

# Is Conceptual Diversity an Advantage for Scientific Inquiry? A Case Study on the Concept of 'Gesture' in Comparative Psychology

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1	Is conceptual diversity an advantage for scientific inquiry? A case study
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19	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 differ regarding the forms of a gesture and the cognitive processes inferred from it, and that these 25 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.

#### 34 Introduction

35 Understanding the evolution and development of human behavior is a relatively recent endeavor at 36 the scale of the history of sciences. Modern psychology, bringing experimental accounts of life-span 37 human cognition, sociality and subjectivity has progressively overtaken philosophy-grounded 38 approaches, in some aspects detrimentally. Indeed, experimental psychology is nowadays traversed 39 by a replication crisis which casts some doubt on the reliability of the scientific methodology and 40 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 41 42 multidisciplinary science in which the same concepts have multiple acceptions. Although polysemy is 43 a richness of natural languages, it may be detrimental to science as soon as 'multiple acceptions' turn 44 to 'loose meaning' or even 'no meaning' of scientific concepts (Machado & Silva, 2007).

45 'Gesture studies' vividly illustrate these transformations. Although gestures have been described 46 from the antiquity (Kendon, 2004), modern gesture studies have dramatically blossomed over the 47 last two decades (Byrne et al., 2017; Liebal & Call, 2012; Pika & Liebal, 2012; Tomasello & Call, 2018) 48 and are supported by the International Society for Gesture Studies (ISGS) founded through the 49 attendance of up to 200 scholars from 18 countries to its first official conference in 2002. The field 50 has also been supported by the journal Gesture since 2001. Since then, the popularity of gesture 51 studies has raised constantly, now joining scholars from disciplines as diverse as anthropology, 52 linguistics, psychology, history, neuroscience, art history, computer science, music, theater or dance 53 (http://gesturestudies.com/). Typing 'gesture' in Google Scholar raises up to 1.6 billion results and 54 restricting it by the year 2018<sup>1</sup> still gives more than a thousand results. Facing this vivid diversity, it is 55 reasonable to think that one gesture study might not necessarily refer to the same phenomenon as 56 another gesture study, although most of them might be broadly concerned with the use of hands or 57 other body parts for communicative purposes (<u>http://gesturestudies.com/</u>). Operational studies of

<sup>&</sup>lt;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).

62 From the perspective of comparative developmental psychology, gestures are considered 63 foundational in the development of communication and language in human infants (Colonnesi, 64 Stams, Koster, & Noom, 2010; Goldin-Meadow & Alibali, 2013; Iverson & Goldin-Meadow, 2005; Kersken, Gómez, Liszkowski, Soldati, & Hobaiter, 2018). Gestural communication precedes speech 65 66 and stages the first manifestations of communicative intention (Bates, Camaioni, & Volterra, 1975; 67 Camaioni, 1997; Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Cochet & Vauclair, 68 2010b; Colonnesi et al., 2010; Crais, Douglas, & Campbell, 2004). In particular, human infants start 69 pointing between 9 and 12 months of age and accompany their pointing gestures with alternated 70 gaze between the targeted object and the recipient, i.e., joint attention (Camaioni, Perucchini, 71 Bellagamba, & Colonnesi, 2004; Carpenter et al., 1998; Liszkowski, Brown, Callaghan, Takada, & Vos, 72 2012). This triadic engagement is considered a hallmark of referential communication (Cochet & 73 Vauclair, 2010b; Colonnesi et al., 2010; Liszkowski, Carpenter, & Tomasello, 2007; Tomasello, 74 Carpenter, & Liszkowski, 2007) and is rapidly followed by the emergence of the first words (Cochet & 75 Byrne, 2016; Iverson & Goldin-Meadow, 2005). By the age of 14 months, children get through a 76 phase of reorganization of emerging speech with existing gestures leading to bimodal utterances 77 characterizing their first sentences (Goldin-Meadow & Alibali, 2013; Guidetti, Fibigerova, & Colletta, 78 2014; Iverson & Goldin-Meadow, 2005). Overall, pointing gestures and joint engagements predict 79 language onset and vocabulary size in later development (Colonnesi et al., 2010; Kita, 2003; 80 Liszkowski et al., 2012), although with differences across cultures (Kita, 2003; Mastin & Vogt, 2016; 81 Salomo & Liszkowski, 2013).

