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Comment

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.

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We want to offer two clarifications pertaining to the WAT proposal: one on the complexity of the relationship between abstract and concrete knowledge domains, the other on the place of number representations in WAT. We hope our contribution will help to stimulate further discussion on both points.

First, Borghi and colleagues [1] correctly note that "abstractness/concreteness … (are) arranged along a continuum (where) … any one concept includes a combination both of concrete and abstract information". Nevertheless, WAT diagnostically contrasts concrete and abstract conceptual domains, with concrete words grounded in interactions with the world and abstract ones in interactions with others (social grounding). This effective dichotomy leaves out other important dimensions associated with our understanding of abstract vs. concrete representations, thus limiting the scope for theoretical generalization. Specifically, the existing literature differentiates abstract from concrete concepts along 3 general dimensions [2,3]:

1. *Grounding:* The relationship between the concept and its physical/material referent. On this account, *Mars* (the planet) is a concrete concept and Love (the feeling) is an abstract one. This is a *phenomenological* dimension of abstractness.
2. *Embodiment:* The relationship between the concept and the associated sensorimotor experience. Note that on this account, *Mars* is an abstract concept as we have little-to-no direct sensorimotor experience associated with it while *Love* is quite concrete as we all have complex but nevertheless quite embodied sensorimotor experiences, reflected in the abundance of similar conceptual metaphors associated with "love" across languages and cultures. This is a *sensorimotor* dimension of abstractness.
3. *Situatedness:* The relationship between the concept and the flexible contexts, in which it features. This, by far, is the most flexible of the three dimensions. For example, *Mars* can have a very concrete sensorimotor representation

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when referring to a Mars chocolate bar, a more abstract object – when referring to the planet, and an even more abstract one – when referring to a deity in Greek mythology. This is a *contextual* dimension of abstractness.

Borghi et al.'s [1] theoretical framework uses the operational definition of abstractness closest to *embodiment*: "Abstractness concerns knowledge domains that are less spatio-temporally bounded and cannot be fully tracked with exteroceptive senses alone" but even then, some of the examples of abstract words used in the paper are quite concrete with regard to their sensorimotor bases (e.g., *wet, eat*). At the same time, it is unclear how this stance accommodates, or differentiates between, the contrasts described as *grounded* or *situated*.

A taxonomic and componential approach to knowledge representation may be useful here. Specifically, some theories [4,5] previously suggested that both abstract and concrete representations encode combinations of the three dimensions by reflecting our experiences in the physical world, our bodily constraints, and the changeable context in which these concepts are used. *Tropic* (or *grounded*) components reflect constraints of the physical world in which the representation is acquired and (re)used (e.g., gravity, stable spatial location of physical objects). *Embodied* components encode the agent's bodily states during the acquisition and activation of conceptual knowledge (e.g., the agent's intrinsic body composition). *Situated* components reflect the specific variable contexts within which representations are formed and used (e.g., left-to-right reading habits, specific type-token relationships). Concepts can be positioned along an abstract-concrete continuum depending on the relative weight of these ingredients.

Similarly continuous and relativist views of *abstractness* are offered elsewhere; i.e., that abstract words are not such, because their meaning is "far from experience" but because of the relative complexity of the attached experiential clusters [2,6,7]. We believe that a hierarchical and componential view of abstractness, similar to the three dimensions described above, may take us closer to a comprehensive understanding of abstractness in knowledge representations, as was illustrated for the example of embodied number knowledge [8].

This proposed componential framing of concepts brings us to our second point. While WATs four core tenets (distinct acquisition and cortical localization, effector specificity and diversity) cover much evidence on abstract knowledge, the authors declared number concepts to be exceptional. Several reasons for this perhaps unnecessary limitation were mentioned in the review. First, WAT "focuses on the mechanisms that underlie the formation and use of ACs" (p. 5) as opposed to their content; this is an important qualification of the meaning of "conceptual grounding" and echoes similar considerations recently advanced for number concepts [8]. Second, confusion seems to exist on how to systematize number knowledge: either with space and time, apparently resulting in high concreteness and low emotion ratings [9], or together with emotions [10]. These divergent approaches reflect distinct research on spatial-numerical associations during concept formation and use (critically reviewed in [11]) or on emotional grounding [12], which is only beginning to accumulate for number representations [13–15]. Third, math-related sentences were associated with hands more than other abstract concepts in a questionnaire [16], which seems to violate the prediction of WAT that abstract concepts are generally related to the mouth; but that study never presented numbers as materials.

