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***Is conceptual diversity an advantage for scientific inquiry? A case study  
on the concept of 'gesture' in comparative psychology***

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Running head: The concept of gesture in comparative and developmental psychology

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primate

## 20   **Abstract**

21   Growing scientific fields often involve multidisciplinary investigations in which the same concepts  
22   may have different meanings. Here, we examine the case of ‘gesture’ in comparative research to  
23   depict how conceptual diversity hidden by the label ‘gesture’ can lead to consistently divergent  
24   interpretations in humans and nonhuman primates. We show that definitions of ‘gesture’ drastically  
25   differ regarding the forms of a gesture and the cognitive processes inferred from it, and that these  
26   differences emerge from implicit assumptions which have pervasive consequences on the  
27   interpretations claimed by researchers. We then demonstrate that implicit assumptions about  
28   scientific concepts can be made explicit using a finite set of operational criteria. We argue that  
29   developing theoretical definitions systematically associated with operational conceptual boundaries  
30   would allow to tackle both the challenges of maintaining high internal coherence within studies and  
31   of improving comparability and replicability of scientific results. We thus offer an easy-to-implement  
32   conceptual tool that should help ground valid comparisons between studies and serve scientific  
33   inquiry.

## Introduction

Understanding the evolution and development of human behavior is a relatively recent endeavor at the scale of the history of sciences. Modern psychology, bringing experimental accounts of life-span human cognition, sociality and subjectivity has progressively overtaken philosophy-grounded approaches, in some aspects detrimentally. Indeed, experimental psychology is nowadays traversed by a replication crisis which casts some doubt on the reliability of the scientific methodology and concepts that are under study (Open Science Collaboration, 2015). Additionally, a growing amount of scientific fields do investigate the *same* concepts using different angles, opening the route for multidisciplinary science in which the *same* concepts have multiple acceptions. Although polysemy is a richness of natural languages, it may be detrimental to science as soon as ‘multiple acceptions’ turn to ‘loose meaning’ or even ‘no meaning’ of scientific concepts (Machado & Silva, 2007).

‘Gesture studies’ vividly illustrate these transformations. Although gestures have been described from the antiquity (Kendon, 2004), modern gesture studies have dramatically blossomed over the last two decades (Byrne et al., 2017; Liebal & Call, 2012; Pika & Liebal, 2012; Tomasello & Call, 2018) and are supported by the International Society for Gesture Studies (ISGS) founded through the attendance of up to 200 scholars from 18 countries to its first official conference in 2002. The field has also been supported by the journal *Gesture* since 2001. Since then, the popularity of gesture studies has raised constantly, now joining scholars from disciplines as diverse as anthropology, linguistics, psychology, history, neuroscience, art history, computer science, music, theater or dance (<http://gesturestudies.com/>). Typing ‘gesture’ in Google Scholar raises up to 1.6 billion results and restricting it by the year 2018<sup>1</sup> still gives more than a thousand results. Facing this vivid diversity, it is reasonable to think that one gesture study might not necessarily refer to the same phenomenon as another gesture study, although most of them might be broadly concerned with the use of hands or other body parts for communicative purposes (<http://gesturestudies.com/>). Operational studies of

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<sup>1</sup> Of January 23<sup>rd</sup> 2018!

gesture, through systematic description, experiment, mathematical modelling or machine learning all work out their own definitions of gesture, which are often tailored to their specific objectives and hence question the use of either broad or narrow, unified or diverse definitions of gesture in comparative science (Scott & Pika, 2012).

From the perspective of comparative developmental psychology, gestures are considered foundational in the development of communication and language in human infants (Colonnesi, Stams, Koster, & Noom, 2010; Goldin-Meadow & Alibali, 2013; Iverson & Goldin-Meadow, 2005; Kersken, Gómez, Liszkowski, Soldati, & Hobaiter, 2018). Gestural communication precedes speech and stages the first manifestations of communicative intention (Bates, Camaioni, & Volterra, 1975; Camaioni, 1997; Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Cochet & Vauclair, 2010b; Colonnesi et al., 2010; Crais, Douglas, & Campbell, 2004). In particular, human infants start pointing between 9 and 12 months of age and accompany their pointing gestures with alternated gaze between the targeted object and the recipient, i.e., joint attention (Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004; Carpenter et al., 1998; Liszkowski, Brown, Callaghan, Takada, & Vos, 2012). This triadic engagement is considered a hallmark of referential communication (Cochet & Vauclair, 2010b; Colonnesi et al., 2010; Liszkowski, Carpenter, & Tomasello, 2007; Tomasello, Carpenter, & Liszkowski, 2007) and is rapidly followed by the emergence of the first words (Cochet & Byrne, 2016; Iverson & Goldin-Meadow, 2005). By the age of 14 months, children get through a phase of reorganization of emerging speech with existing gestures leading to bimodal utterances characterizing their first sentences (Goldin-Meadow & Alibali, 2013; Guidetti, Fibigerova, & Colletta, 2014; Iverson & Goldin-Meadow, 2005). Overall, pointing gestures and joint engagements predict language onset and vocabulary size in later development (Colonnesi et al., 2010; Kita, 2003; Liszkowski et al., 2012), although with differences across cultures (Kita, 2003; Mastin & Vogt, 2016; Salomo & Liszkowski, 2013).

Of great importance for gesture's studies in comparative research is the fact that both children and adult continue to gesture after the emergence of speech, resulting in multimodal language utterances (Aureli et al., 2017; Esteve-Gibert & Guellaï, 2018; Grünloh & Liszkowski, 2015). Gesture studies in verbal individuals have shown that gestures were used to accompany speech (Kendon, 2004; McNeill, 2000), and gave cognitive support in various ways like reducing the speaker's cognitive load (Chu & Kita, 2011), facilitating lexical retrieval and discourse planning (Alibali, Kita, & Young, 2000), or conveying prosodic components like discourse emphasis or disambiguation (Esteve-Gibert & Guellaï, 2018; Guellaï, Langus, & Nespors, 2014; Kendon, 2004). Speech and gestures share similar neurobiological underpinnings and are both under left-hemisphere dominance (Gentilucci & Volta, 2008; Xu, Gannon, Emmorey, Smith, & Braun, 2009). Purely visual utterances like sign language or the initiation of joint attention by looking at the recipient have been shown to activate same brain regions in the addressees as speech does (Courtin et al., 2011; Kampe, Frith, & Frith, 2003). Gestures also facilitate learning in children (Goldin-Meadow, 2009; Goldin-Meadow, Cook, & Mitchell, 2009; Goldin-Meadow & Singer, 2003) and the latter are likely to use gestures to express some conceptual understanding they are not yet able to verbalize (Broaders, Cook, Mitchell, & Goldin-Meadow, 2007; Church & Goldin-Meadow, 1986). Importantly, if gestures are considered as a window into the human mind by developmental psychologists, they are also considered by comparative psychologists as the living fossils of a primitive gestural protolanguage (Fitch, 2010; Hewes, 1973).