82 Of great importance for gesture's studies in comparative research is the fact that both children and 83 adult continue to gesture after the emergence of speech, resulting in multimodal language 84 utterances (Aureli et al., 2017; Esteve-Gibert & Guellaï, 2018; Grünloh & Liszkowski, 2015). Gesture 85 studies in verbal individuals have shown that gestures were used to accompany speech (Kendon, 86 2004; McNeill, 2000), and gave cognitive support in various ways like reducing the speaker's 87 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-88 89 Gibert & Guellaï, 2018; Guellaï, Langus, & Nespor, 2014; Kendon, 2004). Speech and gestures share 90 similar neurobiological underpinnings and are both under left-hemisphere dominance (Gentilucci & 91 Volta, 2008; Xu, Gannon, Emmorey, Smith, & Braun, 2009). Purely visual utterances like sign 92 language or the initiation of joint attention by looking at the recipient have been shown to activate 93 same brain regions in the addressees as speech does (Courtin et al., 2011; Kampe, Frith, & Frith, 94 2003). Gestures also facilitate learning in children (Goldin-Meadow, 2009; Goldin-Meadow, Cook, & 95 Mitchell, 2009; Goldin-Meadow & Singer, 2003) and the latter are likely to use gestures to express 96 some conceptual understanding they are not yet able to verbalize (Broaders, Cook, Mitchell, & 97 Goldin-Meadow, 2007; Church & Goldin-Meadow, 1986). Importantly, if gestures are considered as a 98 window into the human mind by developmental psychologists, they are also considered by 99 comparative psychologists as the living fossils of a primitive gestural protolanguage (Fitch, 2010; 100 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

134 comparison could be made without such a common denominator. Yet, inclusive definitions do not 135 seem necessarily consensual and researchers keep on using definitions based on gesture physical 136 forms at variable levels of granularity (Byrne et al., 2017; Cartmill & Byrne, 2011). Moreover, Scott 137 and Pika (2012)'s comparison of gesture definitions was set up at a large scale of the scientific field 138 that might not have allowed them to grasp more subtle differences between gesture definitions. For 139 example, they relied on one definition used in monkeys' studies and one in apes' studies, while this 140 does not represent the whole diversity of gesture definitions in any of this model species. Critically, 141 Byrne and collaborators recently reviewed their own work on great apes' gestural repertoire and 142 revised their previous classifications using novel heuristics based on both the physical features of 143 gesture and the signalers' intended meaning (Byrne et al., 2017; Hobaiter & Byrne, 2017). 144 Here, we examine some possible causes of the conceptual diversity in gesture definitions and use a

145 slightly different approach to that of promoting the unification of the concept of gesture. We grant a 146 special importance to the payoff of using a particular definition of gesture for a given study. We 147 postulate that researchers who set up and use gesture definitions face both epistemic and 148 methodological obstacles that could influence their choices and that a close examination of these 149 obstacles is a necessary primary step before deciding about unification or multiplication, 150 homogeneity or heterogeneity in defining 'gesture'. Our aims were (i) to clearly establish that 151 gesture definitions differed on several aspects –including the form of the gesture (action pattern) 152 and the cognitive processes inferred from it, (ii) to show that these differences mostly relied on 153 implicit assumptions, which have pervasive consequences on the results claimed by researchers, and 154 (iii) to demonstrate that implicit assumptions can be made explicit by using finite sets of operational 155 criteria to bound theoretical definitions. Our ultimate goal was to bring a new conceptual tool, easy 156 to implement in empirical studies and that will help ground valid comparisons between study 157 populations.

