Book chapter in the book
Filippo Paloma (ed.) (2020). Embodiment and school, Pensa Multimedia: Lecce (pp.29-35).

# EMBODIMENT AND LANGUAGE

**Anna M. Borghi**
Sapienza University of Rome
Institute of Cognitive Sciences and Technologies, CNR
anna.borghi@uniroma1.it

## Abstract

Questo lavoro si propone di mostrare come il movimento e l'azione siano essenziali per la concettualizzazione ed il linguaggio. Adottando la prospettiva della cognizione "embodied" e "grounded", vengono descritte tre linee di ricerca. La prima mostra che concetti e parole si fondano sull'azione, ed influenzano l'azione. La seconda rivela che anche i concetti astratti attivano sistematicamente il sistema motorio della bocca. Infine la terza mostra la centralità del movimento per l'apprendimento della lettura e della scrittura. In generale, l'esperienza corporea è fondamentale per apprendere ed usare concetti e parole e per imparare a leggere e scrivere.

This paper aims to show how movement and action are essential for conceptualization and language. Adopting the perspective of embodied and grounded cognition, I describe three research lines. The first shows that concepts and words are grounded in action and influence action. The second reveals that abstract concepts systematically activate the mouth motor system. Finally, the third one highlights the centrality of movement for learning to read and write. In general, the bodily experience is pivotal to learn and use concepts and words and to learn to read and write.

## Keywords

Embodied cognition; Body; Concepts; Action; Movement.

## Introduction

At the beginning of primary school, Italian children are typically taught to remain quiet during the lessons. They generally remain seated for 5-8 hours a day, with pauses for recess and for eating. In this chapter, I instead contend that moving and acting is crucial for learning (Fugate et al., 2019; Gomez Paloma, 2017). In line with an embodied and grounded cognition perspective (Barsalou, 2008), I argue that: a. object concepts/words are grounded in action and influence actions; b. the acquisition and use of abstract concepts/words are influenced by action; c. hand movement is crucial for learning to write and to count. In the first two sections, I refer mostly to evidence collected in our lab, in the third to studies conducted in other labs.

## 1. The role of movement and action for object concepts/words

In recent years it has been compellingly demonstrated that concepts/words are grounded in action. Various studies have shown that, while reading words referring to objects, we activate their affordances. In a seminal study, Glenberg & Robertson (2000) demonstrated that object affordances influence language comprehension more than associations between words.

Other studies have revealed that language evokes specific kinds of affordances (Borghi, 2018). Borghi and Riggio (2009) performed a sentence-picture matching task presenting participants with sentences like “Look at/grasp the brush/pencil” followed by pictures. Responses were faster when pictures displayed objects oriented for action, i.e., upright instead of reversed. When action sentences were followed by mismatching objects, responses were slower when the image and the sentence referred to an object graspable with the same grip (e.g., a pencil and a thumbtack, both eliciting a precision grip, than a pencil and a brush). Based on evidence like this, we have proposed that words evoke “stable” affordances, related to the grip objects elicit (e.g., precision vs. power

grip) and to the canonical orientation of objects, while “variable” affordances, linked to the current orientation of the object, are activated mostly during online actions. Consistently with this hypothesis, a meta-analysis on fMRI studies showed that stable affordances engage more ventral brain areas, variable ones more dorsal ones (Sakreida et al., 2016).

Hence, language activates affordances associated more permanently to the object. But are affordances always activated? In a recent study, participants read sentences followed by images of 3D everyday objects (e.g., bottle), located either close or far away from them. When participants read action verbs (grasp, use) instead of observation verbs (observe, fixate), they responded faster when the object was close than far. The effect was stronger for verbs related to object use than to object manipulation. Hence reading an action verb, but not an observation one, enhances sensitivity to object affordances (Costantini et al., 2011).

