

What animals can tell us about attentional prerequisites of language acquisition



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ABSTRACT

Theories of human language acquisition frequently posit human-unique attentional specializations to jumpstart language acquisition. There is a broad consensus that the developmental processes supporting language acquisition in our species rely on human-unique cognitive adaptations pertaining to the deployment and understanding of attention. However, close attention to the empirical evidence held to support these hypothetical psychological processes, reveals significant gaps between the nature of the evidence provided and these conclusions. In ape-human comparisons, species is confounded with a myriad of lurking variables. We explore these confounds and their implications for models of human language acquisition that appeal to human-unique attentional adaptations, revealing a large theoretical space wherein the phenomena of attention deployment and understanding can coalesce under particular environmental regimes.

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Joint attention is the capacity to follow or to direct the attention of a social partner to a specific entity, real or conceptual (Leavens, 2021; Leavens and Racine, 2009; Moore and Dunham, 1995). This capacity manifests in Western children in the months leading to and succeeding their first year of life (e.g., Butterworth, 2003; Carpenter et al., 1998). Western children younger than about 8 or 9 months of age usually do not, apparently, discern an extended finger or a directed gaze as a communicative directive to redirect their own attention, nor do they produce such communicative directives, themselves (e.g., Carpenter et al., 1998; Franco and Butterworth, 1996; Leung and Rheingold, 1981). The significance for language development in our species is that these skills help establish associative links between entities in the world and children's growing lexicons: symbol and referent are linked if children can bring referents into their perception at the same time that labels for those entities are uttered (e.g., Baldwin and Markman, 1989). Once productive pointing has emerged, children rapidly begin to use points in apparent attempts to elicit labels for entities (e.g., Begus and Southgate, 2012).

The comprehension and production of directive (nonverbal deictic) cues, thus, have immense significance for understanding how children acquire language in typical development. The capacity for joint attention—following into, together with capturing and directing the attention of others to specific entities and loci—typically occurs predominantly in the visual-auditory modalities during language-learning (e.g., Butterworth, 2003; Mundy, 1995). However, children who are sight-impaired and hearing-impaired still, nevertheless, acquire languages, demonstrating that joint attention is not modality-constrained (e.g., Andersen et al., 1993; Harris and Chasin, 2005; Urwin, 1978). Joint attention is so necessary to the

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building of a common lexicon that many, if not most contemporary researchers characterise these attention-manipulation skills as a human-unique cognitive adaptation that evolved *in order to* foster language acquisition (e.g., [Butterworth, 2003](#); [Tomasello, 2008](#); [Tomasello et al., 2007a](#)). Here, we will briefly review the empirical evidence taken in support of this claim of human exceptionalism, and then critically examine some of that evidence. (We are grateful to an anonymous reviewer for pointing out that animals' use of others' gaze is an active and vibrant area of research, outside the area of language acquisition. For example, gaze-following is well-demonstrated in a variety of animal species and the presence of an observer can influence a range of animal behaviours; see, e.g., [Emery, 2000](#), for a review, [Tomasello et al., 1998](#), for gaze-following in primates, [Emery and Clayton, 2001](#), for effects of gaze on caching behaviour by scrub jays, *Aphelocoma coerulescens*, and [Ristau, 1991](#), for the effects of direct gaze on the “broken-arm” display of piping plovers, *Charadrius melodus*. However, we are concerned, here, with explicitly triadic communication, where at least two agents co-orient to a common focus because of the explicit communication of one of the interactants, [Leavens and Racine, 2009](#).) Finally, we will offer a more integrated perspective on the acquisition of these foundational interaction skills.

