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Cognitive Neuropsychology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/pcgn20

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To cite this article: Bradford Z. Mahon & David Kemmerer (2020) Interactions between language, thought, and perception: Cognitive and neural perspectives, Cognitive Neuropsychology, 37:5-6, 235-240, DOI: 10.1080/02643294.2020.1829578

To link to this article: https://doi.org/10.1080/02643294.2020.1829578

Published online: 10 Nov 2020.

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COGNITIVE NEUROPSYCHOLOGY
2020, VOL. 37, NOS. 5–6, 235–240
https://doi.org/10.1080/02643294.2020.1829578

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Interactions between language, thought, and perception: Cognitive and neural perspectives

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ABSTRACT

The role that language plays in shaping non-linguistic cognitive and perceptual systems has been the subject of much theoretical and experimental attention over the past half-century. Understanding how language interacts with non-linguistic systems can provide insight into broader constraints on cognitive and brain organization. The papers that form this volume investigate various ways in which linguistic structure can interact with and influence how speakers think about and perceive the world, and the related issue of the constraints that in turn shape linguistic representations. These theoretical and empirical contributions support deeper understanding of the interactions between language, thought, and perception, and motivate new approaches for developing directional predictions at both the neural and cognitive levels.

ARTICLE HISTORY
Received 15 September 2020
Revised 23 September 2020
Accepted 24 September 2020

KEYWORDS
Language; perception; Sapir–Whorf; linguistic relativity; semantic; embodied cognition

We start by laying out two guard-rails for this volume: First, there are a range of observations that collectively indicate that sophisticated thought and perception can occur in the absence of language, or at least in the context of "impoverished" language (for review and discussion, see (Kemmerer, 2019)): (i) Pre-linguistic infants have intentions and goals and process complex perceptual events for meaning and remember those events; (ii) nonhuman animals can represent abstractions over perceptual categories in ways that are formally equivalent to humans; and (iii) many perceptual and cognitive abilities can be largely or entirely intact in persons with aphasia due to acquired brain injury. Second, the live and interesting thesis for how language may affect thought and perception is not that language affects speakers' phenomenology, or even that it is *constitutive* of the "core processes" of perception. Rather, the issues concern the conditions under which linguistic distinctions shape how perceptual and conceptual systems package their outputs for subsequent processing, *which* non-linguistic processes are affected by linguistic structure, and how non-linguistic perceptual and cognitive systems shape semantic distinctions that are linguistically coded. Current discussions, as exemplified by the papers in this volume, wrestle with the granular questions of exactly *which* aspects of linguistic structure interact with non-linguistic processes, and the conditions under which such interactions occur.

Linguistic diversity and linguistic universals

In order to demonstrate that perception or thought is affected by linguistic structure, it is necessary to identify and isolate an aspect of linguistic structure that varies in theoretically interesting ways across different perceivers/thinkers, or over time within a speaker. This is an epistemic constraint, and of course not unique to this area of research; there are always asymmetries between certain types of theoretical questions and the types of empirical evidence that bear on those questions. One practical implication is that it can be difficult to provide *positive* evidence from linguistic universals for the thesis that language affects thought or perception. On the

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other hand, if one can identify aspects of language *A* that are different in interesting ways from language *B*, then one can test for traces of that difference on non-linguistic processing in speakers of languages A and B (or over time for a multilingual speaker). In addition, and within a given language, a certain linguistic structure or construction may be used by a speaker in one context but not in another context, providing an opportunity to study the effect of that linguistic structure on nonlinguistic processing. For these reasons, large and productive branches of the literature focus on linguistic *diversity*, and on the context-dependence of how certain linguistic structures are used.

