

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)**ScienceDirect**

Physics of Life Reviews ••• (••••) •••—•••

**PHYSICS of LIFE  
reviews**[www.elsevier.com/locate/plrev](http://www.elsevier.com/locate/plrev)

Reply to comment

# Words as social tools: Flexibility, situatedness, language and sociality in abstract concepts

## Reply to comments on “Words as social tools: Language, sociality and inner grounding in abstract concepts”

Anna M. Borghi<sup>a,b,\*</sup>, Laura Barca<sup>b</sup>, Ferdinand Binkofski<sup>c</sup>, Cristiano Castelfranchi<sup>b</sup>,  
Giovanni Pezzulo<sup>b</sup>, Luca Tummolini<sup>b</sup>

<sup>a</sup> *Sapienza University of Rome, Department of Dynamic and Clinical Psychology, Italy*

<sup>b</sup> *Institute of Cognitive Sciences and Technologies, Italian National Research Council, Rome, Italy*

<sup>c</sup> *University Hospital RWTH Aachen, Germany*

Received 21 June 2019; accepted 25 June 2019

Communicated by J. Fontanari

### 0. Introduction

We would like to thank all the commentators, for the time and energy spent in reading and commenting our article. The commentaries made many fruitful suggestions and allowed us to look at our proposal with new eyes, and either to better clarify or to sharpen, update and in some cases even modify our arguments. Rather than responding to each comment separately, we preferred to address all comments with a comprehensive account that includes some points we have either neglected or not discussed in detail in the target-article.

### 1. Situatedness and contextual flexibility

Some commentators have focused on the limits of the definition we have provided. The difficulty in clearly defining abstract concepts (ACs) is part of the hardness of the enterprise of accounting for them. In any case, we agree that our definition has to be refined and better articulated, and the commentators provided some excellent suggestions.

Cuccio and Caruana [1] contend that, defining ACs with respect to the nature of their intended referent, we implicitly assume an essentialist stance. Myachykov and Fischer [2] propose to qualify the distinction ACs/CCs according to three dimensions: grounding (relationship with the referent), embodiment (relationship with sensorimotor experience) and situatedness (relationship with the context). In partial disagreement with Cuccio and Caruana [1], who contend

DOI of original article: <https://doi.org/10.1016/j.plrev.2018.12.001>.

DOIs of comments: <https://doi.org/10.1016/j.plrev.2019.03.007>, <https://doi.org/10.1016/j.plrev.2019.02.011>,

<https://doi.org/10.1016/j.plrev.2019.03.010>, <https://doi.org/10.1016/j.plrev.2019.05.001>, <https://doi.org/10.1016/j.plrev.2019.04.005>,

<https://doi.org/10.1016/j.plrev.2019.02.009>, <https://doi.org/10.1016/j.plrev.2019.04.002>, <https://doi.org/10.1016/j.plrev.2019.04.007>.

\* Corresponding author.

E-mail addresses: [anna.borghi@gmail.com](mailto:anna.borghi@gmail.com), [anna.borghi@uniroma1.it](mailto:anna.borghi@uniroma1.it) (A.M. Borghi).

<https://doi.org/10.1016/j.plrev.2019.06.004>

1571-0645/© 2019 Published by Elsevier B.V.

that our definition is based on the referent, Myachykov and Fischer [2] argue that the operational definition of ACs we use is mainly based on embodiment.

Following the distinction suggested by Myachykov and Fischer [2], we think that our definition takes into account two of their dimensions, i.e. grounding (relationship with the referent) and embodiment (relationship with sensorimotor experience). In our view, ACs represent domains of knowledge that are (1) difficult to track with exteroceptive senses alone (embodiment) because (2) they are less spatio-temporally bounded (grounding). To further clarify, we suggest that, differently from prototypical concrete concepts, referents of ACs are not typically given by single, clearly bounded objects; rather, ACs refer more frequently to situations, events, elements in relation to each other. As to their relationship with sensorimotor experience, we argue that ACs are more detached from exteroceptive modalities than CCs, while it has been recently shown that the interoceptive modality is quite important for all ACs, or at least for the subset of abstract emotional concepts ([3], Villani et al., in press [4]). While we agree with Myachykov and Fischer [2] that both grounding and embodiment are important dimensions to define ACs, we do not agree with the proposal advanced by Cuccio and Caruana [1] to consider modality of acquisition of words independently of the referent. Abstractness and modality of acquisition are highly correlated, but not the same, as highlighted both by recent and less recent studies (Villani et al., in press [4]; [5]; [6]) and also by the examples given by [1].