158 In section I, we grounded our investigation on four empirical gesture studies in the field of language 159 development and evolution to explore the conceptual diversity in gesture definitions as well as some 160 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). 161 162 Relatedly, each subfield of gesture study possesses its specific research questions that are often not 163 equaled or even hinted at when comparisons are made between studies. Section II examines this 164 issue by comparing the study of the *functions* of deictic gestures in human infants and nonhuman 165 primates. After reviewing the literature on gesture functions in these two domains of research, we 166 will show that the conceptual analysis of gesture functions reveals an implicit hierarchy across 167 species (see Cochet & Byrne, 2016) and across gesture categories. We suggest that differential values 168 are implicitly attributed by researchers with the more or less conscious objective to champion the 169 abilities of a species over another -highlighting for example the flexibility and diversity of the human 170 communicative repertoire compared to other primates- or on the contrary to obscure important 171 differences across species (Leavens, 2018). In section III, we will offer an alternative way of 172 considering conceptual diversity, emphasizing the advantages of setting boundaries to theoretical 173 definitions using finite sets of operational criteria. We will discuss the advantages and limitations of 174 maintaining conceptual diversity in gestural studies in the field of comparative research and we will 175 argue that conceptual diversity is no longer a matter of concern when concepts can be distinguished 176 or merged on the basis of descriptive criteria.

177

#### 178 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.

190

#### 191 Material and methods

192 Our material was composed of four empirical works on gestures used for communicative purposes by 193 olive baboons, Papio anubis, (Studies 1 and 2), chimpanzees, Pan troglodytes, (Study 3) and human 194 infants, *Homo sapiens*, (series of studies – hereafter Study 4). Studies 1 and 3 were observational and 195 study 2 was experimental. Study 4 refers to a dissertation thesis that comprised four empirical 196 studies on toddlers observed at home or in day-care centers: one was observational, the three others 197 were experimental; they all rely on the same definition of gesture (Table 1). 198 Study 1. This study authored by Molesti and collaborators (unpublished data) aimed at establishing 199 the first naturalistic repertoire of gestural communication in a non-ape primate species, the olive 200 baboon. The study provided detailed and quantitative descriptions of 67 communicative gestures 201 defined as any 'movement of the body or part of the body directed to a specific partner or audience'. 202 The objectives were then to study the intentional and flexible use of these gestures by olive baboons. 203 The study relied on a sample size of 47 captive individuals living in social groups and was 204 observational.

205 **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-

207 requesting experimental set-up. The study involved 16 adult baboons trained to produce an

208 extended arm gesture to request food from a human experimenter. Following Scott and Pika (2012), 209 communicative gesture was defined as any 'nonvocal bodily action directed to a recipient that is 210 mechanically ineffective and represents a meaning, beyond itself, that is in part manifested by others 211 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 212 213 the receiver's attention, (ii) the visual monitoring of the interaction and (iii) its goal-directness 214 evidenced by persistence and elaboration in case of communicative breakdowns (Leavens, 2004). 215 Study 3. This on-going study by Cochet and Byrne aimed at describing some features of gestures that 216 are shared between humans and chimpanzees. The study relied on the observation of 23 wild 217 chimpanzees whose gestures were systematically described in terms of form, context, and recipient's 218 response. Gestures were regarded as communicative, intentional and mostly manual. The aim was to 219 determine the extent to which humans and chimpanzees actually shared gesture properties, in terms 220 of flexible, intentional and referential use.

221 Study 4. This series of empirical studies on toddler gestural communication is constitutive of Cochet's 222 thesis dissertation (2011). The different studies describe the production of intentional 223 communicative gestures (i.e., form, function, laterality, associated gaze patterns) in the course of 224 children's development. Intentional communicative gesture was defined as any 'manual gesture used 225 flexibly and deliberately rather than being triggered by specific environmental conditions, through 226 which a specific message is conveyed from a signaler to one or several receivers'. The participants 227 were respectively 26, 8, 25, 48 toddlers who were observed gesturing spontaneously (Cochet & 228 Vauclair, 2010a) or in interaction with the experimenter (Cochet, 2012; Cochet, Jover, & Vauclair, 229 2011; Cochet & Vauclair, 2010b). The ultimate aims of the study were then to relate gesture use with 230 the development of other sociocognitive abilities like joint attention, imitation or language 231 acquisition.

232

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

258 of intentional use to define communicative gesture. Thus, according to definitions 1, 2, and 4, 259 subcategories of communicative gestures that are not intentional do exist whereas definition 3 260 precludes gestures from being non-intentional signals. For example, the case of smiling would be 261 considered a communicative gesture according to studies 1 and 2 but not to studies 3 and 4 (face 262 gesture). Also, a manual gesture that would be triggered by internal state rather than flexibly 263 produced, would still be considered a communicative gesture according to studies 1 and 2, and 264 would qualify as a non-intentional gesture following definition 4, but as a non-gesture following 265 definition 3 (and therefore not further considered in studies 3 and 4).