Indeed, the importance of gestures to communication and language is not restricted to modern humans. Great apes and monkeys, our closest phylogenetic relatives, also possess complex gestural systems of communication (Byrne et al., 2017; Liebal & Call, 2012; Liebal & Oña, 2018; Tomasello & Call, 2018) which are candidate precursors of modern language (Corballis, 2003; Hewes, 1973; Vauclair, 2004). There is good evidence suggesting that gestures might prefigure speech in the evolution of language. In particular, great apes and monkeys have extended gestural repertoires and make a flexible use of gestures to address attentive recipients (apes: Byrne et al., 2017; Genty,

108 Breuer, Hobaiter, & Byrne, 2009; Hobaiter & Byrne, 2017; Hostetter, Russell, Freeman, & Hopkins,  
 109 2007; monkeys: Bourjade, Meguerditchian, Maille, Gaunet, & Vauclair, 2014; Maille, Engelhart,  
 110 Bourjade, & Blois-Heulin, 2012; Meunier, Prieur, & Vauclair, 2013; Molesti, Meguerditchian, &  
 111 Bourjade, *submitted*), persisting or elaborating their gestural utterances in case of communication  
 112 breakdowns (apes: Cartmill & Byrne, 2007; Leavens, Russell, & Hopkins, 2005; Roberts, Vick, &  
 113 Buchanan-Smith, 2013) and conveying specific and sometimes referential meanings (apes: Cartmill &  
 114 Byrne, 2010; Genty & Zuberbühler, 2014; Graham, Furuichi, & Byrne, 2017; Hobaiter & Byrne, 2014,  
 115 2017; Leavens & Hopkins, 1998; Pika & Mitani, 2006). Following humans, chimpanzees and baboons  
 116 also show left-hemisphere dominance for communicative gestures (Hopkins & Vauclair, 2012).  
 117 Current debates in primate gesture research mostly revolve around the question of gesture meaning  
 118 and ostensive communication (Byrne et al., 2017; Hobaiter & Byrne, 2017; Liebal & Oña, 2018;  
 119 Moore, 2016; Scott-Phillips, 2015; Townsend et al., 2017) and on the role of individual learning and  
 120 social experiences in these achievements (Bard, 2017; Bard, Bakeman, Boysen, & Leavens, 2014;  
 121 Bourjade, Canteloup, Meguerditchian, Vauclair, & Gaunet, 2014; Bourjade, Gaunet, Maugard, &  
 122 Meguerditchian, 2019; Byrne et al., 2017; Lamaury, Cochet, & Bourjade, in press; Liebal, Schneider, &  
 123 Errson-Lembeck, 2018; Tomasello & Call, 2018).  
 124 Thus, both comparative and developmental psychologists study gestures by relying on behavioral  
 125 observations, and they both use operational definitions of gesture, albeit not always consistently.  
 126 Previous work by Scott and Pika (2012) has underscored the diversity of gesture definitions and the  
 127 obstacles it constituted for comparative studies. Notably, they identified four subfields of gesture  
 128 studies concerning; (i) human adults, (ii) human infants, (iii) great apes, and (iv) monkeys. They  
 129 reviewed and compared the definitions of gesture used in these four populations so as to identify  
 130 potential gaps and determine the criteria that could be added to fill them up. They then proposed a  
 131 revised definition comprising four dimensions of gesture use designed to permit the study of  
 132 gestures in any animal species, namely the mechanical, perceptual, purposeful and representational  
 133 dimensions. The resulting definition was a “call for conformity” with the argument that no

comparison could be made without such a common denominator. Yet, inclusive definitions do not seem necessarily consensual and researchers keep on using definitions based on gesture physical forms at variable levels of granularity (Byrne et al., 2017; Cartmill & Byrne, 2011). Moreover, Scott and Pika (2012)'s comparison of gesture definitions was set up at a large scale of the scientific field that might not have allowed them to grasp more subtle differences between gesture definitions. For example, they relied on one definition used in monkeys' studies and one in apes' studies, while this does not represent the whole diversity of gesture definitions in any of this model species. Critically, Byrne and collaborators recently reviewed their own work on great apes' gestural repertoire and revised their previous classifications using novel heuristics based on both the physical features of gesture and the signalers' intended meaning (Byrne et al., 2017; Hobaiter & Byrne, 2017).

Here, we examine some possible causes of the conceptual diversity in gesture definitions and use a slightly different approach to that of promoting the unification of the concept of gesture. We grant a special importance to the payoff of using a particular definition of gesture for a given study. We postulate that researchers who set up and use gesture definitions face both epistemic and methodological obstacles that could influence their choices and that a close examination of these obstacles is a necessary primary step before deciding about unification or multiplication, homogeneity or heterogeneity in defining 'gesture'. Our aims were (i) to clearly establish that gesture definitions differed on several aspects –including the form of the gesture (action pattern) and the cognitive processes inferred from it, (ii) to show that these differences mostly relied on implicit assumptions, which have pervasive consequences on the results claimed by researchers, and (iii) to demonstrate that implicit assumptions can be made explicit by using finite sets of operational criteria to bound theoretical definitions. Our ultimate goal was to bring a new conceptual tool, easy to implement in empirical studies and that will help ground valid comparisons between study populations.



In section I, we grounded our investigation on four empirical gesture studies in the field of language development and evolution to explore the conceptual diversity in gesture definitions as well as some of its possible sources. These studies involved three different species covering three of the four distinct populations identified by Scott and Pika (i.e., monkeys, apes, human infants; 2012). Relatedly, each subfield of gesture study possesses its specific research questions that are often not equaled or even hinted at when comparisons are made between studies. Section II examines this issue by comparing the study of the *functions* of deictic gestures in human infants and nonhuman primates. After reviewing the literature on gesture functions in these two domains of research, we will show that the conceptual analysis of gesture functions reveals an implicit hierarchy across species (see Cochet & Byrne, 2016) and across gesture categories. We suggest that differential values are implicitly attributed by researchers with the more or less conscious objective to champion the abilities of a species over another –highlighting for example the flexibility and diversity of the human communicative repertoire compared to other primates– or on the contrary to obscure important differences across species (Leavens, 2018). In section III, we will offer an alternative way of considering conceptual diversity, emphasizing the advantages of setting boundaries to theoretical definitions using finite sets of operational criteria. We will discuss the advantages and limitations of maintaining conceptual diversity in gestural studies in the field of comparative research and we will argue that conceptual diversity is no longer a matter of concern when concepts can be distinguished or merged on the basis of descriptive criteria.

## **Section I: Conceptual diversity in the definitions of ‘gesture’**

Our first aim was to examine two possible sources of conceptual diversity in gesture definition; (i) the necessity of using a specific definition in regards to the study aims and (ii) the presence of hidden assumptions conveyed by ‘companion’ concepts used in the definition (e.g., communication). To achieve these ends, we gathered four empirical studies (co-authored by at least one of the authors of

this article) in the field of comparative developmental psychology that were concerned with language development and/or evolution. We first examined resemblances and differences between gesture definitions, identifying common ground, idiosyncrasies and hidden assumptions. Then, we made covert assumptions overt by specifying related concepts invoked in each of the four definitions. Finally, we explored the consequences of using the broadest and the narrowest definitions in all four studies, while providing evidence of internal coherence from selecting a specific definition of gesture in regards to the aims of each study.

### *Material and methods*

Our material was composed of four empirical works on gestures used for communicative purposes by olive baboons, *Papio anubis*, (Studies 1 and 2), chimpanzees, *Pan troglodytes*, (Study 3) and human infants, *Homo sapiens*, (series of studies – hereafter Study 4). Studies 1 and 3 were observational and study 2 was experimental. Study 4 refers to a dissertation thesis that comprised four empirical studies on toddlers observed at home or in day-care centers: one was observational, the three others were experimental; they all rely on the same definition of gesture (Table 1).

**Study 1.** This study authored by Molesti and collaborators (unpublished data) aimed at establishing the first naturalistic repertoire of gestural communication in a non-ape primate species, the olive baboon. The study provided detailed and quantitative descriptions of 67 communicative gestures defined as any ‘movement of the body or part of the body directed to a specific partner or audience’. The objectives were then to study the intentional and flexible use of these gestures by olive baboons. The study relied on a sample size of 47 captive individuals living in social groups and was observational.