What was less evident in the definition that we provided is the relationship with the context, what Myachykov and Fischer [2] call “situatedness”. Our definition focused on single concepts. We thought that the claim that concepts are flexible was somehow implied in our proposal, but we agree that it needs to be emphasized it more ([7]). Concepts are not isolated ([1]) and conceptual meaning can vary substantially depending on the context. In this respect, the tripartite proposal of Myachykov and Fischer [2] is very fruitful and can help us to better clarify the distinction between concrete and abstract concepts along many dimensions. If we underlie the importance of situatedness, there is no risk to adopt/assume an essentialist stance. Contextual variability characterizes all concepts, but it is particularly crucial for ACs, especially because their referent is not an object (unlike that of CCs). In agreement with what argued by Falandays and Spivey [7], the fact that “context and core meaning are likely processed at the same time” can be especially true for ACs, because the environmental support is less available. In our proposal, we hypothesized that ACs might be more variable across cultures and languages than CCs. Here we want to add that they might be more variable across all kinds of contexts, including linguistic ones. Hence, ACs are characterized by referents that are not single concrete objects, clearly spatially and temporally bounded, they are more detached from sensory modalities than CCs, and they are also more variable across contexts than CCs.

## 2. Beyond single concepts/words

Concepts are not single elements but interconnected ones; they are related to our encyclopedic knowledge structure ([1]), situated, and highly influenced by the context. Depending on the linguistic, social and cultural context they can acquire a different meaning and in some extreme cases they can even change their status from abstract to concrete or vice versa ([2]). This important consideration has two consequences. First, it helps reframing the definition of abstract concepts, highlighting that the concrete/abstract distinction might be relative and fuzzy (see point 1). Second, it contributes to highlight how important is to study concepts in novel ways, relying less on single words – as in the psycholinguistic tradition – and more on words in contexts, and dynamic situations such as conversations (see point 8) ([7], [8]).

## 3. Mouth activation: access, content, both?

In our view, mouth activation is related to the modality used to access to content, and only partially to their content. To clarify: we predict that an abstract concept like “faithfulness” would activate the linguistic system, and hence the mouth motor system, more than a concrete concept like “bag”. However, both concepts also activate brain areas related to their content, e.g. “faithfulness” will be associated to situations such as relationships, in marriage, pets etc., while “bags” to situations like shopping, transporting things, etc.

We believe that the distinction between access and content is crucial. As Miklashevsky [9] puts it, words must relate to something else to acquire meaning, and this “something else” is the conceptual content. As clearly argued by Desai [10], this distinction is useful also in order to interpret brain imaging data. For example, the activation of

ATL for ACs does not mean that ACs representation is amodal, but simply that their content can be activated through different modalities. Following Desai's example, we do not intend to claim that mouth movement determines what "freedom" means. We intend to claim that, because of the abstractness of "freedom", not only we activate the content of the concept (e.g. experiences linked to be free from chains and limitations), but we also activate the mouth motor system – more than we would do with a more concrete concept. The activation of the mouth during processing of ACs would be related to a set of (largely covert) processes, such as the need to re-enact the conceptual acquisition, to innerly re-explain the conceptual meaning or to prepare ourselves to ask information to others, to mitigate the intrinsic uncertainty of our AC representations (social metacognition).

Hence, while the distinction between access and content is crucial, it may be more blurred than implied by Desai [10]. We clarify this point with reference to the Language and Situated Simulation theory ([11]). The LASS theory ([12]) proposed to distinguish language and simulation: the first, which would imply a more superficial processing, would pave the way to the second, deeper form of conceptual processing. Language would thus represent a means to access meaning – or a shortcut ([13]) – while meaning would be captured through simulation. The difference between the LASS and the WAT proposals is that in our view language cannot be considered only as a shortcut to access meaning, but it also provides some content. Language – and the movements associated to overt or covert linguistic production – reflects our past and current experience and contributes to build new categories and new experiences ([14], [15]) (see point 6).