266 Finally, we found several idiosyncrasies across our four gesture definitions. Following Smith (1977)'s 267 definition of communicative signals, study 2 was the only one to mention the criterion of mechanical 268 ineffectiveness although this criterion is widely shared in primate gesture studies (Hobaiter & Byrne, 269 2017; Liebal & Call, 2012; Liebal & Oña, 2018; Scott & Pika, 2012). As previously discussed by Scott 270 and Pika (2012), Liebal and Call (2012), or Tomasello and Call (2018) amongst others, it allows 271 researchers to exclude occurrences in which individuals try to achieve the intended action or result 272 on their own. Instead, communication occurs when the recipient's response fulfils this function. In 273 this respect, a slap in the recipient's face would not be considered a communicative gesture as it 274 attains its goal without leaving room to the recipient's role. That is, it is a mechanically effective 275 social interaction that recipients cannot ignore. The foundations and limits of this criterion are 276 discussed below. Note however, that a slap threat would be considered a communicative gesture 277 according to study 2 as well as the three others. More generally, retaining this criterion to define 278 gesture leads to exclude most of gestures that have a tactile component sufficient to produce the 279 intended effects (but see Perlman, Tanner and King (2012) for a detailed study of 'push' gestures in 280 gorilla). Related to this criterion of mechanical ineffectiveness, study 2 offered the criterion of 281 gesture meaning, taken in its broad sense. Meaning emerges from the recipients' responses to a 282 gesture (Scott & Pika, 2012) leading to a form of holistic meaning. According to this criterion, visual 283 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).

290

## 291 Hidden conceptual diversity about what 'communication' means

292 Interestingly the three idiosyncratic criteria exposed above (i.e., mechanical ineffectiveness, 293 meaning, conveying a message) all have in common some implicit assumptions about what the 294 researchers meant by 'communication'. Bourjade (Study 2) defined communicative acts as 295 specifically addressed to an audience and whose effectiveness relies on the recipients' responses. 296 Consequently, communicative acts are not functionally effective on their own and recipients can 297 respond to or ignore them – the function is then inferred from recipients' most common responses 298 over repeated observations (see section II). Cochet (Studies 3 & 4) defined communication as 299 referring to the numerous means through which a specific message is conveyed from a signaler to 300 one or several receivers. Consequently, communicative acts such as gestures must support some sort 301 of information transfer and hence have 'contents'. While discussing the strengths and limitations of 302 these two definitions goes beyond the scope of this article, it is remarkable that they do not 303 underscore the same aspects of communicative exchanges, targeting mainly the form (Bourjade) or 304 the content (Cochet). Focusing on the form enables scholars of animal behavior to delineate 305 communicative acts from more general social interactions, while ascribing signalers and perceivers 306 distinct roles likely to have evolved under different selection pressures (Rendall, Owren, & Ryan, 307 2009; Scott & Pika, 2012). In contrast, focusing on information transfer is in line with the Shannon-308 Weaver approach of communication (Shannon & Weaver, 1949), although detecting and quantifying

309 (relevant) information in animal signaling or in pre-linguistic children's utterances remains highly

310 challenging (see section II for a discussion of this aspect).

311

312 < Insert Table 2>

313

#### 314 Origins and maintenance of conceptual diversity

In this regard, it is worth noting that each researcher's definition of communication was in good 315 316 coherence with her definition of communicative gestures. Study 2, focusing on baboon gestures, was 317 based on definitions of communication and gestures enabling to extract communicative signals from 318 the flow of interactions without inferring an inaccessible content. This represented an efficient way 319 of achieving the study goals. Likewise, studies 3 and 4 were modelled after children's pointing studies 320 in which the 'content' of communicative exchanges is partly offered by the targeted object and the 321 consistent pattern of reactions between the gesturers and the recipients (but see section II for 322 inaccurate inferences about children's pointing). Thus, the preference for a definition of gesture over 323 another is partly explained by the model species and the scientific goals that were pursued by the 324 researchers.