It is worth revisiting the alleged exceptional status of number concepts by considering the relationship between numbers and language from a componential view. In fact, language is arguably crucial for all numbers exceeding the small range from one to perhaps four or five items – only these are quickly and correctly appreciated in their quantity through a specialized "subitizing" mechanism. All other numbers are linguistically constructed concepts, otherwise not discretely available to the mind. Even numbers still within the finger counting range remain imprecisely represented until we acquire language-based knowledge about addition and multiplication facts (e.g., [17]). Much of our number use, even in simple arithmetic, is affected by articulation and hence mouth-based, from the inversion problem to the native language bias when calculating (for review, see [18]). Thus, the authors' general disclaimer for "number" as deviating from the tenets of WAT unnecessarily diminishes WAT as a welcome and inspiring proposal on the cognitive status of abstract and concrete concepts.

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References

[1] Borghi AM, Barca L, Binkofski F, Castelfranchi C, Pezzulo G, Tummolini L. Words as social tools: language, sociality, and inner grounding in abstract concepts. Phys Life Rev 2019;29:120–53. https://doi.org/10.1016/j.plrev.2018.12.001 [in this issue].

[2] Buccino G, Colagé I, Silipo F, D'Ambrosio P. The concreteness of abstract language: an ancient issue and a new perspective. Brain Struct Funct 2019. https://doi.org/10.1007/s00429-019-01851-7, in press.

[3] Dove G. Three symbol ungrounding problems: abstract concepts and the future of embodied cognition. Psychon Bull Rev 2016;23(4):1109–21.

[4] Fischer MH. A hierarchical view of grounded, embodied, and situated numerical cognition. Cogn Process 2012;13(1):161–4.

[5] Myachykov A, Scheepers C, Fischer MH, Kessler K. TEST: a tropic, embodied, and situated theory of cognition. Top Cogn Sci 2014;6(3):442–60.

[6] Barsalou LW, Dutriaux L, Scheepers C. Moving beyond the distinction between concrete and abstract concepts. Philos Trans R Soc B 2018;373(1752). https://doi.org/10.1098/rstb.2017.0144.

[7] Löhr G. Embodied cognition and abstract concepts: do concept empiricists leave anything out? Philos Psychol 2019;32(2):161–85.

[8] Fischer MH, Shaki S. Number concepts – abstract and embodied. Philos Trans R Soc B 2018;373(1752):20170125. https://doi.org/10.1098/rstb.2017.0125.

[9] Villani C, Lugli L, Liuzza MT, Borghi AM. Varieties of abstract concepts and their multiple dimensions, submitted for publication.

[10] Desai RH, Reilly M, van Dam W. The multifaceted abstract brain. Philos Trans R Soc B 2018;373(1752). https://doi.org/10.1098/rstb.2017.0122.

[11] Shaki S, Fischer MH. Deconstructing spatial-numerical associations. Cognition 2018;175:109–13.

[12] Vigliocco G, Kousta ST, Della Rosa PA, Vinson DP, Tettamanti M, Devlin JT, et al. The neural representation of abstract words: the role of emotion. Cereb Cortex 2013;24(7):1767–77.

[13] Holmes KJ, Lourenco SF. Common spatial organization of number and emotional expression: a mental magnitude line. Brain Cogn 2011;77:315–23. https://doi.org/10.1016/j.bandc.2011.07.002.

[14] Pitt B, Casasanto D. Spatializing emotion: a mapping of valence or magnitude? In: Grodner D, Mirman D, Papafragou A, Trueswell J, editors. Proceedings of the 38th annual conference of the cognitive science society. Austin, TX: Cognitive Science Society; 2018. p. 1056–61.

[15] Woodin G, Winter B. Placing abstract concepts in space: quantity, time and emotional valence. Front Psychol 2018;9. https://doi.org/10.3389/fpsyg.2018.02169.

[16] Ghio M, Vaghi MMS, Tettamanti M. Fine-grained semantic categorization across the abstract and concrete domains. PLoS ONE 2013;8(6):e67090.

[17] Frank MC, Fedorenko E, Lai P, Saxe R, Gibson E. Verbal interference suppresses exact numerical representations. Cogn Psychol 2012;64:74–92.

[18] Nuerk H-C, Moeller K, Klein E, Willmes K, Fischer MH. Extending the mental number line: a review of multi-digit number processing. Z Psychol/J Psychol 2011;219(1):3–22.