and description of full range of behavioural capabilities of plants that cannot be covered by mechanistic or even reductionistic approaches. Natural communication assembles full range of signal-mediated interactions that are necessary to organize coordinations within and between cells, tissues, organs and organisms.

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