

Deviations from optimality should be an integral part of a working definition of SMC
Comment on Pezzulo et al (2018)

The body talks: sensorimotor communication and its brain and kinematic signatures

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In their present article Pezzulo and colleagues (2018) provide a comprehensive overview of a large body of work on sensorimotor communication that will be a highly valuable resource for Cognitive Scientists with an interest in social interaction and communication. Of particular theoretical importance for future research is their clear vision of how sensorimotor communication relates to other forms of communication and to instances of information transfer that could be considered non-communicative. We note that in their current framework the authors seem to leave out one important aspect of sensorimotor communication (SMC) that was central to their previous work (Pezzulo et al., 2013). Below, we elaborate on why we believe that deviation from efficient action performance is a key aspect of sensorimotor communication that should remain an integral part of its definition.

Pezzulo and colleagues define sensorimotor communication (SMC) as implying the use of signals that have a dual nature, in the sense that they combine a pragmatic action and a communicative action. This working definition is useful because it allows the authors to tease apart SMC 1) from other cases of information transfer (IT) that are not communicative according to accepted definitions of communication and 2) from cases where communication is deprived of pragmatic goals, which is often the case for facial expressions, pointing and gestures.

However, what seems to be missing in this new working definition is a principled hypothesis about how co-actors distinguish actions that are used for purely pragmatic goals, and actions that combine pragmatic and communicative goals. Earlier work on sensorimotor communication was more specific in this respect (Pezzulo et al 2013). In line with this earlier work, we would like to argue that the key distinguishing feature is that actions combining pragmatic and communicative goals will always involve *deviations from efficient action performance*. We think that this claim should be an integral part of a working definition of SMC.

As illustrated by the studies in Pezzulo and colleagues' review, the distinguishing feature between a purely pragmatic action and an action that combines pragmatic and communicative goals can be observed at a kinematic level: people will exaggerate their movements to make their actions more readable to onlookers (Sacheli et al. 2013; Vesper et al. 2017). These "exaggerations" are used during social interactions not only to distinguish between actions with a pragmatic and a communicative goal, but also to disambiguate between different action alternatives (e.g. upward and downward movements, see Sacheli et al. 2013). Importantly, such "exaggerations" can be understood as *deviations from efficient action performance* (Pezzulo et al. 2013). Indeed, it has previously been demonstrated that people have expectations about the spatial and temporal parameters of their own and others' actions (Todorov, 2004), and that they rapidly judge actions that are not efficient as more likely to be communicative (Trujillo et al. 2018; Royka et al. 2018, McEllin et al 2018). Thus, this line of research suggests that people's ability to detect SMC relies heavily on their capacity to simulate observed actions (Wilson & Knoblich, 2005) as well as on their capacity to detect deviations from an action's optimal trajectory (Pezzulo et al. 2013). Note that such deviations do not only exist at a kinematic level. They could also exist in deviations from

the most effective order in which a sequence of actions is performed (e.g., repeatedly adding and removing a block from a stack of elements) or in deviations from the most efficient type of action in a given context (e.g., using a power grip for a small object).

Moreover, deviations from optimality play a key role not only during the execution of a joint action, as when someone transporting a table with a co-actor pushes it in a certain direction to signal where he wants to place it (Pezzulo et al. 2013). Such deviations can also be used as a means to open up a communication channel, by recruiting someone's attention. Indeed, people's attention is easily drawn to actions that involve unexpected changes in motion direction (Howard & Holcombe, 2010) or exaggerated movements (Atkinson et al. 2004). Similarly, computational models have shown that different levels of motion exaggeration can be used to increase an observer's attention towards a salient body part (Gielniak & Thomaz, 2012). Such results support the hypothesis that sensorimotor signals, and particularly deviations from efficiency, can be used not only for communication during online social interactions, but also to recruit people's attention in order to plan and engage in future joint actions.

Finally, we think that deviations from optimality can provide a novel link between sensorimotor communication theory and pragmatic theories of language that deserves to be explored. According to pragmatic theories inspired by Grice (1991), communication involves allocating attention to inputs that maximize their expected relevance (or maximize the cognitive effects of these inputs) given a particular context (Sperber & Wilson, 1995). Thus, speakers will try to provide information that is relevant to the conversation, hence minimizing the costs they invest in communication while maximizing the transfer of information to the listener. Importantly, when a speaker overtly violates these expectations of relevance (e.g. cases of irony, metaphor, or hyperbole) this will lead the listener to trigger a search for the most relevant interpretation of the utterance at that point. Assuming that violations of efficiency are key in distinguishing purely pragmatic actions from actions that also have a communicative purpose, the principle of relevance in pragmatic communication may be viewed as an instance of a more general mechanism that computes deviations from what is expected (deviations from efficient action in the motor domain, deviations from higher level expectations in the linguistic domain).

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