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

3

4 *Marie Bourjade^{1*}, H  l  ne Cochet¹, Sandra Molesti^{1,2}, Mich  le Guidetti¹*

5

6 ¹ CLLE, Universit   de Toulouse, CNRS, Toulouse, France

7 ² Aix-Marseille Universit  , PSYCLE EA3273, Aix-en-Provence, France

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

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11 *Corresponding author: M. Bourjade, UMR 5263 Cognition Langues Langage Ergonomie -

12 Laboratoire Travail et Cognition (CLLE-LTC) Maison de la recherche C-616, Universit  

13 Toulouse Jean Jaur  s, 5 all  es Antonio Machado, 31058 Toulouse cedex, France

14 E-mail address: marie.bourjade@univ-tlse2.fr

15 Telephone number: +033 5 61 50 35 41

16 ORCID ID: 0000-0002-3216-8284

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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
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.

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
41 scientific fields do investigate the *same* concepts using different angles, opening the route for
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 2018¹ 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 (<http://gesturestudies.com/>). Operational studies of

¹ Of January 23rd 2018!

58 gesture, through systematic description, experiment, mathematical modelling or machine learning all
59 work out their own definitions of gesture, which are often tailored to their specific objectives and
60 hence question the use of either broad or narrow, unified or diverse definitions of gesture in
61 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;
65 Kersken, Gómez, Liszkowski, Soldati, & Hobaiter, 2018). Gestural communication precedes speech
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, &
88 Young, 2000), or conveying prosodic components like discourse emphasis or disambiguation (Esteve-
89 Gibert & Guellaï, 2018; Guellaï, Langus, & Nespors, 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).

101 Indeed, the importance of gestures to communication and language is not restricted to modern
102 humans. Great apes and monkeys, our closest phylogenetic relatives, also possess complex gestural
103 systems of communication (Byrne et al., 2017; Liebal & Call, 2012; Liebal & Oña, 2018; Tomasello &
104 Call, 2018) which are candidate precursors of modern language (Corballis, 2003; Hewes, 1973;
105 Vauclair, 2004). There is good evidence suggesting that gestures might prefigure speech in the
106 evolution of language. In particular, great apes and monkeys have extended gestural repertoires and
107 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
161 distinct populations identified by Scott and Pika (i.e., monkeys, apes, human infants; 2012).
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’**

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

183 this article) in the field of comparative developmental psychology that were concerned with
184 language development and/or evolution. We first examined resemblances and differences between
185 gesture definitions, identifying common ground, idiosyncrasies and hidden assumptions. Then, we
186 made covert assumptions overt by specifying related concepts invoked in each of the four
187 definitions. Finally, we explored the consequences of using the broadest and the narrowest
188 definitions in all four studies, while providing evidence of internal coherence from selecting a specific
189 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
206 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
212 communication met the criteria of intentional gestural communication, namely (i) the adjustment to
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

284 that holistic meaning, propositional meaning arises when signals act as words whose precise meaning
285 can be combined to form a higher-order meaning (Fitch, 2010), which might occur when one
286 seriously considers the definition given by study 4. Indeed, study 4 was the only one to mention that
287 gestures were used to convey specific messages from signalers to receivers, although whether the
288 message was specific or holistic was underspecified (see the next section for a detailed discussion on
289 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*

315 In this regard, it is worth noting that each researcher’s definition of communication was in good
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
332 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

358 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
385 production in context. However, the single term "function" has been used in both approaches, thus
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*

400 There are numerous classifications of communicative gestures in human studies, mostly inspired by
401 semiotics (Kendon, 2004; McNeill, 2008). Contrary to iconic and symbolic gestures that parallel words
402 in verbal communication, the meaning of gestures characterized as *deictic* is less definite and may be
403 equivocal. Initially used to describe words or phrases that can only be understood depending on the
404 context in which they are used (e.g., "that one", "you", "here"), the term 'deictic' also refers to
405 gestures that are directly connected to and influenced by their referents: pointing gestures are for
406 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

457 with the adult about that picture, but may be characterized as what has been called an *interrogative*
458 gesture if we consider that the child wants to learn about that picture and what it represents
459 (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
462 movement kinematics (e.g., peak velocity), gaze coordination (e.g., frequency of gaze alternation)
463 and vocalizations (e.g., pitch and rhythm contour) (Cameron-Faulkner, 2014; Cochet & Vauclair,
464 2010b; Grünloh & Liskowski, 2015). These micro-analyses, 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
496 cases) to the ‘roll over’ (used with the ASO "start play” or “resume play”). Several gestures also
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).