325 More generally, we found that the main differences between gesture definitions were partly

326 confounded with model species (baboons versus chimpanzees and humans) and study aims (Table 2).

327 Indeed, studies 1 and 2 aimed at investigating whether baboon gestured intentionally or not while

328 studies 3 and 4 selected the gestures of interest based on intentional use (assumed a priori) to

329 further investigate related properties such as referential use or other sociocognitive skills.

330 Furthermore, there is a complete overlap between the baboon as model species, the possibility for

331 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

359 case would have consisted in effectively stirring the young gorilla from one way to another.

360

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

362 In sum, our analysis of gesture definitions raised two agreements and six differences (Table 2) that 363 came from either divergent implicit assumptions about scientific concepts (e.g., communication), 364 specificity of the model species (e.g., meaning, message, mechanical ineffectiveness), study goals 365 (e.g., whether intentionality is assumed or necessary or tested) or a combination of these points. 366 Importantly, we showed that preference for a given definition was internally coherent with the study 367 goals, the model species and the conception of communication as well as with the ways to 368 operationalize it. Although this internal coherence appears a good point for each study taken 369 separately, it might actually prevent scholars from comparing their results. However, conforming to a 370 unique definition might convey scientific costs as for instance, using our narrowest definitions 371 (studies 3 and 4) would prevent studying communicative gestures in baboons as long as it is not 372 clearly stated that baboons gesture intentionally. Consequently, unification tends to broaden 373 definitions – using the broadest definition here (study 1) enables to conduct all four studies – while 374 the scientific costs of broad definitions can be the loss of meaning or information (Machado & Silva, 375 2007). Notwithstanding, it is worth noting that specific definitions provided each study with good 376 internal coherence and this, above all, might represent a relevant obstacle to massive unification.

377

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

379 Another class of hidden assumptions pertains to the study of gesture *functions*. Our second aim was

380 thus to examine the different acceptions of gesture *function* in human infant studies and in

381 nonhuman primate studies. In infant studies, gestures seem to be regarded as intentional a priori,

382 leading to a categorization of functions usually established from inferences about individuals' 383 intentions. By contrast, gestures are not considered as intentional by default in studies involving 384 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 385 386 constituting a heterogeneous category that adds to the complexity of comparing gesture studies. 387 Crucially, these distinct definitions of gesture function emerge from distinct underlying assumptions; 388 the use of the terms social intentions or motives (e.g., Tomasello et al., 2007), communicative 389 function (e.g., Cochet & Vauclair, 2010a), or meanings (e.g., Hobaiter & Byrne, 2014) may reflect 390 researchers' hidden assumptions about the nature of communication in their model species. 391 To achieve this aim, we restrained our analysis to the study of deictic gestures in preverbal children 392 (e.g., pointing) and their equivalent in nonhuman primates. We first reviewed the literature on 393 human infants' pointing gestures and related functions before describing the study of gesture 394 function in the nonhuman primate literature. Then, we outlined the hidden assumptions underlying 395 each definition of gesture function and made them explicit, highlighting the differences between the 396 two model species and the implicit cognitive hierarchy that very often emerges from these distinct 397 premises.

398

#### 399 *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).

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

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

460 There have been some attempts to objectify the difference between imperative and declarative 461 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) 462 463 and vocalizations (e.g., pitch and rhythm contour) (Cameron-Faulkner, 2014; Cochet & Vauclair, 464 2010b; Grünloh & Liszkowski, 2015). These micro-analyzes, in addition to providing rich descriptions 465 of pointing gestures, may give some clues as to their communicative functions but they cannot be 466 used as preliminary and absolute categorization criteria. Conversely, and critically, the absence of 467 any behavioral differences between two pointing gestures does not necessarily imply that they share 468 the same function.