As an example, in languages such as Greek, it is not typical to code the manner of an action, while in English coding manner is typical. In English, one says: The girl *ran* into the house. In Greek, one says (something like): The girl *entered* the house running, where "running" can be dropped. That contrast in linguistic coding of motion events has been leveraged to test whether linguistic processes modulate non-linguistic processing. Skordos and colleagues (Skordos et al., 2019) investigated whether such differences between English and Greek affect participants' memory of previously seen motion events. When English and Greek speakers watched events in silence there were no effects of language on memory. Rather, speakers of English and Greek both remembered paths of motion more accurately than manners of motion. When the experiment was rerun in a way that the perception of the events was accompanied by hearing a path or a manner verb, there was again a lack of an interaction: for both groups of speakers, hearing path verbs reduced memory for manners of motion, but hearing manner verbs did not reduce memory for paths of motion. Such findings indicate that there are strong biases in how events are remembered that can be resilient to linguistic variance in how such information is packaged (for different findings see (Filipović, 2011)). Skordos and colleagues argued their findings suggest that participants are not encoding the events linguistically and are thus not using linguistic vehicles to facilitate subsequent memory – an important conclusion regarding the boundary conditions for when linguistic processes are (and are not) leaned on to support memory of motion events.

In a similar vein, Flecken and van Bergen (Flecken & van Bergen, 2019) studied a linguistic contrast between Dutch and English. In Dutch, posture verbs are used to describe the static locations of objects – for instance, that the bottle stands/lies on the table. In English it is not obligatory to use such posture verbs (i.e., "The bottle is on the table"), but such posture verbs are also acceptable. In this way, the authors identify a linguistic contrast that differs *probabilistically* across languages. The authors used a non-verbal picture-matching task to evaluate whether Dutch speakers are more sensitive to a mismatch between a visual stimulus and the perceptual expectation established by the linguistic expression. The authors found, using behavioural measures and EEG, that a similar pattern emerged for Dutch and English speakers, indicating a lack of evidence for the hypothesis that probabilistic differences in the linguistic encoding of object posture affect the perception of those objects (for related work in the domain of sign language, see Navarrete et al., 2020).

Another approach, taken by Everett (2019), turns the issue of linguistic diversity around and tests whether, for a cognitive ability that is believed to be universal, there is a corresponding linguistic universal. Everett summarizes prior work indicating that the human perceptual system is innately biased to process magnitudes of "1", "2", and "3" through dedicated constrained processes. There is a wealth of evidence – cross-culturally, comparatively, and developmentally – to suggest humans have basic numerical competencies for representing small sets exactly (for review, see for instance, Cantlon, 2018). The question is whether such a cognitive universal, in the domain of numerosity, has resulted in consistent structure across the world's languages in how those numbers are linguistically coded. Everett argues there is only slim evidence for innate constraints on how the world's languages represent the numbers 1, 2, and 3. Franzon and colleagues (2020), in a commentary on Everett (2019), describe a complex interaction between non-linguistic numerical systems, structural properties of communication systems, and number morphology. Franzon and colleagues argue that accounts based only on cultural or experiential factors have difficulty accounting for linguistic coding of 1, 2 and 3 across languages. While not denying innate constraints on non-linguistic numerical processing, Everett (2020) responds by

arguing that the linguistic data can be sufficiently explained without appeal such constraints.