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

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

513

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

516 This close examination of gesture functions in human infant and nonhuman primate studies reveals a
517 critical gap in the phenomena that are referred to by the term ‘function’ in each subfield of research.
518 In line with our examination of conceptual diversity in gesture definitions (section I), we propose that
519 implicit assumptions may underpin such a limited semantic overlap of what ‘function’ means in each
520 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., Liskowski, 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
635 human pointing gesture", the question of pointing functions was not mentioned, but the
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.

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

650 < *Insert Table 3* >

651 Categories of criteria cover the body parts used to gesture, the sensory modalities mobilized by the
652 gesture, the characteristics of its social expression, its communicative properties and intentional
653 properties. Scoring '1' means that the criterion is necessary for a behavior to be categorized as a
654 gesture. Scoring '0' means that the criterion is not necessary for a given behavior to be categorized
655 as a gesture. In study 1 for example, which aimed at investigating the gestural repertoire of olive
656 baboons, the definition of gesture satisfies seven of the 22 criteria. To be considered a gesture in this
657 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

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
718 single or double limb, (4) the use of an object, (5) the rhythmic repetition and (6) the physical
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

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

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

768

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792 **References**

- 793 Alibali, M. W., Kita, S., & Young, A. J. (2000). Gesture and the process of speech production: We think,
794 therefore we gesture. *Language and Cognitive Processes, 15*(6), 593–613.
795 doi:10.1080/016909600750040571
- 796 Aureli, T., Spinelli, M., Fasolo, M., Garito, M. C., Perucchini, P., & D’Odorico, L. (2017). The pointing–
797 vocal coupling progression in the first half of the second year of life. *Infancy, 22*(6), 801–818.
798 doi:10.1111/infa.12181
- 799 Austin, J. L. (1962). *How to Do Things with Words*. Oxford: Oxford University Press.
- 800 Bard, K. A. (2017). Dyadic interactions, attachment and the presence of triadic interactions in
801 chimpanzees and humans. *Infant Behavior and Development, 48*, 13–19.
802 doi:10.1016/j.infbeh.2016.11.002
- 803 Bard, K., Bakeman, R., Boysen, S., & Leavens, D. (2014). Emotional engagements predict and enhance
804 social cognition in young chimpanzees. *Developmental Science, 17*(5), 682–696.
805 doi:10.1111/desc.12145
- 806 Bates, E., Camaioni, L., & Volterra, V. (1975). The acquisition of performatives prior to speech.
807 *Merrill-Palmer Quarterly, 21*(3), 205–226.
- 808 Blake, J., O’Rourke, P., & Borzellino, G. (1994). Form and function in the development of pointing and
809 reaching gestures. *Infant Behavior and Development, 17*(2), 195–203. doi:10.1016/0163-
810 6383(94)90055-8
- 811 Bourjade, M., Canteloup, C., Meguerditchian, A., Vauclair, J., & Gaunet, F. (2014). Training experience
812 in gestures affects the display of social gaze in baboons’ communication with a human.
813 *Animal Cognition, 1*–12. doi:10.1007/s10071-014-0793-5
- 814 Bourjade, M., Gaunet, F., Maugard, A., & Meguerditchian, A. (in prep.). Effects of differential
815 experience on the processing of human cues to attention by olive baboons.

816 Bourjade, M., Meguerditchian, A., Maille, A., Gaunet, F., & Vauclair, J. (2014). Olive baboons, *Papio*
817 *anubis*, adjust their visual and auditory intentional gestures to the visual attention of others.
818 *Animal Behaviour*, *87*, 121–128. doi:10.1016/j.anbehav.2013.10.019

819 Broaders, S. C., Cook, S. W., Mitchell, Z., & Goldin-Meadow, S. (2007). Making children gesture brings
820 out implicit knowledge and leads to learning. *Journal of Experimental Psychology: General*,
821 *136*(4), 539–550. doi:10.1037/0096-3445.136.4.539

822 Byrne, R. W., Cartmill, E., Genty, E., Graham, K. E., Hobaiter, C., & Tanner, J. (2017). Great ape
823 gestures: Intentional communication with a rich set of innate signals. *Animal Cognition*,
824 *20*(4), 755–769. doi:10.1007/s10071-017-1096-4