469

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

471 In nonhuman primate studies, the definition of intentional communicative gestures includes several 472 behavioral criteria (e.g., gazing at the recipient; see section I) and makes usually reference to the 473 consequences of the gestures in the gesturer's environment, through the intermediary of the 474 partner's response and/or the ultimate function fulfilled by gesturing (Pika, 2008b). The 475 characteristics of this response provide a first hint regarding the function of the gesture, without 476 going the route of inferences about individuals' intentions. Scott and Pika (2012) made this 477 distinction explicit by defining the *function* as "the ultimate goal of the signaler as interpreted by the 478 receiver" (p.156) and the *purpose* as the immediate goal of the signaler, whose categorization would 479 be more subject to "observer bias through egocentric interpretations" (p.157). We must note that 480 issues of polysemy and semantic ambiguity apply here to the question of gesture function; the 481 above-mentioned term "purpose" could for example be considered as a synonymous of "intent" or

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

486 More recently, some scholars have described another type of gesture function: the "apparently 487 satisfactory outcome" (ASO) of gestures that they use to define gesture 'meaning' (Cartmill & Byrne, 488 2010). This approach requires to analyze the gesturer's reaction following the recipient's initial 489 response. Cessation of gesturing after the recipient's response, as long as this response implies an 490 actual change in behavior (Graham et al., 2017), is interpreted as a sign of satisfaction, indicating that 491 the gesturer's goal was met. The description of ASO has allowed researchers to establish repertoires 492 of apes' gestural communication, not only in terms of morphological features but also in terms of 493 communicative functions. Through a systematic analysis of intentional communicative gestures in 494 wild chimpanzees, Hobaiter and Byrne (2014) described for example 66 distinct gestures involving 495 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 496 497 include contact with peers, like the 'directed push', used with the ASO "reposition body", although 498 they are still considered as mechanically ineffective. The use of the same classification system, which 499 provides precise definitions of ASO, facilitates comparisons across species: a wide overlap has for 500 example been reported in the functions of gestures produced by bonobos and chimpanzees 501 (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).

513

514 Hidden assumptions about what 'function' of deictic gestures means in human and nonhuman515 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.

521 In human infant studies, declarative pointing is frequently interpreted based upon the assumption 522 that infants understand others as attentional and intentional agents (e.g., Liszkowski, Carpenter, 523 Henning, Striano, & Tomasello, 2004) and communicate for reasons other than achieving egocentric 524 goals (e.g., obtaining an out-of-reach object). Usually described as "the royal road to language" 525 (Butterworth, 2003), declarative pointing is also argued to be closely related to the development of 526 theory of mind abilities (Camaioni et al., 2004). The difference between the declarative and 527 imperative functions pertains as well to the ontogenetic origins of pointing gestures: imperative 528 pointing, which is often produced with the whole hand rather than with the index finger (Cochet, 529 Jover, Oger, & Vauclair, 2014), has been suggested to develop from non-communicative reaching 530 actions through a process of ontogenetic ritualization (Tomasello & Call, 1997). By contrast, the 531 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.

558 Although there have been a few reports of gestures that could be considered as declarative pointing 559 in enculturated apes (Leavens & Hopkins, 1999; Lyn, 2017), it is generally admitted that nonhuman 560 primates lack the motivation of sharing their experiences and interests in external objects or events 561 with others (e.g., Genty & Zuberbühler, 2015). Apes' gestures would therefore differ from human 562 gestures in the range of communicative motives they involve (Gómez, 2007; Tomasello, 2006), which 563 might explain the reluctance to label their deictic gestures as pointing. In wild apes, the rare authors 564 who have unambiguously described deictic gestures have not explicitly mentioned any 565 communicative function, cautiously highlighting that the same interaction could be subject to 566 multiple interpretations (Hobaiter et al., 2014). These researchers have however raised a key 567 question for the field of comparative cognition by inviting the reader to imagine how their 568 observations would be interpreted if human subjects were studied instead of chimpanzees.

569

#### 570 Hierarchy between communicative functions and between species

571 Similar behaviors seem indeed to be characterized in different ways in humans and nonhuman 572 primates. For example, if the ability to use deictic communication allows both human children and 573 captive apes to overcome the referential problem space and thus obtain a specific object (Kishimoto, 574 2013; Leavens et al., 2005), gestures produced by children are more likely to be characterized as 575 imperative pointing (even whole-hand gestures; Cochet & Vauclair, 2010a), while nonhuman 576 primate's gestures are more frequently defined as request or food-beg gestures (Bourjade, 577 Meguerditchian, et al., 2014; Meguerditchian et al., 2010). Likewise, in an attempt to determine the 578 goal of apes' (chimpanzees and bonobos) pointing, researchers have made a distinction between two 579 functions: requesting food and directing a recipient's attention towards food (Halina, Liebal, & 580 Tomasello, 2018). Even though the authors provide clear definition and operationalization of 581 pointing, the essence of this gesture seems in a way negated: the proposed distinction implies at first 582 that the production of pointing to request food does not require genuine triadic communication in