#### 4. Building abstract concepts through language

We acknowledge that distributional approaches are based on important insights and we do not intend to dismiss their role ([14]). However, we favor hybrid approaches that contextualize distributional theories within a more embodied perspective on cognition and conceptual processing. In our view, distributional approaches on their own are not sufficiently able to explain conceptual representations, due to the symbol grounding problem – as exemplified by Miklashevsky's [9] observation that words must be grounded in something else to acquire meaning. We also underlined that, compared to distributional theories, we conceptualize language in a broader perspective ([16]), which gives more relevance to the plurality of contexts (including cultural and social contexts) in which language is used. We however agree with Lupyan [14] that confining the role of distributional approaches to word-to-word associations is too limited: language can have a productive and innovative role in creating new meanings. We believe that language is crucial to form categories, especially abstract concepts, the members of which are highly heterogeneous. This motivates the idea that labels can be seen as a sort of "glue", useful to create new categories. This idea is perfectly in line, we believe, with Lupyan's view that "words chunk sensory input in a way not possible through only perception and action". We like Lupyan's way to consider words as targets used to create new "chunks", and to underline the fact that words can glue not only sparse sensorimotor experiences but also sparse linguistic meanings – a mechanism that might be particularly useful in the case of abstract concepts, due to their heavier reliance on language.

We also agree with Dove's [15] view that language might help extend our cognitive abilities, contributing to the development of the theory of mind which is clearly one among the most prominent and consequential domains of abstract knowledge. Finally, we are happy that Cuccio and Caruana [1] highlight that WAT recognizes the performative power of words – this is another important function of words, which we conceive as social tools that change the social and physical environment. In other words, as argued by Glenberg [8], language is both a tool for communication but to do things.

As noticed above, we believe that language helps us categorizing the world. We want to clear away a possible misinterpretation of our claims ([1]). Our proposal that language plays a major role in the acquisition of AC does not imply at all that language does not play any role in the acquisition of CCs. We rather believe the opposite, as we have extensively argued in several other publications (e.g. [17]; [16]; [18]; [19]): we believe that humans are linguistic beings, and that language is likely to influence categorization from the very start. We are firmly convinced that our categories would not be the same without language. The difference we see – whether quantitative or qualitative difference should be object of further research – is that language plays a more prominent role in building ACs than CCs, since for the latter the environmental scaffold is stronger.

## 5. Syntax

What is the role of syntax in the acquisition and representation of ACs? In our proposal we briefly present the syntactic bootstrapping hypothesis ([20]). We have the impression that Desai devaluates, or at least restricts, the role of syntax, even though we are not sure how to interpret his suggestions. Desai [10] distinguishes between meaning at the template and root levels, and argues that the root meaning can be understood only through grounding in extralinguistic, sensorimotor and social contexts: hearing froze in all its syntactic contexts would not help capture its root meaning. Syntax would thus simply contribute to restrict possible interpretations of word meanings, thus playing a minor role in conceptual processing. Furthermore, the acquisition of concepts would be guaranteed more by inferences based on specific lexical items than by syntax; moreover, such inferences work with all word classes, while syntax primarily with verbs.

We agree with Desai [10] that words need also grounding in an extralinguistic context (i.e., the embodied part of our proposal), even if one of the aims of our proposal is to highlight the importance of having rich linguistic inputs for ACs acquisition and representation. We also agree with him that semantics is more important than syntax in accessing the root meaning. However, we are less pessimistic than Desai as to the role played by syntax. There are several reasons why we should assign a role to syntax for word learning. The first reason is that syntax and semantics are strictly interwoven. For example, when hearing a sentence like “The dog tixed the bone” we easily infer which is the agent and which the patient of the action; these inferences help us to understand the meaning of the verb “to tixe”. As argued by Desai [10], the power of these inferences might be limited, because they need reference to an extralinguistic content, and because they work only with a specific class of words, i.e. verbs. Still, they might play a role, together with other more powerful mechanisms. Another reason why syntax should not be ignored is advanced by Dove [15], who connects the mastery of some syntactic constructions, in particular complement clauses, with the emergence of ToM in children. This is an example of the link between syntax and the emergence of complex inferential abilities.