We may also act with the eyes. Eye-tracking evidence showed that, when participants were told situations occurring on different floors of a skyscraper, their eyes followed the locations described (Spivey, 2001). When they listened to stories with the past progressive (e.g., “was walking”), fixations were shorter, and their eye movements reflected the more dynamic nature of the event compared to stories with simple past (e.g., “walked”) (Huette et al., 2014).

Action grounding clearly influences also word production, not only comprehension. In five experiments (Borghi & Barsalou, 2019), participants were presented with scenarios describing the experience of objects/entities from different spatial perspectives: towards vs. away, near vs. far, beside vs. above, inside vs. outside, and vision vs. audition vs. touch. For example, they had to imagine being on top of a skyscraper vs. standing on a sidewalk next to a skyscraper, had to decide whether a given object/entity could be imagined from that location, and had to produce the properties of some objects/entities (e.g., “tree”). They adopted situational perspectives, flexibly adapting the properties to the context: for example, “roots” was mentioned more often when adopting the beside than the above perspective. At the same time, we found evidence of entrenched perspectives. When required to imagine an object or

entity from far away, from above, and from behind, participants produced its properties as if they were near it, close to it, and in front of it. Hence, they reverted to the perspective more relevant for situated action: we generally interact with objects close to us and in front of us. The results confirm that concepts are flexible but also grounded in typical actions.

We will now see that words not only are grounded in action, but they also influence action.

In a study with immersive virtual reality, we investigated whether labels influence action (Foester, Borghi & Goslin, 2020). We created 3D objects associated with novel names and functions. Possessing labels rendered participants faster and more accurate in using objects, not in manipulating them. Electrophysiological measures (EEG) confirmed the behavioral data. Hence, words influence especially the functional use of objects, likely because they help us to memorize bodily states associated with use.

Words can also modify our bodily space perception. Scorolli et al. (2016) asked children to estimate object's distance, either explicitly or using a toy car. Implicit estimates differed after training participants either with a physical tool (a rake) or a word that allowed them to reach far objects. Real tools and words had, therefore, a similar function in extending the borders of the near space.

To summarize: during language comprehension, action verbs elicit actions, and words referring to objects evoke affordances. Affordances activated through language are mostly stable and related to object function more than object manipulation (Borghi, 2018). Finally, words also impact action, facilitating the use of objects, and modifying bodily space perception.

## 2.The role of movement and action for abstract concepts/words

So far we have spoken of words referring to concrete objects, like "bottle", and of action verbs. But are also abstract concepts/words, like "truth", grounded in the sensorimotor system? The distinction is not clear-cut, since all concepts might include both concrete and abstract components. Acquiring abstract concepts is complex but fundamental: according to some estimates, more than 53% of the words adults use are abstract; they are more than 70% according to

another database (Lupyan & Winter, 2018). And yet, actively moving the mouth is crucial for the acquisition and consolidation in memory of these concepts: using a device that impairs movement, like the pacifier, influences their acquisition. When required to categorize abstract concepts, but not concrete and emotional ones, 8-year-olds who had used the pacifier longer had slower response times (Barca et al., 2020).

Once abstract concepts have been acquired, we hypothesize that an important role is played by different, and not necessarily conflicting, mechanisms underlying their processing. The first is the re-enactment of the acquisition experience, which occurs mainly through linguistic input.

The second is inner speech, a notion introduced by Vygotsky (1986/1934) and now at the center of the debate in various disciplines (Alderson-Day & Fernyhough, 2019; Langland-Hassan & Vicente, 2018). We consider it as a form of real speech, involving the mouth motor system as overt speech does (Borghi, under review). We propose that processing and using abstract concepts is accompanied by a higher feeling of uncertainty compared to concrete concepts. This higher uncertainty leads to a more prolongued inner search, plausibly occurring through inner speech. Consistently, we found slower responses with abstract words, but not with concrete ones, when participants had to concurrently repeat aloud a syllable (articulatory suppression), a process known to disrupt inner speech (Zannino et al., under review).