1. Evidence for the universality of human pointing

In his classic book on human ethology, [Eibl-Eisfeldt \(1989\)](#) reported that pointing with the index finger is a universal human gesture, and that claim has been widely promulgated in the scientific literature (e.g., [Butterworth, 2003](#)). Technically, a scientific claim of human universality in a particular gestural form minimally requires that its presence has been confirmed in all human cultures, without exception. There are, today, over 7000 different languages ([Eberhard et al., 2022](#)), yet, as far as we know, the gesture has been scientifically described in only a few dozen cultures, at most, in many Western and non-western countries (e.g., France [unspecified university]: [Cochet and Vauclair, 2014](#); West Papuo, Indonesia [Eipo], Mindanao, Philippines [Tboli], Arnhemland, Australia [Gidjingali], Venezuela/Brazil [Yanomami], Namibia/Angola/Botswana [!Kung]: [Eibl-Eisfeldt, 1989](#); United Kingdom [southern England]: [Flack et al., 2018](#); Mexico [Tzotzil Mayan]: [Haviland, 2003](#); Italy [Naples]: [Kendon and Versante, 2003](#); Japan [Tokyo]: [Kita, 2003](#); Papua New Guinea [Rossel Islanders], Indonesia [Balinese], Japan [Kyoto], Peru [Montaro Valley], Mexico [Tzeltal Mayan & Yucatec Mayan], Canada [Nova Scotia]: [Liszkowski et al., 2012](#); Mexico [Yucatec Mayan], The Netherlands [Dutch], China [unspecified urban locales]: [Salomo and Liszkowski, 2013](#); Australia [Arrente]: [Wilkins, 2003](#)). If we conservatively allow that pointing with the index finger is confirmed for people speaking 120 different languages, that still represents less than 2% of language groups and this percentage is inflated, when one considers the large number of languages that have been lost to science in the last half-millennium, since the onset of the European colonial era (e.g., [Eberhard et al., 2022](#)). On this basis, it seems to us to be premature to characterise this specific pointing posture as a universal human gesture, although we note, to echo the remarks of an anonymous reviewer, that the existence of pointing with the index fingers has been corroborated widely, to date; the only positive statement of the absence of this specific pointing gesture, to our knowledge, is a second-hand claim by [Wilkins \(2003\)](#) that the Barai people, of Papua New Guinea, lacked pointing with the index finger.

As [Cooperrider et al. \(2018\)](#) pointed out, however, even if it is likely that people point with their index fingers sometimes, “by the same reasoning, non-manual pointing is also likely universal” (p. 1377) and, moreover, non-manual pointing (pointing with the lips, the nose, and other appendages) is the preferred or canonical form of pointing in many cultures (see [Wilkins, 2003](#)). Moreover, it is becoming increasingly clear that the scientific descriptions of the mechanics of establishing simultaneous focus on a common focus have been, historically, deeply rooted in Western, postindustrial populations of humans, who differ from many non-Western cultures in how they deploy their gaze and their limbs in episodes of joint attention (e.g., [Bard et al., 2022](#)). Thus, just as there is no human universal behavioral expression of joint attention, or joint object engagement, animals will also display differences from Western humans in their embodied, kinesic accompaniments to joint attention, both for relatively trivial anatomical reasons (e.g., lacking hands) and, additionally, for reasons attributed to the relevance of joint attention to their specific, ecological circumstances ([Leavens, 2021](#)).

2. Evidence for uniquely human joint attention

The primary empirical basis for claiming that joint attention is a human-unique evolutionary adaptation for learning words is a body of work that directly compared humans and their nearest living relatives, the great apes (Hominidae), on tests of the ability to produce and to comprehend deictic cues (i.e., to point or to follow pointing or gaze gestures; reviewed by [Krause et al., 2018](#)). The general approach of this body of work, however, is deeply flawed; typically, researchers will sample Western, postindustrial children and compare them to cage-living captive apes in their abilities to follow or produce deictic cues (e.g., [van der Goot et al., 2014](#); [Liszkowski et al., 2009](#)). This approach is inherently inadequate to establish whether humans and apes differ in their capacity to produce and follow deictic cues because (a) the animals are tested in different physical contexts; (b) with different protocols; (c) under different sampling regimens (advertisement vs. opportunistic); (d) with radically different levels of pre-experimental task-relevant experience; and (e) at different developmental stages, even to the point of comparing ape adults with human infants (see [Leavens et al., 2019](#), for extended discussion). A primary consequence of this avalanche of lurking, confounded variables is that at the end of these experimental studies, it is impossible to determine whether any group performance differences between nonhuman primates and the human primates are attributable to their different evolutionary histories, as is often claimed, or to one or more of these confounded variables, in which representatives of apes and humans are treated profoundly differently before and during the experimental

treatments (e.g., Leavens, 2022). Thus, based on these elementary principles of research design and interpretation, there is not a single, published direct comparison of apes and humans that can support an interpretation of a species difference between any ape species and humans in their capacities to engage in joint attention, despite numerous contemporary claims to the contrary. It should be uncontroversial that claiming to find a “species difference” after comparing representatives of two species of organisms, using systematically different experimental protocols, at different stages of life, from radically different living environments, with incommensurate levels of task-relevant pre-experimental preparation, and with different sampling protocols is not a scientifically plausible claim, but claims of this precise nature have been relatively commonplace in the last 20 or 30 years (see Leavens et al., 2019, who propose some remediations for these systemic problems with ape-human comparisons, including the importance of explicit training of specific skills). Similar claims to the effect that dogs (*Canis lupus familiaris*) surpass great apes in their capacities to follow deictic cues (e.g., chimpanzees, *Pan troglodytes*, studied by Kirchofer et al., 2012) suffer from a similar lack of experimental and interpretive rigor; in fact, apes have no difficulty following pointing gestures, given a modicum of experience with the gestures (see Clark et al., 2019; Leavens, 2014; Leavens and Clark, 2017; Lyn et al., 2010; Russell et al., 2011).

