The cognitive requirements for developing a multimodal communication system: Evidence from experimental semiotics and comparative cognition

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Specifying the cognitive requirements for developing a structured, symbolic communication system is one of the most central tasks for accounts of what made humans 'language-ready' (Arbib 2012) and enabled them to evolve language. From an evolutionary perspective, it is also a central question to what degree these requirements are shared with other animals and how they evolved. One approach that sheds light on the processes and necessary requirements for the emergence of a symbolic communication system in interaction is that of experimental semiotics, the study of "novel forms of communication which people develop when they cannot use pre-established communication" (Galantucci et al., 2012).

In experimental semiotics, participants have to bootstrap communicative signals and establish a relation between a novel sign and its interpretation. In different paradigms, participants use different signals in different modalities to communicate meanings. For example, they can be asked to communicate via drawings, novel gestures, novel vocalisations, symbols, pantomime, or combining channels of different modalities (see, e.g. Nölle & Galantucci, 2022; for a review). What these experiments show is that participants are able to converge on a shared symbolic communication system, which over time also becomes increasingly structured.

Here, we adopt an evolutionary perspective on the cognitive requirements required for the establishment of shared symbolic systems in experimental semiotics paradigms. Specifically, we ask a) what are the cognitive requirements needed to explain the successful behaviour of participants in experimental semiotics studies; b) what are the evolutionary foundations and the possible evolutionary trajectories of these cognitive abilities.

In order to elucidate the first question, we make use of an existing database of experimental semiotics studies (Delliponti et al. 2023), and add to this database by adding a meta-analysis of the cognitive capacities needed for particular tasks that are explicitly mentioned in these studies. We analyzed the frequency of the cognitive abilities mentioned in the studies in the database created by Delliponti et al. (2023), standardized the labels, and additionally assigned cognitive abilities to general types like general cognition, social cognition, and motor cognition. Our analysis shows that although there is a wide variety of factors discussed in the 59 studies that were surveyed, some abilities occur more frequently, such as theory of mind, categorical perception, and memory factors; the same goes for cognitive types such as social cognition and general cognition.[1] Using such a meta-analytic approach therefore enables us to create a list of some of the most important abilities required for establishing a shared symbolic communication system.

To investigate the question as to the evolutionary foundation of these abilities, we review which of the specified necessary cognitive requirements are present in non-human animals, and if so, to which degree. For instance, regarding Theory of Mind (ToM), we know that human beings resort to metarepresentations, whereby they adopt second-order beliefs in order to anticipate other people's behavior. While many aspects of ToM seem to be shared with other animals, there also seem to be important differences (e.g. Call & Tomasello 2008; Beetle & Rosati 2021). For example there is evidence that chimpanzees use a type of simulative rather than metarepresentational ToM, in order to predict other agents' behavior (Lurz et al. 2022). In the case of Categorical Perception (CP), it was found in nonhuman animals across modalities, as in the case of the CP of sound or color. Field crickets (Wyttenbach et al., 1996), rodents (Sinnott & Mosteller, 2001), and macaques (Sandell, Gross & Bornstein, 1979), are among the cases of non-human animals with CP of sound and/or color, suggesting a deep evolutionary continuity. By adding insights from comparative cognition to the list created by the meta-analysis, we thereby can gather information not only on important abilities required for the establishment of a shared communication system, but also on the degree to which they are shared with other animals, and which aspects are potentially uniquely human. Overall, then, using an approach that combines insights from experimental semiotics and comparative cognition promises to shed light on the evolution of the cognitive requirements for the emergence of symbolic communication systems, and language more generally.

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