825 Camaioni, L. (1997). The emergence of intentional communication in ontogeny, phylogeny, and
826 pathology. *European Psychologist*, *2*(3), 216–225. doi:10.1027/1016-9040.2.3.216

827 Camaioni, L., Perucchini, P., Bellagamba, F., & Colonesi, C. (2004). The role of declarative pointing in
828 developing a theory of mind. *Infancy*, *5*(3), 291–308. doi:10.1207/s15327078in0503_3

829 Cameron-Faulkner, T. (2014). The development of speech acts. *Pragmatic Development in First*
830 *Language Acquisition*, 37–52. doi:10.1075/tilar.10.03cam

831 Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint
832 attention, and communicative competence from 9 to 15 months of age. *Monographs of the*
833 *Society for Research in Child Development*, *63*(4), 1–174. doi:10.2307/1166214

834 Cartmill, E. A., & Byrne, R. W. (2007). Orangutans modify their gestural signaling according to their
835 audience's comprehension. *Current Biology*, *17*(15), 1345–1348.
836 doi:10.1016/j.cub.2007.06.069

837 Cartmill, E. A., & Byrne, R. W. (2011). Addressing the problems of intentionality and granularity in
838 non-human primate gesture. In G. Stam & M. Ishino (Eds.), *Integrating Gestures: The*
839 *Interdisciplinary Nature of Gesture* (p.15-26). Amsterdam, The Netherlands: John Benjamins.

840 Cartmill, E., & Byrne, R. (2010). Semantics of primate gestures: Intentional meanings of orangutan
841 gestures. *Animal Cognition*, *13*(6), 793–804. doi:10.1007/s10071-010-0328-7

842 Chu, M., & Kita, S. (2011). The nature of gestures' beneficial role in spatial problem solving. *Journal of*
843 *Experimental Psychology: General*, 140(1), 102. doi:10.1037/a0021790

844 Church, R. B., & Goldin-Meadow, S. (1986). The mismatch between gesture and speech as an index of
845 transitional knowledge. *Cognition*, 23(1), 43–71. doi:10.1016/0010-0277(86)90053-3

846 Cochet, H. (2011). *Hand shape, function and hand preference of communicative gestures in young*
847 *children: Insights into the origins of human communication* (Doctoral dissertation). Aix-
848 Marseille Université, France.

849 Cochet, H. (2012). Development of hand preference for object-directed actions and pointing
850 gestures: A longitudinal study between 15 and 25 months of age. *Developmental*
851 *Psychobiology*, 54(1), 105–111. doi:10.1002/dev.20576

852 Cochet, H. (2016). Manual asymmetries and hemispheric specialization: Insight from developmental
853 studies. *Neuropsychologia*, 93, 335–341. doi:10.1016/j.neuropsychologia.2015.12.019

854 Cochet, H., & Byrne, R. W. (2016). Communication in the second and third year of life: Relationships
855 between nonverbal social skills and language. *Infant Behavior and Development*, 44, 189–
856 198. doi:10.1016/j.infbeh.2016.07.003

857 Cochet, H., Jover, M., Oger, L., & Vauclair, J. (2014). Morphological differences between imperative
858 and declarative pointing: Hand shape, arm extension, and body posture. *Journal of Motor*
859 *Behavior*, 46(4), 223–232. doi:10.1080/00222895.2014.889066

860 Cochet, H., Jover, M., & Vauclair, J. (2011). Hand preference for pointing gestures and bimanual
861 manipulation around the vocabulary spurt period. *Journal of Experimental Child Psychology*,
862 110(3), 393–407. doi:10.1016/j.jecp.2011.04.009

863 Cochet, H., & Vauclair, J. (2010a). Features of spontaneous pointing gestures in toddlers. *Gesture*,
864 10(1), 86–107. doi:10.1075/gest.10.1.05coc

865 Cochet, H., & Vauclair, J. (2010b). Pointing gestures produced by toddlers from 15 to 30 months:
866 Different functions, hand shapes and laterality patterns. *Infant Behavior and Development*,
867 33(4), 431–441. doi:10.1016/j.infbeh.2010.04.009

868 Colonnesi, C., Rieffe, C., Koops, W., & Perucchini, P. (2008). Precursors of a theory of mind: A
869 longitudinal study. *British Journal of Developmental Psychology*, *26*(4), 561–577. doi:
870 10.1348/026151008x285660

871 Colonnesi, C., Stams, G. J. J., Koster, I., & Noom, M. J. (2010). The relation between pointing and
872 language development: A meta-analysis. *Developmental Review*, *30*(4), 352–366.
873 doi:10.1016/j.dr.2010.10.001