**Study 2.** This study authored by Bourjade and collaborators (2014) addressed whether baboons were able to adjust their gestural communication to the recipient’s visual attention using a food-requesting experimental set-up. The study involved 16 adult baboons trained to produce an

extended arm gesture to request food from a human experimenter. Following Scott and Pika (2012), communicative gesture was defined as any ‘nonvocal bodily action directed to a recipient that is mechanically ineffective and represents a meaning, beyond itself, that is in part manifested by others of the social group’. The ultimate aim of this study was to examine if baboons’ gestural communication met the criteria of intentional gestural communication, namely (i) the adjustment to the receiver’s attention, (ii) the visual monitoring of the interaction and (iii) its goal-directness evidenced by persistence and elaboration in case of communicative breakdowns (Leavens, 2004).

**Study 3.** This on-going study by Cochet and Byrne aimed at describing some features of gestures that are shared between humans and chimpanzees. The study relied on the observation of 23 wild chimpanzees whose gestures were systematically described in terms of form, context, and recipient’s response. Gestures were regarded as communicative, intentional and mostly manual. The aim was to determine the extent to which humans and chimpanzees actually shared gesture properties, in terms of flexible, intentional and referential use.

**Study 4.** This series of empirical studies on toddler gestural communication is constitutive of Cochet’s thesis dissertation (2011). The different studies describe the production of intentional communicative gestures (i.e., form, function, laterality, associated gaze patterns) in the course of children’s development. Intentional communicative gesture was defined as any ‘manual gesture used flexibly and deliberately rather than being triggered by specific environmental conditions, through which a specific message is conveyed from a signaler to one or several receivers’. The participants were respectively 26, 8, 25, 48 toddlers who were observed gesturing spontaneously (Cochet & Vauclair, 2010a) or in interaction with the experimenter (Cochet, 2012; Cochet, Jover, & Vauclair, 2011; Cochet & Vauclair, 2010b). The ultimate aims of the study were then to relate gesture use with the development of other sociocognitive abilities like joint attention, imitation or language acquisition.

233 < Insert Table 1>

234

### 235 *Comparing gesture definitions*

236 All the four gesture definitions have in common the fact that gestures were used for communicative  
237 purposes and three of them explicitly mentioned 'communicative' to label the gesture. Thus, all the  
238 four definitions excluded non-communicative gestures like manipulative or technical gestures (but  
239 see below for various acceptions of 'communication'). Moreover, they all possessed an implicit  
240 agreement upon the visual component of gestures even though gestures can have tactile and  
241 auditory components too. According to the four definitions, 'groaning without moving the face or  
242 body' (an auditory signal which has no visual component) would not qualify as a gesture. Conversely,  
243 'hand-clapping' that possesses both visual and auditory components would qualify as a gesture (i.e.,  
244 multimodal gesture or acoustic gestures). Because all gestures have a visual component, it is  
245 common in the primatology literature to use 'tactile gesture' to refer to gestures that have a tactile  
246 component in addition to the visual one and to use 'acoustic gesture' (e.g., Bourjade,  
247 Meguerditchian, et al., 2014), 'auditory gesture' (e.g., Liebal & Oña, 2018) or 'audible gesture' (e.g.,  
248 Byrne et al., 2017) to refer to gestures that have an acoustic component that does not involve the  
249 vocal folds.

250 The four definitions studied here presented several differences. They mostly differed on the  
251 implication of body parts to support gestural communication, and on the intentional nature of  
252 gesture use. As regards the body parts, studies 1 and 2 had the broadest definitions that considered  
253 any part of the body including the face as possible gestural communicative means, while studies 3  
254 and 4 restricted their definition of gestures to the moves made with the hands, that is 'hand  
255 gestures' or 'manual gestures'. Studies 3 and 4 also considered communicative gestures as  
256 intentional, with intentional use being a necessary component of gesture (study 3) or a specific  
257 category of gesture (i.e., intentional gesture, study 4), while studies 1 and 2 did not use the criterion

of intentional use to define communicative gesture. Thus, according to definitions 1, 2, and 4, subcategories of communicative gestures that are not intentional do exist whereas definition 3 precludes gestures from being non-intentional signals. For example, the case of smiling would be considered a communicative gesture according to studies 1 and 2 but not to studies 3 and 4 (face gesture). Also, a manual gesture that would be triggered by internal state rather than flexibly produced, would still be considered a communicative gesture according to studies 1 and 2, and would qualify as a non-intentional gesture following definition 4, but as a non-gesture following definition 3 (and therefore not further considered in studies 3 and 4).

Finally, we found several idiosyncrasies across our four gesture definitions. Following Smith (1977)'s definition of communicative signals, study 2 was the only one to mention the criterion of mechanical ineffectiveness although this criterion is widely shared in primate gesture studies (Hobaiter & Byrne, 2017; Liebal & Call, 2012; Liebal & Oña, 2018; Scott & Pika, 2012). As previously discussed by Scott and Pika (2012), Liebal and Call (2012), or Tomasello and Call (2018) amongst others, it allows researchers to exclude occurrences in which individuals try to achieve the intended action or result on their own. Instead, communication occurs when the recipient's response fulfils this function. In this respect, a slap in the recipient's face would not be considered a communicative gesture as it attains its goal without leaving room to the recipient's role. That is, it is a mechanically effective social interaction that recipients cannot ignore. The foundations and limits of this criterion are discussed below. Note however, that a slap threat would be considered a communicative gesture according to study 2 as well as the three others. More generally, retaining this criterion to define gesture leads to exclude most of gestures that have a tactile component sufficient to produce the intended effects (but see Perlman, Tanner and King (2012) for a detailed study of 'push' gestures in gorilla). Related to this criterion of mechanical ineffectiveness, study 2 offered the criterion of gesture meaning, taken in its broad sense. Meaning emerges from the recipients' responses to a gesture (Scott & Pika, 2012) leading to a form of holistic meaning. According to this criterion, visual behaviors that would consistently yield no response would not qualify as gestures. As opposed to

that holistic meaning, propositional meaning arises when signals act as words whose precise meaning can be combined to form a higher-order meaning (Fitch, 2010), which might occur when one seriously considers the definition given by study 4. Indeed, study 4 was the only one to mention that gestures were used to convey specific messages from signalers to receivers, although whether the message was specific or holistic was underspecified (see the next section for a detailed discussion on these aspects).

#### *Hidden conceptual diversity about what ‘communication’ means*

Interestingly the three idiosyncratic criteria exposed above (i.e., mechanical ineffectiveness, meaning, conveying a message) all have in common some implicit assumptions about what the researchers meant by ‘communication’. Bourjade (Study 2) defined communicative acts as specifically addressed to an audience and whose effectiveness relies on the recipients’ responses. Consequently, communicative acts are not functionally effective on their own and recipients can respond to or ignore them – the function is then inferred from recipients’ most common responses over repeated observations (see section II). Cochet (Studies 3 & 4) defined communication as referring to the numerous means through which a specific message is conveyed from a signaler to one or several receivers. Consequently, communicative acts such as gestures must support some sort of information transfer and hence have ‘contents’. While discussing the strengths and limitations of these two definitions goes beyond the scope of this article, it is remarkable that they do not underscore the same aspects of communicative exchanges, targeting mainly the form (Bourjade) or the content (Cochet). Focusing on the form enables scholars of animal behavior to delineate communicative acts from more general social interactions, while ascribing signalers and perceivers distinct roles likely to have evolved under different selection pressures (Rendall, Owren, & Ryan, 2009; Scott & Pika, 2012). In contrast, focusing on information transfer is in line with the Shannon-Weaver approach of communication (Shannon & Weaver, 1949), although detecting and quantifying

(relevant) information in animal signaling or in pre-linguistic children's utterances remains highly challenging (see section II for a discussion of this aspect).