In response to an anonymous reviewer’s concerns, we note that it is relatively straightforward to adjust the testing context towards greater similarity across groups than is currently typical in direct ape-human comparisons. For example, for safety reasons, most nonhuman primates are usually tested from within cages (Clark et al., 2019). We have successfully tested both human children (Clark et al., 2020) and dogs (Clark and Leavens, 2019, 2021) in simulated cages, in studies of their abilities to understand deictic cues, thereby making their testing environments more similar to those of nonhuman primates with respect to physical separation between subjects and apparatus.

Empirically, it is well-established that apes who have frequent, extended, daily interactions with people (enculturated apes) have no difficulty with following or producing deictic signals, including manual pointing (e.g., Call and Tomasello, 1994; Leavens and Clark, 2017; Lyn et al., 2010; Russell et al., 2011). For example, Lyn and her colleagues (2010) reported significantly higher performances by enculturated apes, compared to institutionalised apes, on a task requiring comprehension of pointing cues. Similarly, Russell and her colleagues (2011) matched 20 chimpanzees and bonobos (*Pan paniscus*) on age and sex, half of whom lived in institutional settings and half of whom were enculturated, finding that enculturated apes significantly outperformed institutionalised apes on a battery of assessments of both physical and social cognition, including both production and comprehension of deictic cues.

This distinction between institutionalised and enculturated apes warrants some additional discussion. Unsurprisingly, there are meaningful and increasingly well-documented effects of apes’ familiarity with human signalling conventions on their performances in tasks requiring the comprehension or production of conventional human signals, such as manual pointing. Many researchers who are unfamiliar with the institutional environments of great apes living in zoos or biomedical research centres will not necessarily be aware of just how little ape-human interaction occurs in many institutional settings. For example, institutionalised chimpanzees at one major primate research center, during the 1990s, experienced about 4 min of emotionally positive interaction with humans, *per day* (Bard, personal communication) during the 1990s. The number of opportunities for interaction with people vary dramatically for captive apes across the range of captive housing circumstances, and—as discussed above—the level of performance in producing points and in following human deictic signals also varies across apes in different settings and of different rearing histories (e.g., Bard et al., 2014; Leavens and Bard, 2011). This significant source of variability in the display of these social skills is obscured when researchers refer to all apes in all captive circumstances as “human-raised.” For example, Tomasello and Carpenter (2005) studied the cognitive development of three young chimpanzees, two of whom (Alexandra and Annet) had been raised in a biomedical research center for the first 22 months of their lives, before being moved and later incorporated into their study. These manifestly institutionalised apes were described by the authors as “human-raised” (p. 109; see also Tomasello et al., 2012, and Warneken et al., 2006, wherein these same chimpanzees were described as having been raised by humans). To refer to institutionalised apes as “human-raised” is problematic considering the cumulative effects of institutional rearing on cognitive development—for example, Nelson et al. (2007) documented increasingly deleterious effects on cognitive development of institutionalised children: the longer children were exposed to social deprivation, the lower their cognitive performance. Not only does mis-referring to institutionalised apes as “human-raised” mask a prominent and deleterious factor in their mental development, but the widespread failure also to match apes with humans on life-history stage, in direct ape-human comparisons, renders the incorrect impression that the apes, being older, might be advantaged in such comparisons, due to their advanced age.