874 Corballis, M. C. (2003). From mouth to hand: Gesture, speech, and the evolution of right-handedness.
875 *Behavioral and Brain Sciences*, *26*(02), 199–208. doi:10.1017/S0140525X03000062

876 Courtin, C., Jobard, G., Vigneau, M., Beaucousin, V., Razafimandimby, A., Hervé, P.-Y., ..., & Mazoyer,
877 B. (2011). A common neural system is activated in hearing non-signers to process French sign
878 language and spoken French. *Brain Research Bulletin*, *84*(1), 75–87.
879 doi:10.1016/j.brainresbull.2010.09.013

880 Crais, E., Douglas, D. D., & Campbell, C. C. (2004). The Intersection of the development of gestures
881 and intentionality. *Journal of Speech, Language, and Hearing Research*, *47*(3), 678–694.
882 doi:10.1044/1092-4388(2004/052)

883 Esteve-Gibert, N., & Guellaï, B. (2018). Prosody in the auditory and visual domains: A developmental
884 perspective. *Frontiers in Psychology*, *9*. doi:10.3389/fpsyg.2018.00338

885 Fitch, W. T. (2010). *The Evolution of Language*. Cambridge, UK: Cambridge University Press.

886 Gentilucci, M., & Volta, R. D. (2008). Spoken language and arm gestures are controlled by the same
887 motor control system. *The Quarterly Journal of Experimental Psychology*, *61*(6), 944–957.
888 doi:10.1080/17470210701625683

889 Genty, E., Breuer, T., Hobaiter, C., & Byrne, R. W. (2009). Gestural communication of the gorilla
890 (*Gorilla gorilla*): Repertoire, intentionality and possible origins. *Animal Cognition*, *12*(3), 527–
891 546. doi:10.1007/s10071-009-0213-4

892 Genty, E., & Zuberbühler, K. (2014). Spatial reference in a bonobo gesture. *Current Biology*, *24*(14),
893 1601–1605. doi:10.1016/j.cub.2014.05.065

- 894 Genty, E., & Zuberbühler, K. (2015). Iconic gesturing in bonobos. *Communicative & Integrative*
895 *Biology*, 8(1), e992742. doi:10.4161/19420889.2014.992742
- 896 Goldin-Meadow, S. (2009). How gesture promotes learning throughout childhood. *Child Development*
897 *Perspectives*, 3(2), 106–111. doi:10.1111/j.1750-8606.2009.00088.x
- 898 Goldin-Meadow, S., & Alibali, M. W. (2013). Gesture's role in speaking, learning, and creating
899 language. *Annual Review of Psychology*, 64(1), 257–283. doi:10.1146/annurev-psych-113011-
900 143802
- 901 Goldin-Meadow, S., Cook, S. W., & Mitchell, Z. A. (2009). Gesturing gives children new ideas about
902 math. *Psychological Science*, 20(3), 267–272. doi:10.1111/j.1467-9280.2009.02297.x
- 903 Goldin-Meadow, S., & Singer, M. A. (2003). From children's hands to adults' ears: Gesture's role in
904 the learning process. *Developmental Psychology*, 39(3), 509–520. doi:10.1037/0012-
905 1649.39.3.509
- 906 Gómez, J.-C. (2007). Pointing behaviors in apes and human infants: A balanced interpretation. *Child*
907 *Development*, 78(3), 729–734. doi:10.1111/j.1467-8624.2007.01027.x
- 908 Graham, K. E., Furuichi, T., & Byrne, R. W. (2017). The gestural repertoire of the wild bonobo (*Pan*
909 *paniscus*): A mutually understood communication system. *Animal Cognition*, 20(2), 171–177.
910 doi:10.1007/s10071-016-1035-9
- 911 Graham, K. E., Hobaiter, C., Ounsley, J., Furuichi, T., & Byrne, R. W. (2018). Bonobo and chimpanzee
912 gestures overlap extensively in meaning. *PLoS Biology*, 16(2), e2004825.
913 doi:10.1371/journal.pbio.2004825
- 914 Grünloh, T., & Liszkowski, U. (2015). Prelinguistic vocalizations distinguish pointing acts. *Journal of*
915 *Child Language*, 42(6), 1312–1336. doi:10.1017/s0305000914000816
- 916 Guellai, B., Langus, A., & Nespors, M. (2014). Prosody in the hands of the speaker. *Frontiers in*
917 *Psychology*, 5, 700. doi:10.3389/fpsyg.2014.00700
- 918 Guidetti, M. (2002). The emergence of pragmatics: Forms and functions of conventional gestures in
919 young French children. *First Language*, 22(3), 265–285. doi:10.1177/014272370202206603