The third mechanism is the so-called “social metacognition” (Borghi et al., 2018; Fini & Borghi, 2019), i.e., the tendency to rely on the knowledge of others based on the scarce confidence we have in our own knowledge; we hypothesize that we prepare ourselves to ask information to others. Recent evidence shows that when we have to guess abstract or concrete concepts and receive suggestions from different people (Fini, Era, Darold, Candidi, Borghi, 2020), in a subsequent joint action task, we tend to be more synchronous with the person who can give us suggestions on abstract concepts, because we need more his/her help. Thus, the use of abstract concepts, through social metacognition, might enhance prosocial behaviors (Borghi & Tummolini, 2020).

To summarize: movement and action influence abstract concepts acquisition and use; for them, the mouth motor system is particularly relevant.

## 3.The role of hand movement to learn to read and write

Cellular phones, Ipads, and computers are increasingly popular among children. In many countries, digital devices have replaced handwriting at school, the rationale being that typing requires less fine motor control, and it might facilitate learning. And yet, clear evidence demonstrates that handwriting is the most efficacious strategy to learn to write. Handwriting involves translating a memory trace into a sign. It is a sequential activity that requires continuous visuomotor integration, it implies memorizing the shape of each letter, and it involves the sensation of a device (pen, pencil) pressing against a surface, typically paper. In contrast, typing is a bimanual, repetitive activity that requires a schematic representation of how the keys are arranged on the keyboard.

Kiefer et al. (2015) taught 4-6 year-olds eight letters and found that handwriting overcame typing in word writing and, in tendency, in word reading. FMRI studies on 5-year-olds showed that the brain "reading circuit" was engaged after handwriting, but not after typing or letter tracing sessions (James, 2017). Through functional connectivity analysis, Vinci-Booher et al. (2016) found that the left fusiform gyrus, i.e., the visual region engaged during letter perception, becomes functionally connected to motor regions only as a result of handwriting experience and not of typing.

Two processes concur to explain the advantage of handwriting over typing and writing observation: the produced letters are diverse, and the action is self-generated. Unlike when typing, while handwriting, we produce different instances of the same stimulus that have to be categorized, hence improving our cognitive activity. The fact that the action is self-initiated is also crucial to account for handwriting advantages. Kersey and James (2013) found in 7-year-olds that the sensorimotor network associated with letter perception was activated during active writing, not during passive observation. In line with embodied cognition, motor execution plays a crucial role in establishing novel networks for new letters.

## Conclusion

Movement and action are crucial for the acquisition and use of concepts/words, and for the abilities of reading and writing. The hands are engaged while processing manipulable words and manual action sentences, and their use facilitates the learning of writing and reading. The eyes are activated during narratives comprehension. The mouth is crucial for the acquisition and use of abstract concepts.

This deep interrelationship between movement, action, and cognition should be recognized and exploited by the school system—nothing new under the sun. In 1952, Montessori wrote: “Watching a child makes it obvious that the development of his mind comes through his movement”.

## References


Alderson-Day, B., & Fernyhough, C. (2015). Inner speech: development, cognitive functions, phenomenology, and neurobiology. *Psychological bulletin, 141*(5), 931.

Barca, L., Mazzuca, C., Borghi, A.M. (2020). Overusing the Pacifier during Infancy Sets a Footprint on Abstract Words Processing. *Journal of Child Language.*

Barsalou, L.W. (2008). Grounded cognition. *Annual Review of Psychology, 59,* 617-645.

Borghi, A.M. (under review). A future of words: Language and the challenge of abstract concepts. *Journal of Cognition*.

Borghi, A.M. (2018). Affordances, context and sociality. *Synthese*, 1-31. https://doi.org/10.1007/s11229-018-02044-1

Borghi, A.M., Barca, L., Binkofski, F., Castelfranchi, C., Pezzulo, G., Tummolini, L. (2019).Words as social tools: Language, sociality and inner grounding in abstract concepts. *Physics of Life Reviews 29*,120-153.