< Insert Table 2 >

#### *Origins and maintenance of conceptual diversity*

In this regard, it is worth noting that each researcher's definition of communication was in good coherence with her definition of communicative gestures. Study 2, focusing on baboon gestures, was based on definitions of communication and gestures enabling to extract communicative signals from the flow of interactions without inferring an inaccessible content. This represented an efficient way of achieving the study goals. Likewise, studies 3 and 4 were modelled after children's pointing studies in which the 'content' of communicative exchanges is partly offered by the targeted object and the consistent pattern of reactions between the gesturers and the recipients (but see section II for inaccurate inferences about children's pointing). Thus, the preference for a definition of gesture over another is partly explained by the model species and the scientific goals that were pursued by the researchers.

More generally, we found that the main differences between gesture definitions were partly confounded with model species (baboons versus chimpanzees and humans) and study aims (Table 2). Indeed, studies 1 and 2 aimed at investigating whether baboon gestured intentionally or not while studies 3 and 4 selected the gestures of interest based on intentional use (assumed a priori) to further investigate related properties such as referential use or other sociocognitive skills. Furthermore, there is a complete overlap between the baboon as model species, the possibility for communicative gestures to be non-intentional signals and the use of all body parts as possible means to gesture towards a recipient. Here too, there is good internal coherence in these choices. While

333 hand gestures are cortically controlled under the left-hemisphere dominance (Cochet, 2016; Hopkins  
334 & Vauclair, 2012; Meguerditchian, Vauclair, & Hopkins, 2010), they can be used flexibly and  
335 deliberately by gesturers as proposed in study 4. In contrast, emotional facial expressions that have  
336 long been considered as the external manifestations of individuals' internal states out of volitional  
337 control (but see: Scheider, Waller, Oña, Burrows, & Liebal, 2016; Waller, Caeiro, & Davila-Ross, 2015)  
338 were, in accordance, not considered in studies 3 and 4 that aimed at *studying* properties of  
339 intentional gestures, while they were logically included in studies that aimed at *testing* the  
340 intentional use of gestures (e.g., study 1).

341 Finally, some divergences arose from the intricate links between the researchers' implicit conception  
342 of communication and their model species. As stated above, mechanical ineffectiveness is an  
343 efficient criterion for scholars of animal behavior who tend to analyze communication through its  
344 observable effects on receivers' behavior. Recipients of communicative signals can then respond in  
345 different ways, including not responding/ignoring. However, one can argue that tactile gestures, or  
346 say, any gesture that would possess mechanical efficiency can still be interpreted by the receiver in  
347 different ways, including ways that do not correspond to the gesturer's intent. Actually, it might be  
348 that the recipient cannot ignore the mechanical effects of the gesture, but can ignore the gesturer's  
349 intention. Under this view, excluding tactile gestures from communicative gestures might be  
350 misleading, though it is technically challenging to access the interpretation made by a baboon  
351 receiver. In contrast, psychologists who study verbal humans tend to consider that any social  
352 interaction is communicative because it can –and will- be interpreted by receivers using language  
353 and other cultural tools (symbols, beliefs etc.). Thus, if someone slaps you in the face, you cannot  
354 ignore the mechanical effects of it, but you can interpret the gesture in various ways; and this room  
355 for interpretation might well be the essential component of what we call 'communication' and that  
356 animal behavior scholars seek out in *suggestive* mechanically ineffective signals. Perlman et al. (2012)  
357 gave a convincing illustration of 'suggestive' tactile gestures by describing the 'push' gestures used by



a gorilla mother to orient the movements of her young, whereas mechanical effectiveness in this case would have consisted in effectively stirring the young gorilla from one way to another.

### *Consequences of using broad and narrow gesture definitions*

In sum, our analysis of gesture definitions raised two agreements and six differences (Table 2) that came from either divergent implicit assumptions about scientific concepts (e.g., communication), specificity of the model species (e.g., meaning, message, mechanical ineffectiveness), study goals (e.g., whether intentionality is assumed or necessary or tested) or a combination of these points. Importantly, we showed that preference for a given definition was internally coherent with the study goals, the model species and the conception of communication as well as with the ways to operationalize it. Although this internal coherence appears a good point for each study taken separately, it might actually prevent scholars from comparing their results. However, conforming to a unique definition might convey scientific costs as for instance, using our narrowest definitions (studies 3 and 4) would prevent studying communicative gestures in baboons as long as it is not clearly stated that baboons gesture intentionally. Consequently, unification tends to broaden definitions – using the broadest definition here (study 1) enables to conduct all four studies – while the scientific costs of broad definitions can be the loss of meaning or information (Machado & Silva, 2007). Notwithstanding, it is worth noting that specific definitions provided each study with good internal coherence and this, above all, might represent a relevant obstacle to massive unification.

## **Section II: The functions of gestures and related inferences**

Another class of hidden assumptions pertains to the study of gesture *functions*. Our second aim was thus to examine the different acceptions of gesture *function* in human infant studies and in nonhuman primate studies. In infant studies, gestures seem to be regarded as intentional a priori,

leading to a categorization of functions usually established from inferences about individuals' intentions. By contrast, gestures are not considered as intentional by default in studies involving nonhuman primates and the categorization is generally based on the consequences of gestural production in context. However, the single term "function" has been used in both approaches, thus constituting a heterogeneous category that adds to the complexity of comparing gesture studies. Crucially, these distinct definitions of gesture function emerge from distinct underlying assumptions; the use of the terms *social intentions* or *motives* (e.g., Tomasello et al., 2007), *communicative function* (e.g., Cochet & Vauclair, 2010a), or *meanings* (e.g., Hobaiter & Byrne, 2014) may reflect researchers' hidden assumptions about the nature of communication in their model species.

To achieve this aim, we restrained our analysis to the study of deictic gestures in preverbal children (e.g., pointing) and their equivalent in nonhuman primates. We first reviewed the literature on human infants' pointing gestures and related functions before describing the study of gesture function in the nonhuman primate literature. Then, we outlined the hidden assumptions underlying each definition of gesture function and made them explicit, highlighting the differences between the two model species and the implicit cognitive hierarchy that very often emerges from these distinct premises.

### *Gesture functions in infant studies*

There are numerous classifications of communicative gestures in human studies, mostly inspired by semiotics (Kendon, 2004; McNeill, 2008). Contrary to iconic and symbolic gestures that parallel words in verbal communication, the meaning of gestures characterized as *deictic* is less definite and may be equivocal. Initially used to describe words or phrases that can only be understood depending on the context in which they are used (e.g., "that one", "you", "here"), the term 'deictic' also refers to gestures that are directly connected to and influenced by their referents: pointing gestures are for example used to draw the attention of a partner towards a specific object or event, in a specific

407 shared environment. These acts of reference can serve different *functions*, whose classification was  
408 initially borrowed from pragmatics. Theories that have described language as a way of "doing things  
409 with words" (Austin, 1962) and highlighted the dissociation between the form and the function of  
410 language have indeed been adapted to nonverbal behavior (e.g., Guidetti, 2002; McNeill, 1998). In  
411 particular, the *speech act theory*, which describes several speech acts depending on whether one  
412 intends for example to comment, warn, or request (Searle & Vanderveken, 1985), has led to the  
413 current distinction between imperative and declarative pointing gestures. Imperative pointing was  
414 originally defined in infant studies as the "use of the adult as a means to a desired object" and  
415 declarative pointing as the "use of an object as the means to obtaining adult attention" (Bates et al.,  
416 1975, p. 209).