920 Guidetti, M., Fibigerova, K., & Colletta, J.-M. (2014). Gestures and multimodal development: Some
921 key issues for child language acquisition. In M. Seyfeddinipur & M. Gullberg (Eds.), *From*
922 *Gesture in Conversation to Visible Action as Utterance: Essays in Honor of Adam Kendon* (pp.
923 351-370). Amsterdam, Philadelphia: John Benjamins Publishing.

924 Halina, M., Liebal, K., & Tomasello, M. (2018). The goal of ape pointing. *PLoS One*, *13*(4), e0195182.
925 doi:10.1371/journal.pone.0195182

926 Hewes, G. W. (1973). Primate communication and the gestural origin of language. *Current*
927 *Anthropology*, *14*(1/2), 5–24. doi:10.1086/204019

928 Hobaiter, C., & Byrne, R. W. (2014). The meanings of chimpanzee gestures. *Current Biology*, *24*(14),
929 1596–1600. doi:10.1016/j.cub.2014.05.066

930 Hobaiter, C., & Byrne, R. W. (2017). What is a gesture? A meaning-based approach to defining
931 gestural repertoires. *Neuroscience & Biobehavioral Reviews*, *82*, 3–12.
932 doi:10.1016/j.neubiorev.2017.03.008

933 Hobaiter, C., Leavens, D. A., & Byrne, R. W. (2013). Deictic gesturing in wild chimpanzees (*Pan*
934 *troglydytes*)? Some possible cases. *Journal of Comparative Psychology*, *128*, 82–87.
935 doi:10.1037/a0033757

936 Hopkins, W. D., & Vauclair, J. (2012). Evolution of behavioral and brain asymmetries in primates. In
937 M. Tallerman & K. R. Gibson (Eds.), *The Oxford Handbook of Language Evolution* (p. 184-197).
938 Oxford: Oxford University Press.

939 Hopkins, William D., & Wesley, M. J. (2002). Gestural communication in chimpanzees (*Pan*
940 *troglydytes*): The influence of experimenter position on gesture type and hand preference.
941 *Laterality: Asymmetries of Body, Brain and Cognition*, *7*(1), 19–30.
942 doi:10.1080/13576500143000113

943 Hostetter, A., Russell, J., Freeman, H., & Hopkins, W. (2007). Now you see me, now you don't:
944 Evidence that chimpanzees understand the role of the eyes in attention. *Animal Cognition*,
945 *10*(1), 55–62. doi:10.1007/s10071-006-0031-x

946 Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development.
947 *Psychological Science*, 16(5), 367–371. doi:10.1111/j.0956-7976.2005.01542.x

948 Kampe, K. K., Frith, C. D., & Frith, U. (2003). “Hey John”: Signals conveying communicative intention
949 toward the self activate brain regions associated with “mentalizing,” regardless of modality.
950 *Journal of Neuroscience*, 23(12), 5258–5263. doi:10.1523/jneurosci.23-12-05258.2003

951 Kendon, A. (2004). *Gesture: Visible Action as Utterance*. Cambridge: Cambridge University Press.

952 Kersken, V., Gómez, J.-C., Liskowski, U., Soldati, A., & Hobaiter, C. (2018). A gestural repertoire of 1-
953 to 2-year-old human children: In search of the ape gestures. *Animal Cognition*.
954 doi:10.1007/s10071-018-1213-z

955 Kishimoto, T. (2013). Do referential problem spaces affect the frequency of imperative pointing by
956 infants? *Psychology of Language and Communication*, 17(3), 295–307. doi:10.2478/plc-2013-
957 0019

958 Kita, S. (2003). Pointing: A foundational building block of human communication. In S. Kita (Ed.),
959 *Pointing: Where Language, Culture, and Cognition Meet* (p. 1–8). Mahwah: Lawrence
960 Erlbaum Associates.