## 6. Sociality, mirror neurons and Vygotsky

Sociality is fundamental for both CCs and ACs, but especially for the latter. We thank Desai for his claim that social concepts should not be treated as primitives, but that it is important to consider the brain areas that the specific components of the social concepts (e.g. people, objects, emotions etc.) engage. Two important integrations to our proposal are the following:

- a. MNs. MNs play clearly a role during language use, and they likely play an important role in shaping representations of ACs, which likely reflect experiences of language acquisition and use. We are grateful to Art Glenberg [8] for arguing that, when speaking of sociality, we could refer more extensively to the mirror neuron mechanisms. One could even hypothesize that, because ACs involve more extensively sociality compared to CCs, their processing should involve more the MNs than processing of CCs, while the latter should involve more canonical neurons.
- b. Background: Vygotsky. Falandays and Spivey are correct in highlighting the importance of Vygotsky for our proposal. While we have recognized the inspirational role of Vygotsky in previous work ([16], [17]), in the current proposal we did not – hence we thank the commentators for giving us the occasion to amend it. Together with Wittgenstein, we consider Vygotsky (e.g. [21]) as a major source of inspiration of our work, for a variety of reasons: for the idea of words as social tools, for emphasizing the importance of sociality for language acquisition and development, for underlining the regulative and crucial role played by language, especially of inner speech, for cognition (see also [22]; see [23] on inner speech).

## 7. Numerical concepts

In the paper, we argued that numbers might represent a special kind of ACs. Differently from other ACs, numbers have a concrete referent – even if such a referent is not a specific one but can vary, as expressed by the locutions “two dogs, two computers” etc. We are happy that experts on numbers ([2]) welcome WAT as a possible proposal to account for these concepts as well. It is possible that two different numerical representations exist, one for numbers until 4–5 more independent from linguistic experience (subitizing), and another concerning higher number, for which

linguistic information can be more relevant. WAT would thus lead to the proposal that, the higher numerical concepts are, the higher would be their level of abstractness, and the more they would rely on language, possibly activating the mouth motor system.

## 8. Non hearing children

In the paper, we clarified that we do not intend to equate linguistic with acoustic experience; we would like to reiterate this point here to render it clearer. We intend language in its complexity (see also [16]), as a form of rich social experience. We are grateful to Cuccio and Caruana [1] for their observations and agree with them that in formulating our predictions about not hearing children, we should distinguish between early and late learners of sign language, i.e., between children who have deaf parents and use sign language early and children who do not. We might clearly expect more difficulties for ACs in the second case, because of the lacking communication means/language between parents and children. Evidence in favor of our point is provided by Dove [15], who refers to studies in which deaf children of hearing parents who are not fluent signers present delays in the acquisition of ToM, and as proposed by Dove learning of language, i.e. of mental state concepts, can help to master ToM. Further research is needed to address this important issue.

As to the objections of Cuccio and Caruana [1] to the evidence of Wauters et al. [24]: it is true that deaf children have difficulties with written texts; it remains however the fact that the data indicated that such a difficulty is more pronounced with abstract than with concrete words.

## 9. Novel methods to study concepts

Future research on ACs should focus less on single concepts, and more on concepts within rich contexts – and most prominently, interactive contexts. We thank the commentators for raising this point. Conceptual meaning is namely highly variable and flexible, and studying concepts in isolation we certainly miss something important. A very promising proposal is to study them in conversations. As Glenberg [8] argues, we should focus more on language in a social context, studying words as tools “in a complex, collaborative, communicative situations”; see also [25].

As Falandays and Spivey [7] put it, ACs should be studied better with dyads and groups than in situations in which participants process words displayed on the computer screen. Not only words, but also gestures, hand and facial movements and brain activity should be investigated in these rich interactive contexts [26]. Obviously here the mirror neuron system likely plays a major role – in influencing prosody, facial expressions, gestures etc. ([8]).

We are convinced that the future agenda of research on concepts should focus more on the dynamics of conversations, and on the everyday use of language in situations. Comprehension should not be investigated as a solipsistic process of single items but as an online process of more elements. More crucially, we are convinced that these major changes are especially fruitful for research on ACs, due to their exquisite social dimension.

