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# Abstract concepts, language and sociality: from acquisition to inner speech

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The problem of representation of abstract concepts, such as 'freedom' and 'justice', has become particularly crucial in recent years, owing to the increased success of embodied and grounded views of cognition. We will present a novel view on abstract concepts and abstract words. Since abstract concepts do not have single objects as referents, children and adults might rely more on input from others to learn them; we, therefore, suggest that linguistic and social experience play an important role for abstract concepts. We will discuss evidence obtained in our and other laboratories showing that processing of abstract concepts evokes linguistic interaction and social experiences, leading to the activation of the mouth motor system. We will discuss the possible mechanisms that underlie this activation. Mouth motor system activation can be due to re-enactment of the experience of conceptual acquisition, which occurred through the mediation of language. Alternatively, it could be due to the re-explanation of the word meaning, possibly through inner speech. Finally, it can be due to a metacognitive process revealing low confidence in the meaning of our concepts. This process induces in us the need to rely on others to ask/negotiate conceptual meaning. We conclude that with abstract concepts language works as a social tool: it extends our thinking abilities and pushes us to rely on others to integrate our knowledge.

This article is part of the theme issue 'Varieties of abstract concepts: development, use, and representation in the brain'.

## 1. Introduction

Abstract concepts (ACs) are quite heterogeneous: they differ in degree of abstractness, varying from more to less abstract and they belong to subtypes (e.g. emotional, social, mathematical concepts) that can be distinguished in terms of content and neural representation [1–6].

Despite these differences, when compared with concrete concepts like 'table' and 'dog', they have much in common: they are generally difficult to associate with a single image, they do not have a single object/entity as referent, and more often refer to complex situations with multiple objects/entities [7]. Furthermore, even if they are grounded in sensorial modalities, they activate less the five senses than concrete concepts [8] and their content is more variable both within and across participants, as testified for example by the feature variability in property generation tasks [9].

In the first part of the paper we will discuss and substantiate with evidence two claims derived from the words as social tools (WAT) proposal on ACs [9,10]. We state that the more abstract concepts are, (1) the more linguistic and social/interactive input from others is needed to acquire them; (2) the more they are represented activating linguistic brain networks, and engage the mouth motor system and the acoustic system. In the second part we will discuss inner grounding of ACs, and focus on metacognition. We will propose a



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link between activation of the mouth motor representation and metacognitive feeling that we need others' competence to enrich our concepts [11–14].

## 2. Abstractness, linguistic and social input and mouth motor system involvement

### (a) Why language is important for abstract concepts

The view that language is important for AC representation is not new. According to the dual-coding theory [15], concrete concepts evoke imagistic representations, and ACs verbal ones. In line with Paivio [15], we contend that concepts activate multiple representations. Differently from Paivio, we do not equate imageability with concreteness, because the two dimensions have proven to be correlated but not equivalent [16]. In developmental psychology, the syntactic bootstrapping hypothesis (e.g. [17]) proposes that children learn 'easy words' by mapping the words to the objects/entities in the world. Once a substantial number of words have been acquired, learning proceeds by adding structure to the original machinery: this allows acquisition of 'hard words' such as abstract ones. In this process syntax and semantics are strictly linked: syntax cannot substitute semantics, but it can help learners to narrow their hypotheses on the possible word meaning. Recently, proponents of multiple representation views have emphasized the importance of language for AC learning [9,18,19] and representation [10,16,20–23].

Why should language be important for ACs? First of all, it is critical for their acquisition, and this might impact their representation. Different justice situations are far more heterogeneous than different cups, and using a common label helps us assemble them in a category. Furthermore, explanations of the conceptual meaning can be more crucial to form the concept of 'justice', for instance, than that of 'cup'. In order to learn ACs we might also need to actively ask for definitions/contributions from competent community members [12,13] or to resort to recognized information sources (e.g. Wikipedia). Finally, because ACs are heterogeneous and complex, language can help us process them. Language augments our cognitive abilities, computational resources, and problem-solving capacities [24–26]; this extension might be pivotal to use of concepts that are increasingly abstract.