961 Lamaury, A., Cochet, H., & Bourjade, M. (in press). Acquisition of joint attention by olive baboons
962 gesturing towards humans. *Animal Cognition*. doi:10.1007/s10071-017-1111-9

963 Leavens, D. A. (2004). Manual deixis in apes and humans. *Interaction Studies*, 5(3), 387–408.
964 doi:10.1075/is.5.3.05lea

965 Leavens, D. A. (2018). The Cognitive implications of intentional communication: A multifaceted
966 mirror. In L. D. Di Paolo, F. Di Vincenzo, & F. De Petrillo (Eds.), *Evolution of Primate Social*
967 *Cognition* (pp. 59–77). Cham: Springer International Publishing.

968 Leavens, D. A., Bard, K. A., & Hopkins, W. D. (2017). The mismeasure of ape social cognition. *Animal*
969 *Cognition*, 1–18. doi:10.1007/s10071-017-1119-1

970 Leavens, D. A., & Hopkins, W. D. (1998). Intentional communication by chimpanzees: A cross-
971 sectional study of the use of referential gestures. *Developmental Psychology*, *34*(5), 813–822.
972 doi:10.1037/0012-1649.34.5.813

973 Leavens, D. A., & Hopkins, W. D. (1999). The whole-hand point: The structure and function of
974 pointing from a comparative perspective. *Journal of Comparative Psychology*, *113*(4), 417–
975 425. doi:10.1037/0735-7036.113.4.417

976 Leavens, D. A., Russell, J. L., & Hopkins, W. D. (2005). Intentionality as measured in the persistence
977 and elaboration of communication by chimpanzees (*Pan troglodytes*). *Child Development*,
978 *76*(1), 291–306. doi:10.1111/j.1467-8624.2005.00845.x

979 Leavens, D. A., Hopkins, W. D., & Bard, K. A. (2005). Understanding the point of chimpanzee pointing:
980 Epigenesis and ecological validity. *Current Directions in Psychological Science*, *14*(4), 185–189.
981 doi:10.1111/j.0963-7214.2005.00361.x

982 Liebal, K., & Call, J. (2012). The origins of non-human primates' manual gestures. *Philosophical*
983 *Transactions of the Royal Society B: Biological Sciences*, *367*(1585), 118–128.
984 doi:10.1098/rstb.2011.0044

985 Liebal, K., & Oña, L. (2018). Different approaches to meaning in primate gestural and vocal
986 communication. *Frontiers in Psychology*, *9*, 478. doi:10.3389/fpsyg.2018.00478

987 Liebal, K., Schneider, C., & Errson-Lembeck, M. (2018). How primates acquire their gestures:
988 Evaluating current theories and evidence. *Animal Cognition*, 1–14. doi:10.1007/s10071-018-
989 1187-x

990 Liszkowski, U., Brown, P., Callaghan, T., Takada, A., & Vos, C. de. (2012). A prelinguistic gestural
991 universal of human communication. *Cognitive Science*, *36*(4), 698–713. doi:10.1111/j.1551-
992 6709.2011.01228.x

993 Liszkowski, U., Carpenter, M., Henning, A., Striano, T., & Tomasello, M. (2004). Twelve-month-olds
994 point to share attention and interest. *Developmental Science*, *7*(3), 297–307.
995 doi:0.1111/j.1467-7687.2004.00349.x

- 996 Liszkowski, U., Carpenter, M., & Tomasello, M. (2007). Reference and attitude in infant pointing.
997 *Journal of Child Language*, 34(1), 1–20. doi:10.1017/S0305000906007689
- 998 Liszkowski, U., & Tomasello, M. (2011). Individual differences in social, cognitive, and morphological
999 aspects of infant pointing. *Cognitive Development*, 26(1), 16–29.
1000 doi:10.1016/j.cogdev.2010.10.001
- 1001 Lüke, C., Grimminger, A., Rohlfing, K. J., Liszkowski, U., & Ritterfeld, U. (2017). In infants' hands:
1002 Identification of preverbal infants at risk for primary language delay. *Child Development*,
1003 88(2), 484–492. doi:10.1111/cdev.12610
- 1004 Lyn, H. (2017). The question of capacity: Why enculturated and trained animals have much to tell us
1005 about the evolution of language. *Psychonomic Bulletin & Review*, 24(1), 85–90.
1006 doi:10.3758/s13423-016-1129-z
- 1007 Machado, A., & Silva, F. J. (2007). Toward a richer view of the scientific method: The role of
1008 conceptual analysis. *American Psychologist*, 62(7), 671–681. doi:10.1037/0003-066X.62.7.671
- 1009 Maille, A., Engelhart, L., Bourjade, M., & Blois-Heulin, C. (2012). To beg, or not to beg? That is the
1010 question: Mangabeys modify their production of requesting gestures in response to human's
1011 attentional states. *PLoS ONE*, 7(7), e41197. doi:10.1371/journal.pone.0041197
- 1012 Mastin, J. D., & Vogt, P. (2016). Infant engagement and early vocabulary development: a naturalistic
1013 observation study of Mozambican infants from 1;1 to 2;1. *Journal of Child Language*, 43(2),
1014 235–264. doi:10.1017/S0305000915000148
- 1015 Matthews, D., Behne, T., Lieven, E., & Tomasello, M. (2012). Origins of the human pointing gesture: A
1016 training study. *Developmental Science*, 15(6), 817–829. doi:10.1111/j.1467-
1017 7687.2012.01181.x
- 1018 McNeill, D. (1998). Speech and gesture integration. *New Directions for Child and Adolescent*
1019 *Development*, 1998(79), 11–27. doi:10.1002/cd.23219987902
- 1020 McNeill, D. (2000). *Language and Gesture* (Vol. 2). Cambridge: Cambridge University Press.
- 1021 McNeill, D. (2008). *Gesture and Thought*. Chicago: University of Chicago press.