583 nonhuman primates. Yet, pointing is inherently produced to direct the other's attention on a 584 referent. Why has this study never been conducted in human children? The answer may well lie with 585 the influence of some implicit assumptions –here the existence of a hierarchy between the abilities 586 of nonhuman primates and human children, as well as between the two communicative functions of 587 pointing- on the initial formulation of research hypotheses. The declarative function seems to 588 benefit from a more "noble" status than the imperative function. This may be explained by the close 589 relationship between declarative pointing and language development (e.g., Camaioni, 1997) or by 590 the scarcity of declarative pointing reported in nonhuman primates. This highlights some 591 contradiction in comparative studies between a claimed search for continuity between human and 592 nonhuman primates, in particular for the question of communicative abilities, and the implicit 593 assumption that human cognitive abilities have no parallel in other primates (see Leavens, Bard, & 594 Hopkins, 2017). Rather than an actual hypothesis to test, the notion of cognitive hierarchy may 595 therefore sometimes take the shape of an initial premise that strengthens the contrast between 596 human and nonhuman primates through the different terms used and their definitions, and that 597 influences methodological choices.

598

#### 599 Summary

600 The scientific literature in either developmental psychology or comparative psychology has proposed 601 different terms and definitions to describe what we have referred to as the gesture functions, which 602 impacts the operationalization of gesture studies and may give rise to some oversights in the field of 603 comparative cognition. In human development, identifying gesture functions usually involves some 604 inferences about intentions, i.e., children are assigned with specific aims, plans or desires that are 605 regarded as the cause of their gestures. This approach is likely to be biased to some extent by our 606 representation of adult communication and does not acknowledge the lack of direct access to 607 infants' subjectivity, especially when verbal language is not yet accessible.

608 By contrast, the functions of communicative gestures in nonhuman primate studies are generally 609 inferred from their following consequences (ASO) in a given context, without any mention of 610 individuals' mental intents. Compared to research in human development, this approach thus 611 provides more restrictive but also more objective information about social interactions. 612 Notwithstanding, the use of ASO is not perfectly effective as it does not always take account of 613 motivational and contextual factors that can lead to cessation of gesturing, even though the initial 614 goal has not been reached. It remains also sometimes difficult to classify communicative gestures, 615 even when focusing on their immediate consequences rather than on inferred intentions, when 616 these consequences are not clear in the environment. Repeated occurrences are therefore usually 617 needed to remove any ambiguity in interaction situations and allow researchers to define the 618 function of a given gesture based on its most common outcome.

619

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

621 As we have illustrated above, both conceptual diversity and hidden assumptions can lead to 622 fallacious comparisons between gesture studies. Following Machado and Silva (2007), the concept of 623 gesture suffers from several conceptual weaknesses that are; (i) various degrees of semantic 624 ambiguity,(ii) several unacknowledged assumptions, and (iii) inappropriate classifications of what a 625 gesture is and is not, from one study to another. Semantic ambiguity occurs when one term is used 626 to refer to different phenomena, starting here with the concept of gesture itself, but involving also 627 the 'function' of gesture. Unacknowledged assumptions are the covert assumptions made by 628 researchers, most probably unconsciously, about a concept that is necessarily defined using other 629 concepts taken as logical premises. We provided an example of this issue with the different 630 conceptions of 'communication' that were used to define a 'communicative gesture'. The implicit 631 cognitive hierarchy between imperative and declarative pointing gestures provides another example. 632 Covert assumptions generally rely on several 'steps' in the argument that are implicitly known by the

633 author of a given claim, but which become illogical for anyone who does not share the same original 634 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 635 636 experiments were designed to elicit exclusively declarative gestures (Liszkowski & Tomasello, 2011), 637 indirectly suggesting that only the latter can be considered as genuine human pointing. This study 638 might thus lead to conclusions that are incompatible with imperative pointing, and therefore 639 fallacious or illogical for researchers who do not share the view that human pointing gesture is 640 necessarily declarative. Then, inappropriate classifications occur when a given behavior is alternately 641 categorized as a gesture or as a non-gesture under various definitions of the concept. Furthermore, 642 inappropriate classifications also occur –and it is much worse- when two researchers using the same 643 definition categorize the same behavior as either a gesture or a non-gesture. This issue arises when 644 definitions possess too much room for interpretation, or in other words when definitions do not 645 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.