### (b) Language and vocalization

When we are exposed to words, their sub-vocal pronunciation is activated [27]. This mechanism underlies the exposure to all words, but we propose that it is more pronounced in the case of abstract words. Owing to the heterogeneity of their members, we contend that in order to acquire ACs the scaffolding of the physical environment has to be complemented by linguistic information, for example, labels and explanations. This information can be conveyed either by others (e.g. parents, experts) or by written sources (e.g. books, Internet), depending on expertise and age. In our view the activation of linguistic experience has an embodied counterpart: it should lead to a sub-vocal pronunciation of the words and/or of (part of) their explanations. Responses with the mouth should thus be facilitated during AC processing. Conversely, occupying the mouth during AC acquisition and processing should induce an interference, impairing acquisition and slowing down responses.

### (c) Evidence on mouth motor system activation during abstract concept learning and processing

In this section, we will overview studies performed to test the hypothesis that AC processing involves the mouth more than does concrete concept processing. First, we found facilitation of mouth responses in studies on learning of novel/artificial categories in adults. We operationalized concrete categories as having a single, concrete object as referent, rich in perceptual features; abstract categories were instead operationalized by multiple interacting elements (e.g. small cylinders moving in spirals and then knocking against each other) [28]. Once they learned these novel categories, participants were taught their names. Results of a subsequent property verification task revealed a facilitation of microphone (mouth) responses to abstract words. This facilitation was more pronounced when the word meaning had been explained to the participants. Responses to concrete words were instead facilitated when participants responded by pressing a key with the hand (figure 1*a*).

Second, facilitation of the mouth responses occurred also in the processing of real abstract words. Borghi & Zarcone [29] asked participants to decide whether abstract and concrete prime-definitions matched with Italian concrete and abstract target-words: to respond they pressed a key with the hand or a device with the teeth. The advantage of hand over mouth responses disappeared with abstract words, confirming that AC processing activates the mouth motor system (figure 1*b*). The finding is consistent with results from explicit ratings with words and sentences. Participants think that abstract words involve the mouth more and concrete words the hand more [31]. Similarly, the content of mental state sentences was more associated with mouth actions than with hand or leg actions, while the content of maths-related sentences was more associated with the hand [3], likely due to the activation of finger-counting habits [32].

The studies illustrated so far provide evidence of facilitation with mouth responses when processing novel and real abstract words. If the activation of the mouth motor system is not simply a by-product of AC processing, then occupying the mouth should interfere with word acquisition and processing. We performed two developmental studies investigating whether pacifier use influences language acquisition and processing later in life, and one study investigating whether actively moving the mouth (gum chewing) affects adults' online processing of ACs. Barca *et al*. [33] asked first-grade children to define abstract (agreement), concrete (flag) and emotional (pain) words. Children were divided in groups depending on how long they had been using the pacifier (never, until age 2, until age 3, beyond 3 years). Definitions were then evaluated in terms of accuracy and the conceptual relations provided to define the words were coded (i.e. perceptual, spatial, action–function, emotion, situation, experiential, superordinate, subordinate, norms, free association). Pacifier overuse did not influence accuracy of definitions. However, the pattern of conceptual relations elicited by the three kinds of words clearly differed depending on pacifier use. The distinction between emotional and concrete words was less marked for children who used a pacifier for more than 3 years, and the distinction between concrete and abstract words became progressively less marked for children who used it until 3 years and beyond. Independently from the type of word they had to define,