417 This distinction is still widely used in developmental psychology, although some of the definitions  
418 have slightly changed. Imperative gestures can also include requests for specific actions (Colonnesi,  
419 Rieffe, Koops, & Perucchini, 2008) and declarative gestures reflect for some researchers the *intention*  
420 to share interest in a specific referent with the adult or to help the adult by providing him/her useful  
421 information (Tomasello et al., 2007). In this perspective, researchers therefore attribute  
422 unobservable mental states to pre-verbal children in order to identify the so called *function of*  
423 *pointing*, thus bypassing the issue of its intentional nature. The production of pointing is indeed  
424 regarded as a key evidence of intentional communication, emerging in typical human development  
425 from as early as 9 months of age (Colonnesi et al., 2010).

426 To experimentally assess the function of pointing gestures, infants are observed in various situations  
427 that are supposed to elicit different functions of pointing. For example, the adult can show the child a  
428 toy and leave it out of his/her reach to elicit imperative pointing. Declarative pointing is expected to  
429 be produced in response to surprising and exciting situations, for example when a mechanical toy is  
430 suddenly being activated in front of the child (e.g., Tomasello et al, 2007). The recourse to these  
431 structured situations dates back to the 1990's (Blake, O'Rourke, & Borzellino, 1994) and several

432 authors now consider that some experimental settings "specifically elicit gestures with either an  
433 imperative or declarative motive" (Lüke, Grimminger, Rohlfing, Liszkowski, & Ritterfeld, 2017), to  
434 such an extent that they do not verify or question the function of pointing a posteriori (Camaioni et  
435 al., 2004; Cochet et al., 2011).

436 On the contrary, some researchers attempted to identify the function of pointing gestures and  
437 established intercoder reliability once the data have been collected, even though they had created  
438 specific situations to elicit either imperative or declarative pointing. In that perspective, Cochet and  
439 Byrne (2016) have observed children's potential signs of dissatisfaction following the adult's first  
440 reaction to their pointing gesture (i.e., whining, crying, and/or prolonged or repeated gesture). In a  
441 declarative pointing situation, the adult for example emoted positively about a wind-up mechanical  
442 toy that is being activated, without giving it to the child. If the latter repeated his/her gesture and/or  
443 starts crying, he/she was then being attributed an imperative intention. The authors also chose to  
444 exclude from their analyses gestures whose function "did not match the different pointing situations,  
445 or could not be clearly established" (Cochet & Byrne, 2016).

446 Indeed, some situational or motivational factors do not always allow researchers to infer the  
447 communicative function of gestures: the eliciting stimuli may not provoke in all children the  
448 necessary enthusiasm to repeat a pointing gesture until the communicative goal is reached, and the  
449 testing conditions do not always include enough time to observe the children's reactions after the  
450 adult's response. These issues are even more important in naturalistic studies in which researchers  
451 aim to identify the communicative functions of gestures in children's spontaneous repertoires, which  
452 may go beyond the dichotomy between imperative and declarative pointing. In these settings, the  
453 coding criteria are generally explicit (e.g., Cochet & Vauclair, 2010a), but the reference to the  
454 gesturers' intents leaves some ambiguity. The description of a child's gesture in a given context can  
455 lead to different interpretations: a point towards a dog picture on the wall may for example be  
456 characterized as a declarative gesture if we consider that the child wants to share his/her interest

with the adult about that picture, but may be characterized as what has been called an *interrogative* gesture if we consider that the child wants to learn about that picture and what it represents (Southgate, Van Maanen, & Csibra, 2007).

There have been some attempts to objectify the difference between imperative and declarative pointing through the analysis of quantifiable characteristics associated with gestures like the movement kinematics (e.g., peak velocity), gaze coordination (e.g., frequency of gaze alternation) and vocalizations (e.g., pitch and rhythm contour) (Cameron-Faulkner, 2014; Cochet & Vauclair, 2010b; Grünloh & Liszkowski, 2015). These micro-analyses, in addition to providing rich descriptions of pointing gestures, may give some clues as to their communicative functions but they cannot be used as preliminary and absolute categorization criteria. Conversely, and critically, the absence of any behavioral differences between two pointing gestures does not necessarily imply that they share the same function.

#### *Gesture functions in nonhuman primate studies*

In nonhuman primate studies, the definition of intentional communicative gestures includes several behavioral criteria (e.g., gazing at the recipient; see section I) and makes usually reference to the consequences of the gestures in the gesturer's environment, through the intermediary of the partner's response and/or the ultimate function fulfilled by gesturing (Pika, 2008b). The characteristics of this response provide a first hint regarding the function of the gesture, without going the route of inferences about individuals' intentions. Scott and Pika (2012) made this distinction explicit by defining the *function* as "the ultimate goal of the signaler as interpreted by the receiver" (p.156) and the *purpose* as the immediate goal of the signaler, whose categorization would be more subject to "observer bias through egocentric interpretations" (p.157). We must note that issues of polysemy and semantic ambiguity apply here to the question of gesture function; the above-mentioned term "purpose" could for example be considered as a synonymous of "intent" or

“intention”. From evolutionary theory, the ‘function’ of gestures has also been described within evolutionary contexts (e.g., foraging, mating, playing etc). A large body of evidence has shown that a given gesture has multiple ultimate functions in great apes and monkeys, i.e., means-ends dissociation (e.g., Molesti et al., unpublished data; Pika, 2008a).

More recently, some scholars have described another type of gesture function: the "apparently satisfactory outcome" (ASO) of gestures that they use to define gesture ‘meaning’ (Cartmill & Byrne, 2010). This approach requires to analyze the gesturer's reaction following the recipient's initial response. Cessation of gesturing after the recipient's response, as long as this response implies an actual change in behavior (Graham et al., 2017), is interpreted as a sign of satisfaction, indicating that the gesturer's goal was met. The description of ASO has allowed researchers to establish repertoires of apes' gestural communication, not only in terms of morphological features but also in terms of communicative functions. Through a systematic analysis of intentional communicative gestures in wild chimpanzees, Hobaiter and Byrne (2014) described for example 66 distinct gestures involving the individual's body, from the ‘hand fling’ (corresponding to the ASO “move away” in the majority of cases) to the ‘roll over’ (used with the ASO "start play” or “resume play”). Several gestures also include contact with peers, like the ‘directed push’, used with the ASO “reposition body”, although they are still considered as mechanically ineffective. The use of the same classification system, which provides precise definitions of ASO, facilitates comparisons across species: a wide overlap has for example been reported in the functions of gestures produced by bonobos and chimpanzees (Graham, Hobaiter, Ounsley, Furuichi, & Byrne, 2018).

In line with the dissociation of forms and functions in human infant gestures (Guidetti, 2002; Guidetti et al., 2014), nonhuman primate gestures, at both proximate and ultimate levels, can fulfill different communicative functions and the same function can be achieved through different gestures (e.g., Hobaiter & Byrne, 2017). This degree of flexibility was reported to vary across gestures, which has led some authors to distinguish between tight, loose, and ambiguous meanings via the ASO approach,

depending on “the probability that gestures would be used with particular goal–outcome matches” (Cartmill & Byrne, 2010). Focusing on the consequences of gestural production, through thorough behavioral descriptions in different contexts, has also highlighted the diversity of communicative functions in apes: e.g., initiating, maintaining or ending play or contact with peers, acquiring object, directing sexual attention, eliciting collective movements (e.g., “climb on me”, “move closer”, “move away”; (Cartmill & Byrne, 2010; Hobaiter & Byrne, 2014).