Borghi, A.M., & Barsalou, L.W. (2019). Perspective in the Conceptualization of Categories. *Psychological research*, 1-23.

Borghi, A.M., & Riggio, L. (2009). Sentence comprehension and simulation of object temporary, canonical and stable affordances. *Brain Research, 1253*, 117-128.

Borghi, A.M., Tummolini, L. (2020). Touch me if you can: The intangible but grounded nature of abstract concepts. *Behavioral and Brain Sciences*, 43, e123, DOI: https://doi.org/10.1017/S0140525X19003091, commentary to Gilead, Trope & Liberman.

Costantini, M., Ambrosini, E., Scorolli, C., & Borghi, A. M. (2011). When objects are close to me: affordances in the peripersonal space. *Psychonomic bulletin & review, 18*(2), 302-308.

Fini, C., & Borghi, A.M. (2019). Sociality to Reach Objects and to Catch Meaning. *Frontiers in psychology, 10*.

Fini, C., Era, V., Darold, F., Candidi, M., Borghi, A.M. (2020). The role of social dimension during abstract concepts processing: a kinematic study of human-avatar motor interaction. OSF preprint, https://osf.io/wyqdm.

Foerster, F., Borghi, A., Goslin, J. (2020). Labels strengthen motor learning of new tools. *Cortex 129,* doi: 10.1016/j.cortex.2020.04.006.

Fugate, J.M., Macrine, S.L., & Cipriano, C. (2019). The role of embodied cognition for transforming learning. *International Journal of School & Educational Psychology, 7*(4), 274-288.

Glenberg, A.M., & Robertson, D.A. (2000). Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning. *Journal of memory and language, 43*(3), 379-401.

Gomez Paloma F., (2017). *Embodied Cognition. Theories and Applications in Education Sciences.* New York (USA): Nova Science Publisher.

Huette, S., Winter, B., Matlock, T., Ardell, D.H., & Spivey, M. (2014). Eye movements during listening reveal spontaneous grammatical processing. *Frontiers in Psychology, 5*, 410.

James, K.H. (2017). The importance of handwriting experience on the development of the literate brain. *Current Directions in Psychological Science, 26*(6), 502-508.

Kersey, A.J., & James, K.H. (2013). Brain activation patterns resulting from learning letter forms through active self-production and passive observation in young children. *Frontiers in Psychology, 4*, 567.

Kiefer, M., Schuler, S., Mayer, C., Trumpp, N.M., Hille, K., & Sachse, S. (2015). Handwriting or typewriting? The influence of pen-or keyboard-based writing training on reading and writing performance in preschool children. *Advances in cognitive psychology,11*(4), 136.

Langland-Hassan, P., & Vicente, A. (Eds.). (2018). *Inner speech: New voices*. Oxford University Press.

Lupyan, G., & Winter, B. (2018). Language is more abstract than you think, or, why aren't languages more iconic?. *Philosophical Transactions of the Royal Society B: Biological Sciences, 373*(1752), 20170137.

Montessori, M. (1952). *Mente assorbente*. Milano: Garzanti.

Sakreida, K., Effnert, I., Thill, S., Menz, M.M., Jirak, D., Eickhoff, C.R., Borghi, A.M. & Binkofski, F. (2016). Affordance processing in segregated parieto-frontal

dorsal stream sub-pathways. *Neuroscience & Biobehavioral Reviews, 69*, 89-112.

Scorolli, C., Daprati, E., Nico, D., & Borghi, A.M. (2016). Reaching for objects or asking for them: distance estimation in 7-to 15-year-old children. *Journal of motor behavior, 48*(2), 183-191.

Vinci-Booher, S., James, T.W., & James, K.H. (2016). Visual-motor functional connectivity in preschool children emerges after handwriting experience. *Trends in Neuroscience & Education, 5*(3), 107–120.

Vygotsky, L.S. (1986/1934). *Thought and language*.Cambridge: Cambridge University Press.