The fact that some animals, including great apes, reliably develop gaze-following, point-following and related capabilities to interpret and manipulate the attention of their social partners, when they are given similar levels of exposure to human nonverbal signalling as human children receive, significantly challenges claims that such skills derive from human species-specific cognitive adaptations. Moreover, any organism who displays a lexicon (i.e., language-competent organisms), *ipso facto*, displays evidence of joint attentional competence. When Kanzi, a bonobo, placed a telephone on a television set in response to the verbal command “Put the telephone on the TV,” he evinced his shared attention with the experimenter to both the telephone and the television set (Savage-Rumbaugh et al., 1993, Tble 4, Example 30). There is little dispute that most language-trained great apes have acquired lexicons (e.g., Chantek, an orangutan, *Pongo pygmaeus/abellii* hybrid: Miles, 1990; Koko, a gorilla (*Gorilla gorilla*): Patterson and Cohn, 1990; Kanzi, a bonobo: Savage-Rumbaugh et al., 1993; Washoe, a chimpanzee: Gardner and Gardner, 1969), and this is also true of some other vertebrates (e.g., Alex, an African grey parrot,

Psittacus rithacus: Pepperberg, 1994), Thus, the fact of receptive and productive lexicons in animals entails that language-trained animals are capable of coordinating their attention with their social partners to specific loci (i.e., animals are capable of joint attention).

3. The Horowitz validation protocol

The sensitivity of great apes to deictic cues is often obscured by a systematic lack of regard for the developmental histories and life stages of great apes in direct ape-human comparisons (e.g., Bard and Leavens, 2014; Leavens et al., 2019). Almost never are great apes (or, indeed, other primates) compared to humans at the same life history stage; often, these comparisons involve the administration of infant- or child-appropriate assays to the young humans and, also, to the very much older apes; almost never have these infant-appropriate protocols been validated by their administration to human beings at the same life history stages at which they have been administered to great apes (e.g., Horowitz, 2003; Leavens and Bard, 2021).

The sheer scale of the problem of comparing across incommensurate life history stages is exemplified in Table 1, in which we documented the titles of published scientific articles that directly compared human infants or children with great apes. On 7 July 2022, we used the Web of Science database to search for titles with the following search criteria: (TI=(infants or children)) AND TI=(apes or chimpanzees). We then excluded secondary literature, chapters in books, non-behavioural dependent variables, and conference abstracts. This rendered a list of 109 titles, of which only nine (8%) matched the humans and apes on life history stage. From 1930 to 2022, only 11 of the 109 article titles (10%) specified the life history stages of the ape participants—in the remaining 98 cases, they were simply described in terms of their taxonomic status. In addition, prompted by a query from an anonymous reviewer, we found that of the 11 articles with titles containing a life history stage descriptor for ape participants, a large minority matched life history stages across humans and ape participants (5 of 11, or 45%). In contrast, of the 98 articles lacking life history stage descriptions in the titles, only four matched the groups on age class (4%). Thus, published research papers that included life history descriptors for the ape participants in their titles were more than 11 times more likely to have matched the groups on life history stage, compared to those studies that lacked this titular description. Perusal of Table 1 also makes clear that this disregard for the life history status of great apes is not a recent trend, but a longstanding characteristic of direct comparisons of humans with apes, from 1930 to the present day.

This denial of life history status to our nearest living relatives has significant implications for the interpretation of any group differences in response profiles: primarily, if a group difference is found, it is impossible to know whether this is because the groups are sampled from different taxa (phylogenetic explanation) or because the task at hand elicits different response profiles from infants and much older individuals (ontogenetic explanation). In other words, the comparison is structurally incapable of isolating phylogeny as an explanatory factor in the reported group difference (Leavens et al., 2019).

That life history status matters in direct species comparisons between humans and apes was demonstrated by Horowitz (2003) and Thomas and her colleagues (2008); in both of these studies, child-friendly research designs, previously developed by other researchers in direct human-ape comparisons, were administered to human adults, with the result that human adults displayed response profiles more similar to those of the apes in the previous studies and correspondingly dissimilar to the response profiles of the human children in those studies. The validation comprises a simple, two-step procedure for validating findings from previously published research: first, assume that human adults represent the pinnacle of cognitive sophistication, then, second, validate protocols originally used with human babies and nonhuman animals by administering them to human adults. If the adult humans' response profiles are more similar to those of the human children in the previous ape-human comparisons, then the original procedure is validated for discriminating between the species (albeit such a result would not isolate evolutionary history as the reason for the difference). Alternatively, if the adult humans' response profiles are more similar to those of the great apes in the previous studies, then this implies that the apes had displayed a pattern of responses congruent with those of human adults, who can be reasonably assumed to apply the most mature or sophisticated cognitive capabilities. Where the original study had reported a group difference between young humans and older apes and then interpreted this difference as evidence for human species-specific cognitive abilities, this second type of result—similarity in response pattern between apes and human adults—would imply that the apes' responses in the original study had been misinterpreted as evidence for the apes' inferior cognitive skills.