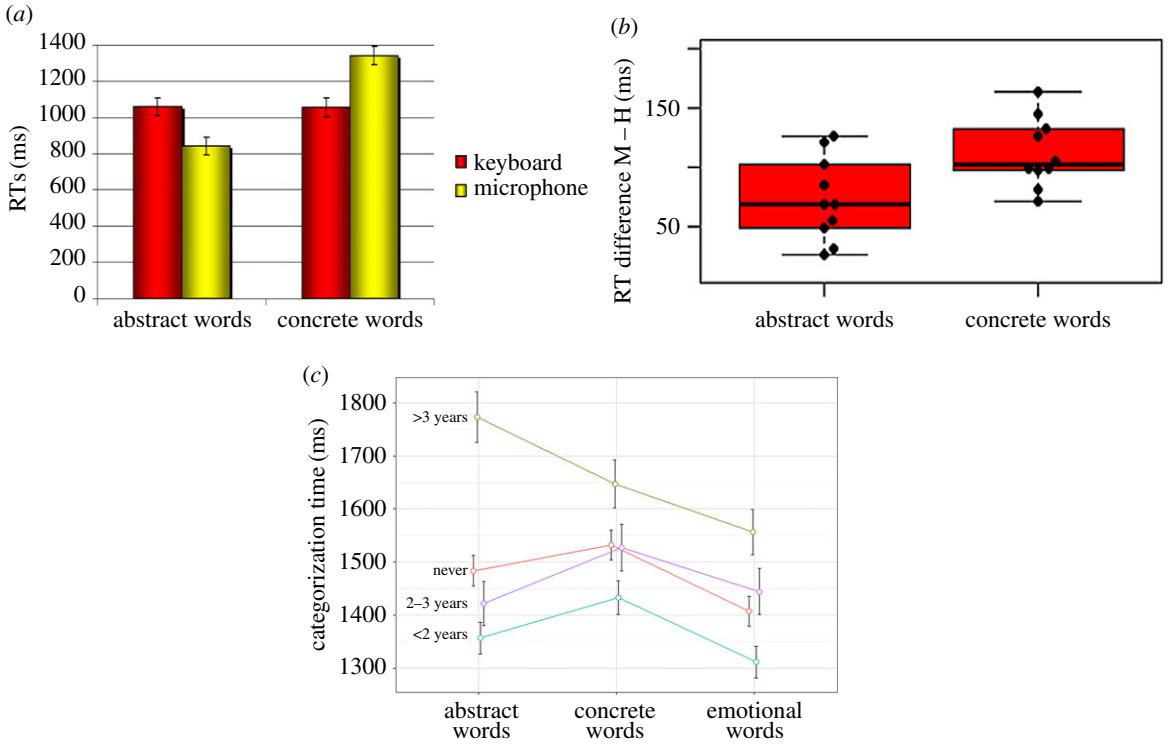


**Figure 1.** Interactions between response effector and kind of concept showing a facilitation of the mouth responses with abstract concepts. (*a*) Property verification task (from Borghi *et al*. [28]). Interaction obtained with novel categories. (*b*) Definition–word matching task (from Borghi & Zarcone [29]). Interaction obtained with real categories. (*c*) Semantic categorization task (from Barca *et al.* [30]). Interaction between pacifier use and kind of concept, revealing longer response times (RTs) with abstract concepts for late-users of pacifier. (Online version in colour.)

children who overused the pacifier produced fewer free associations (the only feature more frequent in abstract than in other concepts), fewer emotional, experiential and interactive relations, and slightly more subordinates. The results suggest that overuse of pacifier during language acquisition, even if it does not affect accuracy in defining words, influences later conceptualization: it is namely correlated with a less marked distinction between emotional and concrete words, and between concrete and abstract words.

Two different mechanisms might be responsible for this phenomenon: mouth motor system interference and facial mimicry. The mouth motor system interference one is based on the WAT proposal: by keeping the mouth actively occupied, the pacifier would hinder the benefits of linguistic input, which is particularly crucial to learn ACs, and to rehearse the word and/or its explanation via inner speech. Inner speech can also serve as vehicle to metacognition, preparing children to interact with others when they feel scarcely confident on their knowledge (see later discussion on metacognition).

Alternatively, the reduced facial mimicry induced by pacifier use might reduce motor resonance with others, thereby making the grounding of emotional concepts more difficult. Importantly, the two mechanisms are not in contrast and might even overlap. However, we are inclined to think that they play a different role for abstract and emotional words. We hypothesize that the mouth motor system interference mechanism concerns specifically abstract words, in line with the WAT view, while the facial mimicry one concerns emotional words, in keeping with evidence showing a relationship between pacifier use and development of emotional competence [34].