### *Hidden assumptions about what ‘function’ of deictic gestures means in human and nonhuman primate studies*

This close examination of gesture functions in human infant and nonhuman primate studies reveals a critical gap in the phenomena that are referred to by the term ‘function’ in each subfield of research. In line with our examination of conceptual diversity in gesture definitions (section I), we propose that implicit assumptions may underpin such a limited semantic overlap of what ‘function’ means in each domain.

In human infant studies, declarative pointing is frequently interpreted based upon the assumption that infants understand others as attentional and intentional agents (e.g., Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004) and communicate for reasons other than achieving egocentric goals (e.g., obtaining an out-of-reach object). Usually described as “the royal road to language” (Butterworth, 2003), declarative pointing is also argued to be closely related to the development of theory of mind abilities (Camaioni et al., 2004). The difference between the declarative and imperative functions pertains as well to the ontogenetic origins of pointing gestures: imperative pointing, which is often produced with the whole hand rather than with the index finger (Cochet, Jover, Oger, & Vauclair, 2014), has been suggested to develop from non-communicative reaching actions through a process of ontogenetic ritualization (Tomasello & Call, 1997). By contrast, the development of declarative pointing would rely on prior social cognitive skills, like the ability to

532 follow the gaze direction of a partner, as well as on social scaffolding like maternal pointing  
533 frequency (Carpenter et al., 1998; Matthews, Behne, Lieven, & Tomasello, 2012). These distinct  
534 developmental trajectories remain primarily hypothetical given the difficulty of obtaining empirical  
535 evidence on the question of pointing origins, but they may still reflect (and contribute to) the  
536 superior status of declarative pointing compared to imperative pointing (Leavens, 2018). This is all  
537 the more true as declarative pointing is only scarcely reported in nonhuman primates (see below).  
538 This more or less explicit hierarchy in cognitive complexity between imperative and declarative  
539 gestures may thus parallel a hierarchy between species, the declarative motivation to communicate  
540 usually being regarded as a hallmark of the human species (e.g., Pika, 2008a; Tomasello, 1995).

541 A few evidence of deictic gestures has been described in wild apes (e.g., in bonobos: Genty &  
542 Zuberbühler, 2014; in chimpanzees: Hobaiter & Byrne, 2017; Hobaiter, Leavens, & Byrne, 2014; Pika  
543 & Mitani, 2006). Using ASO, researchers have identified that these gestures were made in reference  
544 to spatial locations or indicated directions (e.g., travel path, grooming location). In addition, a great  
545 deal of experimental studies have investigated the deictic properties of nonhuman primate  
546 requesting gestures that are frequent in captivity (Lyn, 2017; Pika, 2008a; Tomasello & Call, 2018).  
547 However, the ability to establish a triangle of reference with a communicative partner and a target  
548 object or event in triadic communication seems indeed (more or less explicitly) regarded as the  
549 preserve of humans, which may have restrained researchers from using the term pointing to define  
550 deictic gestures. It seems anyway restricted to captive individuals interacting with human  
551 experimenters (e.g., in chimpanzees: Hopkins & Wesley, 2002; in baboons: Meunier et al., 2013), as  
552 well as contingent upon specific morphological features of gestures such as the pronation vs.  
553 supination of the hand (Leavens & Hopkins, 1998) or the degree of arm extension (Meunier et al.,  
554 2013). These experiments have shown that the ASO of nonhuman primates' 'pointing' gestures is  
555 mostly to obtain unreachable food items. Individuals are indeed likely to repeat their gesture until  
556 the experimenter gives them a desired specific item (Leavens et al., 2005), thus implying an  
557 imperative function.



Although there have been a few reports of gestures that could be considered as declarative pointing in enculturated apes (Leavens & Hopkins, 1999; Lyn, 2017), it is generally admitted that nonhuman primates lack the motivation of sharing their experiences and interests in external objects or events with others (e.g., Genty & Zuberbühler, 2015). Apes' gestures would therefore differ from human gestures in the range of communicative motives they involve (Gómez, 2007; Tomasello, 2006), which might explain the reluctance to label their deictic gestures as pointing. In wild apes, the rare authors who have unambiguously described deictic gestures have not explicitly mentioned any communicative function, cautiously highlighting that the same interaction could be subject to multiple interpretations (Hobaiter et al., 2014). These researchers have however raised a key question for the field of comparative cognition by inviting the reader to imagine how their observations would be interpreted if human subjects were studied instead of chimpanzees.

#### *Hierarchy between communicative functions and between species*

Similar behaviors seem indeed to be characterized in different ways in humans and nonhuman primates. For example, if the ability to use deictic communication allows both human children and captive apes to overcome the referential problem space and thus obtain a specific object (Kishimoto, 2013; Leavens et al., 2005), gestures produced by children are more likely to be characterized as imperative pointing (even whole-hand gestures; Cochet & Vauclair, 2010a), while nonhuman primate's gestures are more frequently defined as request or food-beg gestures (Bourjade, Meguerditchian, et al., 2014; Meguerditchian et al., 2010). Likewise, in an attempt to determine the goal of apes' (chimpanzees and bonobos) pointing, researchers have made a distinction between two functions: requesting food and directing a recipient's attention towards food (Halina, Liebal, & Tomasello, 2018). Even though the authors provide clear definition and operationalization of pointing, the essence of this gesture seems in a way negated: the proposed distinction implies at first that the production of pointing to request food does not require genuine triadic communication in

nonhuman primates. Yet, pointing is inherently produced to direct the other's attention on a referent. Why has this study never been conducted in human children? The answer may well lie with the influence of some implicit assumptions –here the existence of a hierarchy between the abilities of nonhuman primates and human children, as well as between the two communicative functions of pointing– on the initial formulation of research hypotheses. The declarative function seems to benefit from a more “noble” status than the imperative function. This may be explained by the close relationship between declarative pointing and language development (e.g., Camaioni, 1997) or by the scarcity of declarative pointing reported in nonhuman primates. This highlights some contradiction in comparative studies between a claimed search for continuity between human and nonhuman primates, in particular for the question of communicative abilities, and the implicit assumption that human cognitive abilities have no parallel in other primates (see Leavens, Bard, & Hopkins, 2017). Rather than an actual hypothesis to test, the notion of cognitive hierarchy may therefore sometimes take the shape of an initial premise that strengthens the contrast between human and nonhuman primates through the different terms used and their definitions, and that influences methodological choices.

## *Summary*

The scientific literature in either developmental psychology or comparative psychology has proposed different terms and definitions to describe what we have referred to as the gesture functions, which impacts the operationalization of gesture studies and may give rise to some oversights in the field of comparative cognition. In human development, identifying gesture functions usually involves some inferences about intentions, i.e., children are assigned with specific aims, plans or desires that are regarded as the cause of their gestures. This approach is likely to be biased to some extent by our representation of adult communication and does not acknowledge the lack of direct access to infants' subjectivity, especially when verbal language is not yet accessible.

By contrast, the functions of communicative gestures in nonhuman primate studies are generally inferred from their following consequences (ASO) in a given context, without any mention of individuals' mental intents. Compared to research in human development, this approach thus provides more restrictive but also more objective information about social interactions. Notwithstanding, the use of ASO is not perfectly effective as it does not always take account of motivational and contextual factors that can lead to cessation of gesturing, even though the initial goal has not been reached. It remains also sometimes difficult to classify communicative gestures, even when focusing on their immediate consequences rather than on inferred intentions, when these consequences are not clear in the environment. Repeated occurrences are therefore usually needed to remove any ambiguity in interaction situations and allow researchers to define the function of a given gesture based on its most common outcome.