- 1022 Meguerditchian, A., Vauclair, J., & Hopkins, W. D. (2010). Captive chimpanzees use their right hand to
1023 communicate with each other: Implications for the origin of the cerebral substrate for
1024 language. *Cortex*, *46*(1), 40–48. doi:10.1016/j.cortex.2009.02.013
- 1025 Meunier, H., Prieur, J., & Vauclair, J. (2013). Olive baboons communicate intentionally by pointing.
1026 *Animal Cognition*, *16*(2), 155–163. doi:10.1007/s10071-012-0558-y
- 1027 Molesti, S., Meguerditchian, A., & Bourjade, M. (unpublished data). Gestural communication in olive
1028 baboons (*Papio anubis*): Repertoire and properties.
- 1029 Moore, R. (2016). Meaning and ostension in great ape gestural communication. *Animal Cognition*,
1030 *19*(1), 223–231. doi:10.1007/s10071-015-0905-x
- 1031 Open Science Collaboration (2015). Estimating the reproducibility of psychological science. *Science*,
1032 *349*(6251), aac4716. doi:10.1126/science.aac4716.
- 1033 Penn, D. C., & Povinelli, D. J. (2013). The Comparative delusion: The “behavioristic/mentalistic”
1034 dichotomy in comparative theory. In J. Metcalfe & H. S. Terrace (Eds.), *Agency and Joint*
1035 *Attention* (p. 62–81). New-York: Oxford University Press.
- 1036 Perlman, M., Tanner, J. E., & King, B. J. (2012). A mother gorilla’s variable use of touch to guide her
1037 infant. In S. Pika & K. Liebal (Eds.), *Developments in Primate Gesture Research* (p. 55–72).
1038 Amsterdam: John Benjamins Publishing.
- 1039 Pika, S. (2008a). Gestures of apes and pre-linguistic human children: Similar or different? *First*
1040 *Language*, *28*(2), 116–140. doi:10.1177/0142723707080966
- 1041 Pika, S. (2008b). What is the nature of the gestural communication of great apes? In J. Zlatev, T.
1042 Racine, C. Sinha, & E. Itkonen (Eds.), *The Shared Mind* (p. 165–186). Amsterdam: John
1043 Benjamins Publishing.
- 1044 Pika, S., & Liebal, K. (2012). *Developments in Primate Gesture Research*. Amsterdam: John Benjamins
1045 Publishing.
- 1046 Pika, S., & Mitani, J. (2006). Referential gestural communication in wild chimpanzees (*Pan*
1047 *troglodytes*). *Current Biology: CB*, *16*(6), R191-192. doi:10.1016/j.cub.2006.02.037