The role played by the two mechanisms can be disentangled with the help of a further study [30]. We asked 8-year-olds with a different history of pacifier use to perform a semantic categorization task: they had to press a different key on the keyboard if the word displayed on the screen referred to an animal or to something else. The non-animal words were our critical items: abstract, concrete and emotional words. Response times analyses revealed that children who overused the pacifier processed abstract words slower than all other children. Given that the effect was specific for ACs and did not involve emotional ones, the result is consistent with the view that pacifier overuse interferes with processing of ACs and influences their representation.

The interference effect elicited by active engagement of the mouth during AC processing is also revealed by another recent study [35] in which adult participants rated complexity and pleasantness of abstract and concrete concepts. When participants chewed gum, perceived pleasantness of ACs decreased and perceived complexity of ACs increased compared with concrete concepts. Gum chewing has been associated with reduction of nociception and increase of alertness, while it is debated whether it increases calmness and contentedness (e.g. [36]). If the mood change induced by gum chewing had an effect on performance, we should find a general increase of pleasantness ratings and a decrease of difficulty ratings, but we found the opposite, and the effect was specific for ACs. We are, therefore, inclined to believe that the effect is not due to mood or alertness modifications but rather, as predicted by WAT, to the interference induced by actively moving the mouth, which conflicts with activation of the mouth during AC processing.

### (d) Mechanisms underlying mouth motor system activation

The mouth activation with abstract words, leading to facilitation if the mouth is a response effector or to interference if the mouth is actively occupied during word processing, could be due to three different mechanisms: (1) the *re-enactment* of the experience of conceptual acquisition, which typically occurred through the linguistic mediation, in a social context. (2) The *re-explanation to oneself* of the word meaning, possibly through inner speech [26]. (3) The *preparation to ask* others for information on word meanings [12–14]. Results on acquisition of novel categories showing a facilitation of mouth responses and extended-in-time interference effects of pacifier overuse on processing of ACs are compatible with the re-enactment explanation: likely children were not able to fully benefit from the input of others owing to the pacifier, and this might influence the re-enactment of the acquisition experience. Results showing facilitation of mouth responses with ACs (e.g. [28,29]) and interference when the mouth is actively involved in gum chewing are more compatible with the second and third mechanisms, i.e. re-explanation to oneself and/or the preparation to ask others for information. Importantly, however, these mechanisms could coexist; further research is needed in order to better disentangle them. Notice that all mechanisms help grounding, because they assist us in tracking conceptual referents.

These three mechanisms might be implemented through *inner articulation of the label* and *inner speech*, viewed as a more complex and possibly discourse-like internal articulation of the word sound.

#### (i) Inner articulation of the label

While silently reading words, we covertly articulate their sound, producing a mouth movement [27,37] or activating the speech-motor cortex [38]. Pronouncing the name of an object and internally articulating its label is useful to memorize it but it also improves object perception. It can indeed facilitate object finding in a visual search task [39]: using the word 'tree' is better than simply thinking about a tree to perceptually detect trees. We propose an extension of this hypothesis: in our view the effect of labels is more crucial with ACs. Pronouncing/hearing their labels can help us to put together dissimilar category exemplars, thus reducing the working memory overload linked to the generation of many hypotheses. In addition, labels can help us to select the relevant cues: while we observe a scene with people running in a field we interpret it differently if we hear/pronounce the word 'freedom' or the word 'grass'.

#### (ii) Inner speech

We propose that with ACs the need to speak to ourselves or to prepare to interact with others is stronger than with concrete concepts. Inner speech can help us retrieve information on the category exemplars, reflect on the word meaning, reconstruct the linguistic explanations we received, predict what we will need to search [40] and prepare ourselves to interact with others when we feel scarcely confident in our own knowledge. We propose that the probability of using inner speech becomes higher with the increase of abstractness and complexity of concepts.

The proposal that AC processing likely involves inner articulation of the label and inner speech is compatible with neural evidence on the role of both semantic and phono-articulatory aspects of language for ACs. Consistently, meta-analyses and functional magnetic resonance imaging (fMRI) studies have shown a higher left-hemispheric activation, determined by stronger activation of the left inferior frontal gyrus, typically associated with phonological working memory, left middle temporal gyrus [41], anterior superior temporal sulcus [42], and superior temporal gyrus, associated with acoustic experience [43].

