Is rich behavior the solution or just a (relevant) piece of the puzzle?: Comment on "Beyond simple laboratory studies: Developing sophisticated models to study rich behavior" by Maselli, Gordon, Eluchans, Lancia, Thiery, Moretti, Cisek, and Pezzulo

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The move towards the study of rich behavior is unquestionably relevant for behavioral and brain sciences, especially if seen as a potential solution to the ongoing challenges of reproducibility and replication in scientific studies [1,2]. Indeed, besides methodological or technical aspects [3], discrepancies in research findings often arise from overlooking the complexity of behavioral/cognitive processes. For this reason, we praise the Maselli and colleagues effort [4]; by delving into rich behavior, we can intercept potential 'intervening variables' that mediate the multi-layered relationship between the experimental manipulation and the observed effects, and thus have a clearer comprehension of complex phenomena. However, as argued by Munafò and Smith [5], and largely in line with the Maselli et al.'s main message, the focus on rich behavior cannot be the panacea. To discuss the potential limitations of this method, we use a camera analogy: we will 'zoom out' and 'zoom in' to get different perspectives.

From a 'zoom out' perspective, a first point concerns the study of rich behavior in *controlled lab settings*. While investigating rich behavior can be beneficial for improving the internal validity of an *in-lab* research, it is worth underlining that some of the most impactful discoveries in behavioral and brain sciences come from brilliant insights rather than elaborated settings. In motor control, Fitts' Law [6] was initially identified in simple lab settings and nowadays widely applied in areas like ergonomics [7], or human-computer interaction [8]. Beyond motor control, associative learning provides another example. Initially studied in laboratory, its principles still find application in diverse domains including developmental psychology [9], marketing [10] or clinical rehabilitation [11–13].

A second point concerns the study of rich behavior *in the wild*. Studying behavior in the wild introduces several complexities, such as the puzzle of distinct conceptual uses of 'causality' [14], and the tension between internal and external/ecological validity. In real-world contexts, researchers ideally should be able to reproduce not just the behavior but also the specific situations in which it occurs. However, this is often virtually impossible. Consider the uniquely high-pressure situation when Roberto Baggio missed the penalty kick during the 1994 World Cup final against Brazil. Such moments are so idiosyncratic and shaped by their context, making them difficult to recreate and posing challenges for drawing broader conclusions. Yet just because these instances are hard to replicate, it does not mean that they lack value or are beyond the scope of meaningful studies.

We should thus be cautious about equating richer behavior and full ecological context with a complete representation of 'real' phenomena. It is important to acknowledge the inherent limitations in capturing every subtle nuance, like the myriad emotions, thoughts and potential motor solutions running through Roberto Baggio's mind before his kick. Perhaps, as Haeffel suggests [15], "*we need to get tired of winning"*, because there is value in embracing limitations and understanding that certain aspects might remain out of our grasp.

Taking a closer 'zoom in' look offers further clarity on this matter. Maselli et al., promote the value of studying rich behaviors to address new questions and challenges. They acknowledge that natural settings, like playing soccer, do not offer the level of experimental control that classic lab settings do. They claim that if in the laboratory we have discrete 'trials' and controlled manipulations, in real life defining when an action starts – e.g., when a driver changes lanes during the continuous act of driving - becomes ambiguous (p. 221). Our additional point is: is it truly clear when events *begin* in a lab setting? We believe that it is not, and we provide theoretical, methodological, and technical reasons for this claim.

First, an intriguing philosophical debate tries to address the paradoxical condition of (any) beginning [16,17]. Any 'beginning' reflects the establishment of a threshold, a demarcation between a 'before' and an 'after'. *A priori* any threshold is punctual (it is a point, an instant) but *de facto* it is only conventionally punctual, although this is a reasonable shared convention. The fact that for daily life purposes these thresholds are most often unquestionable, raises the illusion that these kinds of conventions automatically reflect a state-of-reality (in other words, the conventional threshold becomes an ontological threshold). Unfortunately, this illusion is nonsense from a philosophical point of view.

Second, traditional methods often simplify complex processes. Consider multisensory integration (MSI) in a stream-bounce task. It was believed to occur precisely when disks overlap with a simultaneous sound [18]. This supported the effort in testing if MSI could be impaired in certain clinical conditions [19]. However, MSI does not occur (=begins) at a specific instant, and not even in a specific 'window' (cf. The notion of temporal binding window [20]); integration is a multi-layered process. Thus, it cannot be simply impaired, but rather anomalous. A methodological shift in perspective is needed to overcome the notion that there is a rigid instant/window in which MSI occurs (=begins) [21]. We should thus promote – even in *in-lab* settings - a comprehensive tracking of the multisensory integration/segregation dynamics, and more generally of the dynamics of cognitive processes and behaviours.

Third, technical concerns also challenge the common notion of beginning. For example, when does the BOLD response captured by fMRI really begin? When does the ERP signal of a particular event begin? Any researcher in brain sciences knows that the answers depend on numerous statistical, algorithmic, and operational assumptions. In summary, theoretical, methodological, and technical factors underscore the inherent complexity of defining 'beginnings'. And interestingly, also 'endings' come with their own set of challenges [e.g., 22].

In conclusion, we commend Maselli et al. for proposing the study of rich behavior, which undoubtedly holds promise in addressing the replication crisis. Still, challenges remain. Science, as Guttinger and Love [23] emphasized, is "epistemically risky" and inherently fraught with uncertainty. While perfection in experimental design may be elusive, this does not lower the significance of scientific work. From an ethical point of view, for example, we cannot ask healthy non-smokers to smoke just to prove the causality between smoking and lung cancer. However, this does not undermine the compelling evidence for the harmful effects of smoking [24]. The effort in promoting multiple levels of analysis with triangulation methods is a promising strategy [5,24]. The study of rich behavior represents undeniably a crucial step in this direction.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Declaration of interests

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