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Are language-cognition interactions bigger than a breadbox? Integrative modeling and design space thinking temper simplistic questions about causally dense phenomena

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In response to: **Beyond playing 20 questions with nature: Integrative experiment design in the social and behavioral sciences**

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Debra Titone , Esteban Hernández-Rivera , Antonio Iniesta , Anne L. Beatty-Martínez  and Jason W. Gullifer 

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Abstract

We affirm the utility of integrative modeling, according to which it is advantageous to move beyond “one-at-a-time binary paradigms” through studies that position themselves within realistic multidimensional design spaces. We extend the

integrative modeling approach to a target domain with which we are familiar, the consequences of bilingualism on mind and brain, often referred to as the “bilingual advantage.” In doing so, we highlight work from our group consistent with integrative modeling.

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The history of science abounds with self-reflections about whether its questions, methods, and theories are sufficiently rigorous to clarify complex unknowns. Metascientific accounts pervade our own fields of language and cognition, which coincidentally coalesced when “20 Questions” was a popular television show (Van Deventer, 1952). After Newell's (1973) prescient warnings about playing 20 questions with Nature, current views about language–cognition interactions vary along many metascientific dimensions. We are thus grateful to Almaatouq et al. for reanimating Newell's proposal in their paper, which names, operationally defines, and advocates for an *integrative modeling approach*.

Cognitive scientists have long debated how language and cognition interact. These debates take many forms, including the consequences of bilingualism on mind and brain, often referred to as the “bilingual advantage” (see Titone, Gullifer, Subramaniapillai, Rajah, & Baum, 2017, for historic overview). The initial rationale of this hypothesis is that people who speak multiple languages have heightened daily experience suppressing/inhibiting knowledge of one language when speaking another (e.g., Bialystok, Craik, Klein, & Viswanathan, 2004). Because researchers presumed that suppression/inhibition is part of a domain-general cognitive control capacity, the bilingual advantages position hypothesized that this daily practice would preferentially strengthen cognitive control for bilinguals compared to monolinguals, causing them to perform better on cognitive control tasks.

When the bilingual advantage hypothesis emerged (Bialystok et al., 2004; see also Peal & Lambert, 1962), it was refreshing in its celebration of bilinguals' cognitive capacities compared to biased and culturally damaging notions of bilingualism as a liability (e.g., Goodenough, 1926; Saer, 1923). Nevertheless, it was much too simple in a “20-questions,” yes–no binary way. While early findings were

supportive, it did not take long for mixed findings to emerge. Relevant to our commentary are researchers' attributions for the sources of these mixed findings, which we class in two nonmutually exclusive ways – a “replication crisis” account, and – building upon Almaatouq et al. – an “integrative modeling/design space” account.

A “replication crisis” account presumes that replicable findings are true, and nonreplicable findings are false. However, jumping to conclusions prematurely risks perpetuating a 20-questions mindset by presuming that all studies are interchangeable (i.e., commensurate), when they may differ in a myriad of incommensurate ways (e.g., Are bilingual and monolingual groups comparably designated? Are all bilinguals the same in terms of language and cognitive experiences? Are all geographies equally supportive of bilingualism? Are all cognitive tasks equivalent? Does suppression/inhibition mean the same thing across all cognitive tasks?). Further, a potentially erroneous corollary of a reflexive replication crisis view is that there is one general cognitive reality applicable to all bilingual people, and that any experiment is an equipotent reflection of that reality.

In contrast, an “integrative modeling/design space” account takes mixed findings at face value and actively accounts for systematic differences across study details that could have elicited them. Indeed, much of our field has moved into this post-20-questions phase of inquiry (e.g., Navarro-Torres, Beatty-Martínez, Kroll, & Green, 2021), and now investigates the links between individual differences among bilinguals and a variety of performance outcomes (e.g., Wagner, Bekas, & Bialystok, 2023). As one example, our group developed new tools and methods for capturing nuanced differences among bilinguals (language entropy, social network analysis), including analytic approaches (e.g., machine-learning approaches such as leave one out cross-validation) that distinguish explanation and prediction, referred to in the target article (Gullifer, Pivneva, Whitford, Sheikh, & Titone, 2023; Gullifer & Titone, 2021; see also Hofman et al., 2021).

As another example compatible with the target article's research cartography idea, our group posited the *systems framework of bilingualism* (Titone & Tiv, 2023; Tiv, Gullifer, Feng, & Titone, 2020; Tiv et al., 2022; see also Beatty-Martínez & Titone, 2021), which sketches a design space for language–cognition interactions. This framework builds upon socioecological accounts of human behavior (e.g., Atkinson et al., 2016; Bronfenbrenner, 1977; de Bot, Lowie, & Verspoor, 2007), and

our prior efforts to encourage researchers to abandon simple bilingual/monolingual group comparisons for tasks that may not tap into the same cognitive constructs (e.g., Baum & Titone, 2014; Beatty-Martínez & Titone, 2021, 2024; Gullifer & Titone, 2021; Titone & Baum, 2014; Tiv et al., 2020). Accordingly, people's individual language and cognitive behaviors are embedded within a multilevel set of nested social influences (i.e., daily interactions, local neighborhoods, laws regulating language use). Thus, to fully describe language-cognition interactions among bilinguals (or anyone), one must attend to these influences, and how participants across studies systematically vary in these ways. This means that any one study is but a single point within a much larger space, that mixed findings may be meaningful, and that conclusions about bilingualism may be less general or unitary than one might originally believe. Such an approach respects the complexity of the phenomena such that, regardless of where the data ultimately lead, our conclusions will be more rigorously and honestly earned.

In closing, we agree with Almaatouq et al. that it is advantageous to move beyond “one-at-a-time binary paradigms” through studies that position themselves within realistic multidimensional design spaces (i.e., a preplanned meta-analytic approach). We are ever mindful that our work on language and cognition is conducted within a unique multilingual city where language use is legally regulated and often interpersonally, culturally, and politically charged. Consequently, what is possible for us to capture empirically about language-cognition interactions will be necessarily impacted by our unique positionality. Importantly, we are not alone, as every research group has its own unique positionality that must be considered. Thus, let us profit from the wisdom and humility implicit in the Almaatouq et al.'s target article and Newell's (1973) original proposal, by recognizing that it may not be possible for any one experiment or research group to speak definitively to an entire design space of causally dense, socially situated behavioral phenomena.









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Competing interest

None.

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