## 3. Kinds of concepts, inner grounding and mouth motor system activation

As anticipated in the Introduction, although ACs have typically been considered a unitary whole, they might greatly differ in their content. Consistently, fMRI studies have shown that, for example, the concept 'arithmetic' activates numerical cognition areas, while the mental state concept 'convince' engages mentalizing and social cognition areas [4,44]. Other concepts like 'confidence' and 'self-esteem' might instead be grounded on metacognition. Along similar lines, Barsalou [45] proposed that the grounding of ACs such as 'truth' depends on the monitoring of internal, inferential processes, such as the successful/unsuccessful matching of expectations and sensations. We will here contend that metacognition not only is relevant to explain the differences in *content* between ACs but also can offer a new *mechanism*.

We have extensively discussed one of the crucial mechanisms involved in AC processing, namely linguistic activation. We will now illustrate a second mechanism that in our view characterizes AC representation, and propose a possible relationship between metacognition and language covert activation.

### (a) Inner grounding

Inner grounding is the process of grounding concepts on perceptual systems tracking states and processes in the environment inside the body. Internal perceptual systems can be contrasted with perceptual systems that track information in the environment outside the body or at the interface between body and external environment (e.g. vision, audition, touch). Some concepts are grounded mostly on perceptual systems that track information about what happens in the outside world, while other concepts are more related to the inside world. Different perceptual systems are tuned to track information on internal states and processes. Interoception tracks information about the state and processes of the body organs, while proprioception tracks information about the state and processes of the body itself and its parts. We consider metacognition as another kind of internal perceptual process, tuned to track information about *cognitive* states and brain processes.

We hypothesize that concepts that are grounded on metacognitive processes are perceived as more abstract than those grounded on interoception and proprioception. A possible reason is that the information tracked by proprioception and interoception could also be partly picked up by exteroception. Only metacognition tracks precisely the kind of information that cannot be picked up by any external perceptual system, much like colour information cannot be tracked by the haptic system and temperature cannot be tracked by the visual system.