In thinking about the effect of a linguistic distinction on non-linguistic processes, a key issue is how different languages "package" semantic space with words. *That* lexicalization status can affect nonlinguistic processing is well established; the big question is *why* the lexicalization status of a perceptual dimension should matter for non-linguistic processes. For instance, Greek has distinct colour terms for "dark blue" and "light blue" while English does not have such terms. Perceptual categorization tasks (pick the odd colour patch of the group) are performed differently by speakers of the two languages when the stimuli cross a boundary that is lexicalized in one language and not another (Kay & Kempton, 1984; Roberson et al., 2008; Winawer et al., 2007), and such effects can be more pronounced in the right visual field, suggesting verbal mediation (Drivonikou et al., 2007; Gilbert et al., 2006; Witzel & Gegenfurtner, 2011; but see Brederoo et al., 2019; Witzel & Gegenfurtner, 2011). Note that it is not that English speakers *cannot* communicate the distinction between light and dark blue in language (we just did). Rather, lexical contrasts may modulate perceptual systems by influencing how those perceptual systems package their outputs in support of downstream communicative needs (see, for instance, Thierry, 2016)). In such a framework, the presence of certain lexical boundaries over a perceptual continua may serve to bias processing (e.g., attention) to specific regions of a perceptual continuum (Reines & Prinz, 2009). Language is, to use the terminology of Dove (2019), a type of neuro-enhancement that provides a scaffold that helps to support and structure the non-linguistic systems with which it interacts (Hermer & Spelke, 1994; Lupyan & Bergen, 2016). The implication is that the "posture" of the system when categorizing the perceptual input is oriented toward distinctions demanded of how that perceptual categorization will be *used*; if the "use" of the perceptual categorization is realized through a particular linguistic structure or construction, then the perceptual system can be thought of as being organized in a manner that "anticipates" those linguistic distinctions.

Zaslavsky and colleagues (2019) herein consider similar issues, but through the lens of a causal arrow that points from non-linguistic perceptual and cognitive systems *toward* language. Those authors are interested in the constraints that shape semantic categories used in language, and use colour naming as the reference domain. Specifically, Zaslavsky and colleagues focus on the interaction of perception and communicative need in colour naming, and the factors that characterize and constrain communicative need within an information-theoretic framework (see also, Zaslavsky et al., 2018).

Malt (2019) argues for a principled distinction between conceptual and semantic representations. Specifically, Malt explores arguments as to why words and their meanings should be treated as distinct from general purpose, non-linguistic conceptual knowledge. The goal is thus to understand specifically *which* meaning representations are affected by interactions with language. Malt argues for a robust notion of semantic representations that, roughly, cuts at least as fine as the lexicon, in contrast to conceptual representations that do not necessarily represent lexically salient distinctions in meaning. If there is a level of lexical semantic representation that is at the granularity of lexical items, then one issue becomes how that parse of semantic information via the lexicalization patterns of a language may affect conceptual representations and/or perception.

A cognitive neuropsychological approach can provide leverage on these issues by supporting causal inferences about the relations among language, thought and perception (Paluy et al., 2011). Patients who have lost certain linguistic abilities due to acquired brain injury can be evaluated for whether they can nonetheless carry out certain cognitive or perceptual processes that are hypothesized to depend on those linguistic representations. In the measure to which the non-linguistic processes remain intact despite deficits for the relevant linguistic distinctions, such studies can offer causal evidence that the non-linguistic processes in question do not necessarily depend on the linguistic processes. Siuda-Krzywicka, Witzel, Taga, et al. (2019) took a neuropsychological approach in the domain of colour through detailed testing of a patient with a dissociation between linguistic and perceptual abilities (see also Siuda-Krzywicka, Witzel, Chabani, et al., 2019). Patient RDS, who had experienced a left occipito-temporal stroke, has intact colour perception, object naming and verbal knowledge of object

colour. For instance, he is able to accurately indicate the colour of a lemon. However, RDS is impaired at matching colour names to coloured objects, as well as matching colour patches to grey-scale objects. While the implications of this case study do not directly constrain theories of the effects of language-specific knowledge on perception, the pattern suggests a model in which representations of objects and their typical colours are holistically represented.