## 10. Impact and implications

In the paper we focused on the tenets of the WAT proposal and the mechanisms of acquisition and representation of abstract concepts. We did not discuss its potential impact. We will do it now.

In terms of scientific impact, we think it will be important for the future to build a theory that keeps together an approach centered on development with an approach that considers mechanisms underlying conceptual representation in adults, its neural underpinnings and also its social bases, thus building a bridge between developmental psychology, cognitive psychology and cognitive science, cognitive and social neuroscience, cross-cultural psychology. In the paper we did not treat ACs from an evolutionistic perspective, and this is a limitation future studies should address. We also think it is important to bridge and hybridize different theories of meaning, i.e. the distributional approaches and the embodied approaches, because both have had important insights on how meaning is construed and represented.

We thank Miklashevsky [9] for addressing the issue of impact also a more applied point of view, and for highlighting possible implications WAT can have. This perspective was missing in our target article. As he argues, WAT can have implications for education at all levels, as well as for intercultural communication and for migrant integration. Future research should be devoted to investigate possible practical implications of current work.

## 11. Conclusion: language, sociality, flexibility

A successful approach to understanding ACs should consider seriously how they develop, bridging information on their acquisition with evidence on their brain representation and on their everyday use.

In the recent literature two major contenders existed: embodied and grounded theories and distributional theories of meaning. In the last years we have assisted to the rise and increased success of multiple representation views. WAT, the multiple representation view that we prefer, can be seen as a hybrid view: it underlines the importance of grounding in sensorimotor system, in line with embodied and grounded views, but it also emphasizes the important contribution of the linguistic experience, taking inspiration from distributional theories. It also attempts to integrate a developmental approach, with approaches focusing on brain representation and conceptual use in adults.

The commentaries helped us to refine our proposal, in many different ways. We list here only some broader areas in which we benefited from the insights provided by the commentaries. First of all, they helped us to better define ACs, stressing the importance of contextual variability. ACs differ from more concrete concepts for their referent, for their relationship with sensorimotor experience and their acquisition modality, and for their higher variability across contexts and languages. Second, they helped us to better focus the contributions that language – the role of semantics and syntax, the role of words as glue both of sensorimotor experiences and sociality play for ACs representation. Third, they allowed us to understand that language (and possibly mouth activation) might be relevant also for a special kind of abstract concepts, such as numbers. Finally, they allowed us to think of practical implications of our work and they force us to think of new ways to study conceptual representation, using methods that are more ecological and more adequate to investigate the flexibility and contextual influence of concepts.

Future research on ACs has to face several challenges. We will have to better comprehend how language influences conceptual representation – e.g., the role of semantics, syntax, linguistic contexts, and the influence of the different languages –, the mechanisms underlying sociality – e.g., the involvement of the MNs system, other possible mechanisms underlying social practices –, the role of inner bodily and cognitive processes – e.g., interoception, metacognition, social metacognition, inner speech. Researchers will have to design new, more ecological methods to study concepts, that do not investigate them in isolation but captures them in online, situated interactions. They will have to develop more sophisticated techniques and ways to understand the subtle differences between concepts kinds. We are excited to see what the future will bring to us, and to take part to this fascinating enterprise.

## Acknowledgement

Funding: grant to A.M. Borghi, Sapienza University of Rome, 2018: Inner grounding and abstract concepts: the role of interoception and social metacognition, grant n. RM11816428832AC7.