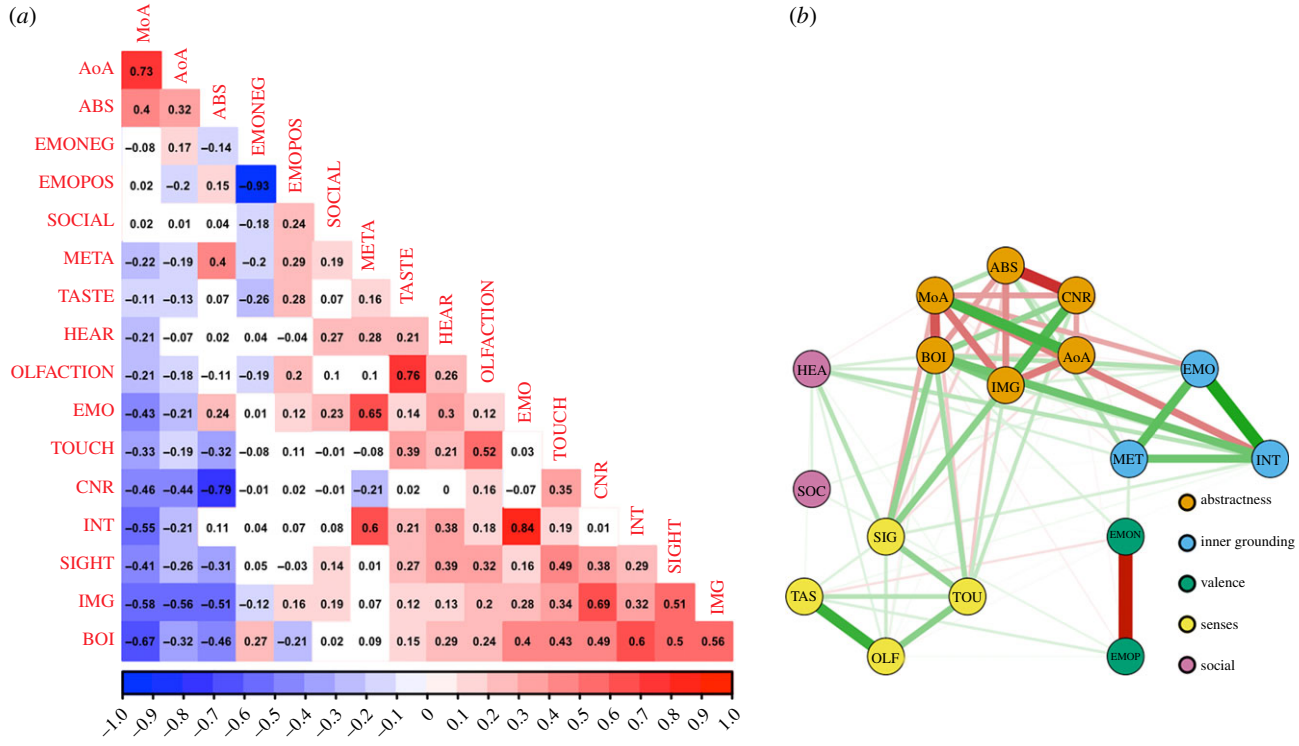


**Figure 2.** From Villani *et al.* [6]. (*a*) Correlation matrix describing correlations between each of the individual dimensions. (*b*) Network representing latent factors and correlations. AoA, age of acquisition; ABS, abstractness; EMONEG/EMON, negative emotion; EMOPOS/EMOP, positive emotion; SOCIAL/SOC, social valence; META/MET, metacognition; HEAR/HEA, hearing; EMO, emotional valence; CNR, concreteness; INT, interoception; SIGHT, vision; IMG, imageability; BOI, body–object interaction; SIG, sight; TOU, touch; TAS, taste; OLF, olfaction. (Online version in colour.)

## (b) Metacognition

Inner grounding in general, and metacognition in particular, can be important mechanisms useful to distinguish between abstract and concrete concepts, and also to identify different kinds of ACs. We identify two forms of metacognition that might characterize ACs. *General metacognition* concerns more generally the tracking of states and processes occurring in the brain. For example, to classify an experience as a recall/memory, rather than as mere imagery, we need to interpret the image as deriving from a memory trace. Instead, if the image is a 'fantasy', we keep trace of having built it within our mind. These inner brain operations share many aspects with introspective properties that, according to Barsalou & Wiemer-Hastings [46], characterize ACs; they need not have a specific feeling associated with them, and are likely unconscious. We hypothesize that *general metacognition* involves the majority of ACs, but especially mental state ones.

There is another dimension to metacognition that we propose to be crucial for grounding of ACs. This dimension is inspired by the distinction introduced by Shea [14] between implicit deference—the disposition to rely on others while using a concept—and explicit deference—a judgment on our own mental states, for example leading us to decide that our concept is not adequate. This distinction is at the basis of the notion of *social metacognition* we propose. One of the reasons why language and sociality are important for ACs, is that we might need to rely on others to fix reference. This process is based on a metacognitive assessment: we reflect on our own concepts, realizing that to fully capture their meaning we need the contribution of others. We use the term social metacognition to suggest a link between an internal process, the awareness of our knowledge inadequacy, and the need to activate actions directed toward others. Studies on testimony reveal the increasing ability of children to rely on others as information sources especially in abstract domains, such as God, death and life, and to monitor their competence [47]. We hypothesize that this form of metacognition increases with the increase of the abstractness level, and that it might explain the activation of the mouth motor representation. The idea that language can provide access to grounding is compatible also with the recent fMRI finding [48] that ACs activate both linguistic contextual information and semantic features, but in different brain regions: linguistic contextual information is reflected mostly in high-level linguistic areas, whereas semantics engages distributed brain areas.