### **Section III: setting boundaries to the concept of gesture using operational criteria**

As we have illustrated above, both conceptual diversity and hidden assumptions can lead to fallacious comparisons between gesture studies. Following Machado and Silva (2007), the concept of gesture suffers from several conceptual weaknesses that are; (i) various degrees of semantic ambiguity, (ii) several unacknowledged assumptions, and (iii) inappropriate classifications of what a gesture is and is not, from one study to another. Semantic ambiguity occurs when one term is used to refer to different phenomena, starting here with the concept of gesture itself, but involving also the 'function' of gesture. Unacknowledged assumptions are the covert assumptions made by researchers, most probably unconsciously, about a concept that is necessarily defined using other concepts taken as logical premises. We provided an example of this issue with the different conceptions of 'communication' that were used to define a 'communicative gesture'. The implicit cognitive hierarchy between imperative and declarative pointing gestures provides another example. Covert assumptions generally rely on several 'steps' in the argument that are implicitly known by the

author of a given claim, but which become illogical for anyone who does not share the same original assumptions as logical premises. For example, in a study focusing on the "psychological origins of the human pointing gesture", the question of pointing functions was not mentioned, but the experiments were designed to elicit exclusively declarative gestures (Liszkowski & Tomasello, 2011), indirectly suggesting that only the latter can be considered as genuine human pointing. This study might thus lead to conclusions that are incompatible with imperative pointing, and therefore fallacious or illogical for researchers who do not share the view that human pointing gesture is necessarily declarative. Then, inappropriate classifications occur when a given behavior is alternately categorized as a gesture or as a non-gesture under various definitions of the concept. Furthermore, inappropriate classifications also occur –and it is much worse– when two researchers using the same definition categorize the same behavior as either a gesture or a non-gesture. This issue arises when definitions possess too much room for interpretation, or in other words when definitions do not possess clear conceptual boundaries.

We propose that setting boundaries to the concept of gesture could be easily achieved using a set of operational criteria that researchers would make explicit in their published work. The table 3 provides an example of such criteria that can be used to tie up any of the four definitions of gesture used in the present paper and extended according to the necessities of other studies.

*< Insert Table 3 >*

Categories of criteria cover the body parts used to gesture, the sensory modalities mobilized by the gesture, the characteristics of its social expression, its communicative properties and intentional properties. Scoring '1' means that the criterion is necessary for a behavior to be categorized as a gesture. Scoring '0' means that the criterion is not necessary for a given behavior to be categorized as a gesture. In study 1 for example, which aimed at investigating the gestural repertoire of olive baboons, the definition of gesture satisfies seven of the 22 criteria. To be considered a gesture in this study, the behavior had to be produced by any body part including the face, be visual or visual and

658 auditory or tactile, be produced in the presence of an audience and directed to specific partner(s).  
659 Any behavior corresponding to this series of criteria was thus categorized as a gesture. Then, the fact  
660 that no intentional property was specified as a criterion for defining gesture does not imply that  
661 baboon gestures were not intentional. Actually baboons use gestures intentionally (Molesti et al.,  
662 *submitted*).

663 The intellectual virtue of delineating a scientific concept with a set of operational criteria is that any  
664 behavior must fall either into the category or into the negation of the category. Table 4 provides  
665 some examples of behavior that can be categorized as a gesture or a non-gesture according to our  
666 four definitions. We suggest that one efficient way to set (and improve) boundaries to a definition of  
667 a scientific concept is to use its negation, for example asking oneself about what a gesture is not to  
668 make sure about what a gesture is. Negating a proposition leads to unequivocal results if we accept  
669 the principle of non-contradiction (i.e., the propositions P and non-P (negation) cannot be both true)  
670 and the principle of excluded middle (i.e., the propositions P and non-P (negation) cannot be both  
671 false). On these logical bases, negating a given definition of gesture would necessarily lead to the  
672 definition of a non-gesture. One word must be said about the possible caveats of this approach  
673 applied to developmental studies. The risk entailed in adopting this dichotomy may at first be to  
674 overlook the transitional phenomena typically observed during development, for example as children  
675 learn that their failed attempts to directly grasp an object can gradually acquire a communicative  
676 status through the adult's reaction. However, this approach may on the contrary help disentangle the  
677 criteria of interests that are required to take a close look at developmental processes. In such cases,  
678 it would reconcile operational categorizations with the complex dynamics of communication  
679 development. In the previous example, the child's gaze alternation between the adult and the object  
680 could be used as one criterion of the expected transition from a mechanical action to a  
681 communicative gesture. This entails that actions produced without gaze alternation would not be  
682 categorized as gesture, while actions produced with gaze alternation would.

683

684 < Insert Table 4 >

685 Note that our four definitions of gesture do not result in similar categorization of behavior as a  
686 gesture or as a non-gesture. We argue that it is not an obstacle to scientific advances as long as the  
687 source of variability is known; that is the criteria used by researchers are explicit and accessible. In  
688 other words, there is no longer semantic ambiguity when the exact series of criteria can be used to  
689 compare two definitions of a gesture, and therefore two gestures from different studies. We suggest  
690 that these criteria must be understood and utilizable (operational) by any researcher, as well as  
691 explicitly associated with the theoretical definition of any study. As a consequence, the use of these  
692 criteria as definition boundaries should lead different researchers to same categorization results of a  
693 given behavior as a gesture or as a non-gesture while using the same definition/series of criterion. It  
694 would also allow to compare different studies on the basis of the criteria that are shared for defining  
695 gestures; if criteria do not entirely overlap between two studies, it is still possible to compare the  
696 results on the basis of the lowest common denominator for defining gesture. For example, using  
697 Table 3 instructs the reader that the gestures sampled by study 4 can be compared with a subset of  
698 gestures sampled by study 1, namely the manual intentional signals. Also, Table 4 shows that the  
699 gestures ‘slap in the face’, ‘tickling’, or ‘open-palmed strike on other’s chest’ can all be compared  
700 directly between studies 1, 3 and 4. For these reasons, we propose that using theoretical definitions  
701 systematically associated with a set of restrictive operational criteria adapted to the study necessities  
702 would yield a scientifically stable trade-off between unification and diversity, hence improving study  
703 comparability while maintaining each study's internal coherence.

704 The recent work by Hobaiter and Byrne (2017) nicely illustrates this claim. These authors have  
705 questioned the meaning of the concept of gesture and the different categorizations made by their  
706 research group working on chimpanzees. Although their approach slightly differed from ours, they  
707 provided explicit definitions of gestures, meaning, ASO and operational criteria of intentionality

resulting in the possibility to directly compare their study with the four studies presented here using Table 3. In this regard, chimpanzee gestures in their revised catalogue; (i) involve moves of any body part including face, (ii) have visual component associated or not with auditory and tactile components – the possible use of vocal chords is unspecified, (iii) are produced towards a specific recipient while looking at it, (iv) are a subcategory of signal that are mechanically ineffective and in most cases followed by a change in the recipient's behavior, (v) are necessarily intentional signals – defined as being produced towards attentive recipient and/or followed by responses waiting and/or repeated or elaborated until satisfying outcome is attained, and finally, they are expressed in various contexts and associated with ASOs. Moreover, the authors offered a series of six physical features to qualify any of the gestures of their catalogue; (1) the movement, (2) the body part, (3) the use of single or double limb, (4) the use of an object, (5) the rhythmic repetition and (6) the physical contact. All were associated with definite possible values that had to be recorded for any gesture of the catalogue. While it is clear that these features add a critical step forward a systematic description of gestures, we argue that specifying operational criteria associated with 'what we consider to be a gesture' is a preliminary step of scientific description that must not be overlooked. Thus, we advocate using theoretical definitions bounded up with a series of operational criteria (e.g., Hobaiter & Byrne (2017); the present paper) from the first stage of the scientific description. Then, computing the logical combinations of all possible gestures using a finite set of physical features will undoubtedly lead to higher scientific fecundity regarding the testability of hypotheses in the domain of gestural communication (Vautier, 2011).