- 1048 Rendall, D., Owren, M. J., & Ryan, M. J. (2009). What do animal signals mean? *Animal Behaviour*,
1049 78(2), 233–240. doi:10.1016/j.anbehav.2009.06.007
- 1050 Roberts, A. I., Vick, S.-J., & Buchanan-Smith, H. M. (2013). Communicative intentions in wild
1051 chimpanzees: Persistence and elaboration in gestural signalling. *Animal Cognition*, 16(2),
1052 187–196. doi:10.1007/s10071-012-0563-1
- 1053 Salomo, D., & Liszkowski, U. (2013). Sociocultural settings influence the emergence of prelinguistic
1054 deictic gestures. *Child Development*, 84(4), 1296–1307. doi:10.1111/cdev.12026
- 1055 Scheider, L., Waller, B. M., Oña, L., Burrows, A. M., & Liebal, K. (2016). Social use of facial expressions
1056 in hylobatids. *PLoS ONE*, 11(3), e0151733. doi:10.1371/journal.pone.0151733
- 1057 Scott, N. M., & Pika, S. (2012). A call for conformity Gesture studies in human and non-human
1058 primates. In S. Pika & K. Liebal (Eds.), *Developments in Primate Gesture Research* (p. 147–
1059 164). Amsterdam: John Benjamins Publishing.
- 1060 Scott-Phillips, T. C. (2015). Nonhuman primate communication, pragmatics, and the origins of
1061 language. *Current Anthropology*, 56(1), 56–80. doi:10.1086/679674
- 1062 Searle, J. R., & Vanderveken, D. (1985). Speech acts and illocutionary logic. In D. Vanderveken (Ed.),
1063 *Logic, Thought and Action* (p. 109–132). Berlin: Springer.
- 1064 Shannon, C. E., & Weaver, W. (1949). *A Mathematical Model of Communication*. Urbana: University
1065 of Illinois Press.
- 1066 Smith, W. J. (1977). *The Behavior of Communicating: An Ethological Approach*. Cambridge: Harvard
1067 University Press.
- 1068 Southgate, V., Van Maanen, C., & Csibra, G. (2007). Infant pointing: Communication to cooperate or
1069 communication to learn? *Child Development*, 78(3), 735–740. doi:10.1111/j.1467-
1070 8624.2007.01028.x
- 1071 Tomasello, M. (1995). Joint attention as social cognition. In C. Moore & P. J. Dunham (Eds.), *Joint*
1072 *Attention: Its Origins and Role in Development* (p. 103–130). Hillsdale, NJ, USA: Lawrence
1073 Erlbaum Associates, Inc.

- 1074 Tomasello, M. (2006). Why don't apes point? In N. J. Enfield & S. C. Levinson (Eds.), *Roots of Human*
1075 *Sociality: Culture, Cognition and Interaction* (pp. 506–524). Oxford & New-York: Berg.
- 1076 Tomasello, M., & Call, J. (1997). *Primate cognition*. Oxford: Oxford University Press.
- 1077 Tomasello, M., & Call, J. (2018). Thirty years of great ape gestures. *Animal Cognition*.
1078 doi:10.1007/s10071-018-1167-1
- 1079 Tomasello, M., Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. *Child*
1080 *Development*, 78(3), 705–722. doi:10.1111/j.1467-8624.2007.01025.x
- 1081 Townsend, S. W., Koski, S. E., Byrne, R. W., Slocombe, K. E., Bickel, B., Boeckle, M., ..., & Manser, M.
1082 B. (2017). Exorcising Grice's ghost: an empirical approach to studying intentional
1083 communication in animals. *Biological Reviews*, 92(3), 1427–1433. doi:10.1111/brv.12289
- 1084 Vauclair, J. (2004). Lateralization of communicative signals in nonhuman primates and the hypothesis
1085 of the gestural origin of language. *Interaction Studies*, 5(3), 365–386.
1086 doi:10.1075/is.5.3.04vau
- 1087 Vautier, S. (2011). The operationalization of general hypotheses versus the discovery of empirical
1088 laws in Psychology. *Philosophia Scientiæ*, 15(2), 105–122.
1089 doi:10.4000/philosophiascientiae.656
- 1090 Waller, B. M., Caeiro, C. C., & Davila-Ross, M. (2015). Orangutans modify facial displays depending on
1091 recipient attention. *PeerJ*, 3, e827. doi:10.7717/peerj.827
- 1092 Whiten, A. (1996). When does smart behaviour-reading become mind-reading? In P. Carruthers & P.
1093 K. Smith (Eds.), *Theories of Theories of Mind* (p. 277-292). Cambridge: Cambridge University
1094 Press.
- 1095 Xu, J., Gannon, P. J., Emmorey, K., Smith, J. F., & Braun, A. R. (2009). Symbolic gestures and spoken
1096 language are processed by a common neural system. *Proceedings of the National Academy of*
1097 *Sciences*, 106(49), 20664–20669. doi:10.1073/pnas.0909197106
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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)

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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 acceptions 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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