## (c) Inner grounding and language: evidence

Preliminary results of a recent study can give some hints on the role played by language and inner grounding for ACs [6]. Participants rated 425 Italian abstract concepts on a variety of dimensions, from the most classical ones, typically used to identify ACs (abstractness, concreteness, imageability), to more novel ones, such as emotional valence [16], interoception [49], body–object interaction (BOI: ease with which a human body can physically interact with a word's referent; [50]), social valence [1,9], perceptual strength in sight, hearing, touch, taste, olfaction [8], age of acquisition (AoA), modality of acquisition (MoA: based more on experience or more on language; [51]), and general-metacognition (reliance on internal mental/cognitive processes). Interestingly, abstractness was positively correlated with modality of acquisition (MoA) and metacognition, and negatively correlated with imageability, BOI, concreteness, touch and sight (figure 2*a*). Hence, ACs are associated with linguistic acquisition, which occurs late. Five latent factors underlie the original dimensions (figure 2*b*). Factors aggregated as follows: (1) abstractness, including the opposition between concreteness, BOI, vision/sight and imageability to abstractness, AoA and MoA; (2) inner grounding, characterized by the positive correlations between

interoception, emotion and general-metacognition; (3) senses, i.e. the four external perceptual modalities, except hearing likely because highly correlated with social valence; (4) emotion polarity (negative and positive emotions); (5) social dimension, including social valence and audition. Thus inner grounding factor is independent from abstractness, while linguistic MoA is not. This distinction is reflected in analyses on concept kinds. We classified the terms into 11 categories, following the major classifications of the literature (e.g. emotions, mental states, institutional concepts). Further cluster analyses will allow us to test our hypotheses on how items/words group together. We performed ANOVAs to ascertain whether and how the categories identified by the experimenters differed from each other on each dimension. We found a major distinction between ACs such as 'emotions' and 'bodily states', characterized by higher scores in interoception and BOI, and 'institutional' and 'knowledge domains' (e.g. *philosophy*) concepts, judged to be linguistically acquired (higher MoA).

This study suggests that perceived differences in concept kinds depend not only on content but also on mechanisms, such as interoception and language activation. Interestingly, the more concepts are grounded in external and internal perception (interoception), the less linguistic experience weighs. Consistently, recent fMRI evidence revealed that mental state concepts activate the face motor system in the brain more than emotional concepts [52].

As to metacognition, as expected, general-metacognition was more strongly correlated to abstractness than emotion (interoception was not correlated to abstractness), but ratings did not differ between concepts kinds. However, ratings might be limited in accessing a likely largely unconscious dimension. The case is different for social-metacognition, not tested in this preliminary study. Social-metacognition might be more explicit because it leads to an action with others. In future work we plan to investigate how it characterizes ACs and whether it interacts with mouth motor system activation. We predict that the more concepts are abstract and complex, the more social-metacognition weighs, and the more the mouth is activated, either to re-explain to ourselves conceptual meaning or to prepare ourselves to ask/negotiate it to/with others.

## 4. Conclusion

The WAT view proposes that ACs activate linguistic and social experience. We overviewed recent studies supporting this proposal, showing that language activation engages the mouth motor system. Mouth involvement seems to play a substantial role, as interference effects (pacifier overuse in infancy, gum chewing during online processing) reveal. The reviewed evidence suggests that this activation is due to the inner articulation of the label and/or to inner speech, contributing either to the re-enactment of the acquisition experience, to the re-explanation to ourselves of the conceptual meaning and/or to the information request on the conceptual meaning to others. Across the three mechanisms, phonological and semantic information are strictly interwoven. Importantly, all mechanisms contribute to grounding, because through different strategies they help us to search for conceptual referents.

The activation of language and of the mouth motor system does not occur to the same extent with all concepts. We argued that ACs are characterized by inner grounding. While for more 'embodied' ACs interoception and proprioception play a major role, for less 'embodied' ACs we might need language and metacognition. We propose that even abstract metacognitive processes are accomplished with the help of a bodily medium, the mouth. Sub-vocalizations and inner speech can namely facilitate tracking of information about cognitive states and brain processes. We predict that the mouth motor system activation is particularly pronounced when we feel uncertain of our concepts and need to rely on others (social metacognition).

In conclusion, words are social tools in many senses: in the most obvious sense that they help us to communicate with others and change the state of the world, and in two most subtle senses discussed in this paper: words extend our thinking abilities, and they open us to sociality when we doubt our knowledge and we need to share and align with others [53].

Data accessibility. This article has no additional data.

Authors' contributions. A.M.B., L.B. and L.T. conceived the paper. A.M.B. drafted the text and all authors provided critical revisions to it. All authors approved the final version.

Competing interests. We have no competing interests.

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