## References

- [1] Cuccio V, Caruana F. Rethinking the abstract/concrete concepts dichotomy: Comment on “Words as social tools: language, sociality and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.04.007>.
- [2] Myachykov A, Fischer MH. A hierarchical view of abstractness: grounded, embodied, and situated aspects: Comment on “Words as social tools: language, sociality and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.04.005>.
- [3] Connell L, Lynott D, Banks B. Interoception: the forgotten modality in perceptual grounding of abstract and concrete concepts. *Philos Trans R Soc Lond B, Biol Sci* 2018;373. <https://doi.org/10.1098/rstb.2017.0143>.
- [4] Villani C, Lugli L, Liuzza MT, Borghi AM. Varieties of abstract concepts and their multiple dimensions. *Lang Cogn* [in press].
- [5] Della Rosa PA, Catricalà E, Vigliocco G, Cappa SF. Beyond the abstract-concrete dichotomy: mode of acquisition, concreteness, imageability, familiarity, age of acquisition, context availability, and abstractness norms for a set of 417 Italian words. *Behav Res Methods* 2010;42:1042–8. <https://doi.org/10.3758/BRM.42.4.1042>.
- [6] Wauters LN, Tellings AE, Van Bon WH, Van Haaften AW. Mode of acquisition of word meanings: the viability of a theoretical construct. *Appl Psycholinguist* 2003;24:385–406.
- [7] Falandays JB, Spivey MJ. Abstract meanings may be more dynamic, due to their sociality: Comment on “Words as social tools: language, sociality and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.02.011>.
- [8] Glenberg AM. Turning social tools into tools for action: Comment on “Words as social tools: language, sociality and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.02.009>.
- [9] Miklashevsky A. Words as social tools: the old and the new. Bridging cognition and communication: Comment on “Words as social tools: language, sociality and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.04.002>.

- [10] Desai RH. Access and content of abstract concepts: Comment on “Words as social tools: language, sociality, and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.03.010>.
- [11] Barsalou LW. Grounded cognition. *Annu Rev Psychol* 2008;59:617–45.
- [12] Barsalou LW, Santos A, Simmons WK, Wilson CD. Language and simulation in conceptual processing. *Symb Embodiment Mean* 2008;245–83.
- [13] Connell L, Lynott D. Flexible and fast: linguistic shortcut affects both shallow and deep conceptual processing. *Psychon Bull Rev* 2013;20:542–50. <https://doi.org/10.3758/s13423-012-0368-x>.
- [14] Lupyan G. Language as a source of abstract concepts: Comment on “Words as social tools: language, sociality and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.05.001>.
- [15] Dove G. Language influences social cognition: Comment on “Words as social tools: language, sociality and inner grounding in abstract concepts” by Anna M. Borghi et al. *Phys Life Rev* 2019. <https://doi.org/10.1016/j.plrev.2019.03.007>.
- [16] Borghi AM, Binkofski F, Castelfranchi C, Cimatti F, Scorolli C, Tummolini L. The challenge of abstract concepts. *Psychol Bull* 2017;143:263–92. <https://doi.org/10.1037/bul0000089>.
- [17] Borghi AM, Cimatti F. Words as tools and the problem of abstract words meanings. In: *Proc. 31st Annu. Conf. Cogn. Sci. Soc.*, vol. 31. 2009. p. 2304–9.
- [18] Granito C, Scorolli C, Borghi AM. Naming a Lego world. The role of language in the acquisition of abstract concepts. *PLoS ONE* 2015;10:e0114615. <https://doi.org/10.1371/journal.pone.0114615>.
- [19] Borghi AM, Scorolli C, Caligiore D, Baldassarre G, Tummolini L. The embodied mind extended: using words as social tools. *Front Psychol* 2013;4:214. <https://doi.org/10.3389/fpsyg.2013.00214>.
- [20] Gleitman L. The structural sources of verb meanings. *Lang Acquis* 1990;1:3–55.
- [21] Vygotsky LS. *Thought and language*. Rev. edition. Cambridge, MA: MIT Press; 1986.
- [22] Clark A, Toribio J. Magic words: how language augments human computation. *Lang. Mean. Cogn. Sci.* Routledge; 2012. p. 33–51.
- [23] Langland-Hassan P, Vicente A. Inner speech: new voices – introduction; 2018.
- [24] Wauters LN, Tellings AE, Van Bon WH, Mak WM. Mode of acquisition as a factor in deaf children’s reading comprehension. *J Deaf Stud Deaf Educ* 2007;13:175–92.
- [25] Pezzulo G. The “interaction engine”: a common pragmatic competence across linguistic and non-linguistic interactions. *IEEE Trans Auton Ment Dev* 2011.
- [26] Pezzulo G, Donnarumma F, Dindo H, D’Ausilio A, Konvalinka I, Castelfranchi C. The body talks: sensorimotor communication and its brain and kinematic signatures. *Phys Life Rev* 2018. <https://doi.org/10.1016/j.plrev.2018.06.014>.