## **Conclusion**

Definitions are social conventions that result from more or less implicit categorization processes. It is not surprising that everyone does not categorize exactly the same way, partly under the influence of covert assumptions. The resulting conceptual diversity might not be prejudicial for science as long as

733 concepts possess known boundaries. By contrast, semantic ambiguity is more problematic for  
734 science because it is a fertile ground for implicit assumptions and hidden steps in arguments. Here,  
735 we offered an alternative way of considering conceptual diversity by associating each definition with  
736 a finite set of operational criteria that drastically reduce semantic ambiguity, while maintaining  
737 conceptual diversity. These criteria give limitations or boundaries to the concept of gesture and allow  
738 any researcher, interchangeably, to confidently categorize a communicative act as a gesture or as a  
739 non-gesture. Focusing on these operational definitions can also prove valuable to characterize more  
740 closely the dynamics of developmental processes. We suggest that this methodology should increase  
741 the validity of the descriptions, while enhancing the comparability between studies, and the  
742 replicability of the results as well.

743 Moreover, we have argued that the existence of distinct terminologies and epistemologies in human  
744 children and nonhuman primates resulted from a framework in which it became easier to support  
745 the hypothesis of “human superiority” in terms of communicative abilities. Our attempt here was to  
746 address this issue by revealing the theoretical and methodological gaps existing between the studies  
747 of deictic gestures in infants and nonhuman primates. We suggest that, in addition to providing  
748 explicit and precise definitions of each concept based on operational criteria, it may be necessary to  
749 set aside the question of psychological processes, including communicative intentions, as long as the  
750 latter cannot be identified or operationalized (but see original propositions in Leavens et al., 2017;  
751 Penn & Povinelli, 2013; Whiten, 1996). Scholars of animal behavior undeniably face epistemic  
752 challenges about the attribution of significations to animal communicative signals. Overcautiousness  
753 in choosing terminology and in attributing meaning to animal behavior may be another possible  
754 source of polysemy. Yet, it is also a good opportunity to specify the observable components of  
755 hidden psychological motives shared by humans and nonhumans (Leavens, 2018). In this perspective,  
756 the methodology commonly used in the study of nonhuman primate gestures could be applied to  
757 human studies and thus facilitate the comparison of communicative repertoires between species.  
758 Recently, some authors have described the gestures produced by 1-2-year old human children in a



natural setting with peers and caregivers (Kersken et al., 2018); they have shown by the means of ASO that the majority of these gestures were also present in the chimpanzee repertoire, thus calling for a new look at comparative cognition.

In sum, although conceptual diversity might impede comparative science at first sight, semantic ambiguity more than conceptual diversity should be a brake on scientific advances. We argue that developing theoretical definitions systematically associated with conceptual boundaries that take the form of a finite set of operational criteria would allow to tackle both the challenges of maintaining high internal coherence within studies and of improving comparability and replicability of scientific results.

## **Statements**

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1099 Tables

1100 Table 1. Empirical work used for analyzing conceptual diversity in gesture studies

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Study number	Species	Methodology and sample size	Gesture category	Definition of gesture	Reference
Study 1	Olive baboon (captive)	Observational N = 47	Communicative gesture	Any movement of the body or part of the body directed to a specific partner or audience	Molesti et al. (submitted)
Study 2	Olive baboon (captive)	Experimental N = 16	Communicative gesture	Any non-vocal bodily action directed to a recipient that is mechanically ineffective and represents a meaning, beyond itself, that is in part manifested by others of the social group	Bourjade et al. (2014)
Study 3	Chimpanzee (wild)	Observational N = 23	Gesture	Communicative intentional manual actions	Cochet & Byrne (on-going)
Series of four studies - hereafter Study 4	Human (toddlers observed at home or in day-care centers)	Observational N <sub>1</sub> = 26  Experimental N <sub>2</sub> = 8 N <sub>3</sub> = 25 N <sub>4</sub> = 48	Intentional communicative gesture	Any manual gesture used flexibly and deliberately rather than being triggered by specific environmental conditions, through which a specific message is conveyed from a signaler to one or several receivers	Cochet (2012) including Cochet & Vauclair (2010ab); Cochet et al. (2011); Cochet (2012)

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1106 Table 2. Results of the direct comparison of the four gesture definitions

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	Overt characteristics	Covert characteristics
Shared characteristics	All definitions assume gesture to be a communicative means	All definitions assume gesture to possess a visual component
Divergent characteristics	Bodily versus manual gestures Intentional versus non-intentional gestures Gestures are mechanically ineffective Gestures possess a meaning manifested by recipients' responses Gestures convey messages to recipients	Communication possesses different acceptations according to the four studies' first author

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1118 Table 3. Criteria for defining 'gesture'. *Na*: not available



Category of criteria	Specific criteria for defining Communicative Gesture (CG)	Study 1	Study 2	Study 3	Study 4
Body part	CG is a move of any body part including face	1	1	0	0
	CG is a move of any body part excluding face	0	0	0	0
	CG is exclusively manual	0	0	1	1
	CG is exclusively facial	0	0	0	0
Sensory modality	CG has necessarily a visual component	1	1	1	1
	CG is visual or visual and auditory	1	1	1	<i>na</i>
	CG is visual or visual and vocal (mobilizing the vocal chords)	<i>na</i>	0	0	0
	CG is visual or visual and tactile	1	1	1	1
Social expression	CG is produced in the presence of an audience	1	1	<i>na</i>	1
	CG is addressed to specific recipient(s)	1	1	<i>na</i>	1
	CG is produced while looking at the recipient	0	0	<i>na</i>	<i>na</i>
Communicative property	CG encompasses all communicative signals	0	0	0	0
	CG is a subcategory of communicative signals	1	1	1	1
	CG is mechanically ineffective	<i>na</i>	1	<i>na</i>	<i>na</i>
	CG is followed by a change in the recipient's behavior in most cases	<i>na</i>	1	<i>na</i>	<i>na</i>
Intentional property	CG is necessarily an intentional communicative signal	0	0	1	1
	CG is produced towards a visually attentive recipient	0	0	<i>na</i>	<i>na</i>
	CG is followed by response waiting (a pause in the gesturer's actions)	0	0	<i>na</i>	<i>na</i>
	CG is repeated, combined or replaced by other CGs if no response comes	0	0	<i>na</i>	<i>na</i>
	CG is not consistently triggered by specific environmental conditions	0	0	1	1
	CG is expressed in various functional contexts	0	0	<i>na</i>	<i>na</i>
	CG is associated with an Apparently Satisfactory Outcome (ASO)	0	0	<i>na</i>	1

1119 Table 4. Categorization of behavior as gesture versus non-gesture depending on the definition used.

Example of behavior to categorize as a gesture or as a non-gesture	Study 1	Study 2	Study 3	Study 4
Smile	gesture	gesture	non-gesture	non gesture
Slap in the face	gesture	non-gesture	gesture	gesture
Tickling	gesture	non-gesture	gesture	gesture
Grooming	gesture	non-gesture	non-gesture	non-gesture
Kiss	gesture	non-gesture	non-gesture	non-gesture
Physically turning the head of the recipient using two hands on the scalp	gesture	non-gesture	gesture	gesture
Open-palmed strike on other's chest	gesture	gesture	gesture	gesture

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