650 < 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

auditory or tactile, be produced in the presence of an audience and directed to specific partner(s).
Any behavior corresponding to this series of criteria was thus categorized as a gesture. Then, the fact
that no intentional property was specified as a criterion for defining gesture does not imply that
baboon gestures were not intentional. Actually baboons use gestures intentionally (Molesti et al., *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 some examples of behavior that can be categorized as a gesture or a non-gesture according to our 665 666 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.

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

708 resulting in the possibility to directly compare their study with the four studies presented here using 709 Table 3. In this regard, chimpanzee gestures in their revised catalogue; (i) involve moves of any body 710 part including face, (ii) have visual component associated or not with auditory and tactile 711 components – the possible use of vocal chords is unspecified, (iii) are produced towards a specific 712 recipient while looking at it, (iv) are a subcategory of signal that are mechanically ineffective and in 713 most cases followed by a change in the recipient's behavior, (v) are necessarily intentional signals -714 defined as being produced towards attentive recipient and/or followed by responses waiting and/or 715 repeated or elaborated until satisfying outcome is attained, and finally, they are expressed in various 716 contexts and associated with ASOs. Moreover, the authors offered a series of six physical features to 717 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 718 719 contact. All were associated with definite possible values that had to be recorded for any gesture of 720 the catalogue. While it is clear that these features add a critical step forward a systematic description 721 of gestures, we argue that specifying operational criteria associated with 'what we consider to be a 722 gesture' is a preliminary step of scientific description that must not be overlooked. Thus, we 723 advocate using theoretical definitions bounded up with a series of operational criteria (e.g., Hobaiter 724 & Byrne (2017); the present paper) from the first stage of the scientific description. Then, computing 725 the logical combinations of all possible gestures using a finite set of physical features will 726 undoubtedly lead to higher scientific fecundity regarding the testability of hypotheses in the domain 727 of gestural communication (Vautier, 2011).

728

#### 729 Conclusion

730 Definitions are social conventions that result from more or less implicit categorization processes. It is 731 not surprising that everyone does not categorize exactly the same way, partly under the influence of 732 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.

768

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781

## 782 Statement of ethics

783 The authors have no ethical conflicts to disclose.

## 784 **Disclosure Statement**

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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 $N_1 = 26$ Experimental $N_2 = 8$ $N_3 = 25$ $N_4 = 48$	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)

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

## 1107

	Overt characteristics	Covert characteristics
Shared characteristics	All definitions assume gesture to be a	All definitions assume gesture to
	communicative means	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 acceptions according to the four studies' first author
	Shared characteristics Divergent characteristics	Overt characteristics           Shared characteristics         All definitions assume gesture to be a communicative means           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

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 melduling 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	na
	CG is visual or visual and vocal (mobilizing the vocal chords)	na	0	0	0
	CG is visual or visual and tactile	1	1	1	1
Social expression	CG is produced in the presence of an andience	1	1	na	1
	CG is addressed to specific recipient(s)	1	1	na	1
	CG is produced while looking at the recipient	0	0	na	na
Communicative	CG encompasses all communicative signals	0	0	0	0
property	CG is a subcategory of communicative signals	1	1	1	1
	CG is mechanically ineffective	па	1	na	na
	CG is followed by a change in the recipient's behavior in most cases	na	1	na	na
Intentional	CG is necessarily an intentional communicative signal	0	0	1	1
property	CG is produced towards a visually attentive recipient	0	0	na	na
	CG is followed by response waiting (a pause in the gesturer's actions)	0	0	na	na
	CG is repeated, combined or replaced by other CGs if no response comes	0	0	na	na
	CG is not consistently triggered by specific environmental conditions	0	0	1	1
	CG is expressed in various fonctional contexts	0	0	na	na
	CG is associated with an Apparently Satisfactory Outcome (ASO)	0	0	na	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