Broader considerations for a theory of meaning

There are interesting and potentially instructive parallels between current discussions of the relation of thought and language, and current discussions of the relation of concept representation and the sensorimotor systems. The "embodied cognition" hypothesis refers to the idea that cognitive representations can be boot-strapped from sensorimotor representations and processes, such that concept representation is "re-representation" (i.e., reactivation) of sensorimotor content. Common to strong forms of the embodied thesis and the Whorfian view is a claim about how the intrinsic structure of one system (language on the Whorfian view, sensorimotor systems on the embodied view) drives representation and organization of a different system. But, and also in parallel between the Whorfian and embodied views, the field has largely moved beyond the first generation of (what are now viewed as) overly strong formulations of those views. The new-generation of "Whorfian" views emphasize that language *interacts* with perceptual and conceptual systems. Similarly, new formulations of embodied views emphasize that concepts are abstract symbolic abstractions, *and* they are connected to and heavily interactive with sensorimotor systems (e.g., Barsalou, 2016; Binder, 2016; Mahon, 2015; Mahon & Caramazza, 2008; Pulvermuller, 2013). The questions thus shift to understanding the conditions under which sensory/motor/affective systems (for embodied views) or linguistic structure (for "Whorfian" views) affect conceptual processing.

Speed and Majid's (2019) contribution explores just this intersection between the neo-Whorfian and neo-embodied theories, specifically with respect to the representational basis of touch, taste and smell. Based on a review of the literature, the authors argue that the evidence in support of sensorimotor simulation in the domains of taste, touch and smell is weak, and that comprehension of language related to touch, taste, and smell relies on simulation of emotion. The proposal that conceptual knowledge of touch, taste, and smell depends on emotion systems motivates careful consideration of whether the types of distinctions that are made on the basis of touch, taste and smell could have a basis in emotion (for broader discussion of interactions between emotion and cognitive systems, see Barrett, 2017).

In a related line, Athanasopoulos and Casaponsa (2020) review a series of verbal interference studies that demonstrate context sensitivity of the effects of language on non-linguistic processes. The logic of such studies is to engage subjects in a perceptual task, and to prevent linguistic processes from influencing task performance by simultaneously engaging subjects in a verbal shadowing or rehearsal task. Using this approach, Athanasopoulos and colleagues (2015) studied German-English bilinguals who were engaged in a verbal interference task that required them to repeat strings of numbers in German or English. At the same time, the bilingual subjects were engaged in a primary task of categorizing the similarity of motion events, where one choice in the categorization task would match similarity that follows German grammatical constraints, while the other choice would align with similarity from English grammatical constraints. When the subjects performed the verbal interference task in German, there was an influence of the properties of English on similarity judgments; and when subjects had to repeat numbers in English, there was an influence of German on similarity judgments. In other words, there was an effect on the task of the language that subjects spoke, but only if that language was not engaged in a verbal shadowing task. As Athanasopoulos and Casaponsa discuss, what this shows is that when the primary task *can* be recoded linguistically, then there is an effect of language.

Looking forward

Some language computations are likely to be proprietary to language and not affect systems outside of language. Other computations within "language" may be more or less promiscuous in how they interact

with, place developmental pressures on, and ultimately shape, non-linguistic processes.

Currently viable Whorfian (and embodied) theories emphasize that language (or sensorimotor systems) are not the representational *basis* of perception (or cognition). For the Whorfian view, perception can (but doesn't always) offload its contents for linguistic encoding. Similarly, conceptual processing can (but doesn't always) lean on sensorimotor simulations in an adjutant manner to flesh out meaning representation. The operative word here is "can" – which is to say that the relation of language and thought, and sensorimotor systems and thought, is task and context dependent. The original formulations of the Whorfian and embodied views, or at least their popular caricatures, clearly went too far and are demonstrably wrong; at the same time, those theoretical proposals have highlighted pervasive phenomena in which representationally separable systems in the brain are heavily interactive. This has usefully pushed the field to consider the implications of heavily interactive architectures.

What we need as a field is much easier said than done: theoretical frameworks with computationally explicit proposals about the dynamics of information exchange among representationally separable systems. That would support a new granularity of experimental predictions that specify the direction and time-course of those interactions (Lupyan & Clark, 2015; Regier & Xu, 2017). The collection of papers that make up this volume is an excellent start, and serves to frame the exciting scientific adventures that lie ahead in research on the relations among language, thought, meaning representation, and perception.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by NIH [grant numbers R01NS089069, R01EY028535].

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