We have previously termed this procedure *The Method of Validation by Zenith* (Leavens, 2018), but here we propose the *Horowitz Validation Protocol* as a more apt expression, in honor of the progenitor of the method, Alexandra Horowitz. We recommend the adoption of this validation method in all direct ape-human comparisons—it is essential for theory development that similarity in response profiles of humans at different life history stages is not assumed, but directly examined. The Horowitz Validation Protocol could also be applied, post-hoc, to all previously published claims of “species differences” between older apes and younger humans, by the recruitment of humans matched for life history stage to the apes in the earlier published studies (Horowitz, 2003; Thomas et al., 2008).

Before 12 months of age, chimpanzees display striking behavioral differences in their joint attentional skills, as a function of their rearing histories. At one biomedical research center, some nursery-reared infant chimpanzees were raised in an experimental caregiving regime, in which they were exposed to 4 h per day of responsive caregiving with specially trained staff; this protocol was designed to foster context- and species-appropriate social skills (Bard et al., 2014). The responsive care treatment group ($n = 17$) significantly outperformed the standard nursery care group ($n = 28$) in the display of joint attentional competence (testing such skills as orienting towards the same object as an experimenter, mimicking an experimenter's action, etc.). Thus, significant differences in the developmental trajectories of

Table 1

A list of published titles of direct ape-human comparisons.

Title	Human Life History	Ape Life History	Matched on Life History Stage?	Source
The mentality of a child compared with that of apes	Child	–	No ^a	Brainard (1930)
Form discrimination in chimpanzees and two-year-old children: I. Form (triangularity) <i>per se</i>	Two-year-old children	–	No	Gellermann (1933a)
Form discrimination in chimpanzees and two-year-old children: II. Form versus background	Two-year-old children	–	No	Gellermann (1933b)
The perception of movement by young chimpanzees and human children	Children	Young	No ^b	Carpenter and Carpenter (1958)
Ability of chimpanzees to respond to symbols of quantity in comparison with that of children and of monkeys	Children	–	No ^c	Brown et al. (1978)
Object permanence in child and chimpanzee	Child	–	Yes ^d	Wood et al. (1980)
Partitioning the influence of level from rate factors on the performance of children and apes on a cognitive task	Children	–	Yes ^e	Hall et al. (1982)
Logical and illogical errors made by apes and children on a cognitive task	Children	–	No? ^f	Braggio et al. (1982)
Development of manipulations with objects in ape and human infants	Infants	Infants	Yes	Vauclair and Bard (1983)
The communicative context of object manipulation in ape and human adult-infant pairs	Infant	Infant	Yes	Bard and Vauclair (1984)
Language comprehension in ape and child	Child	–	No	Savage-Rumbaugh et al. (1993)
Processes of social learning in the tool use of chimpanzees (<i>Pan troglodytes</i>) and human children (<i>Homo sapiens</i>)	Children	–	No	Nagell et al. (1993)
Imitative learning of actions on objects by children, chimpanzees, and enculturated chimpanzees.	Children	–	No	Tomasello et al. (1993)
Levels of causal understanding in chimpanzees and children	Children	–	Yes ^g	Premack and Premack (1994)
Joint attention and imitative learning in children, chimpanzees, and enculturated chimpanzees	Children	–	No	Carpenter et al. (1995)
Imitative learning of artificial fruit processing in children (<i>Homo sapiens</i>) and chimpanzees (<i>Pan troglodytes</i>)	Children	–	No	Whiten et al. (1996)
Exploitation of pointing as a referential gesture in young children, but not adolescent chimpanzees	Young children	Adolescent	No	Povinelli et al. (1997)
Comprehension of novel communicative signs by apes and human children.	Children	–	No	Tomasello et al. (1997)
Distinguishing intentional from accidental actions in orangutans (<i>Pongo pygmaeus</i>), chimpanzees	Children	–	No	Call and Tomasello (1998)

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Table 1 (continued)

Title	Human Life History	Ape Life History	Matched on Life History Stage?	Source
(<i>Pan troglodytes</i>), and human children (<i>Homo sapiens</i>) Use of experimenter-given cues during object-choice tasks by chimpanzees (<i>Pan troglodytes</i>), an orangutan (<i>Pongo pygmaeus</i>), and human infants (<i>Homo sapiens</i>)	Infants	–	No	Itakura and Tanaka (1998)
A nonverbal false belief task: The performance of children and great apes	Children	–	No	Call and Tomasello (1999)
Comprehension of seeing as a referential act in young children, but not juvenile chimpanzees	Young children	Juvenile	No	Povinelli et al. (1999)
Object permanence in orangutans (<i>Pongo pygmaeus</i>), chimpanzees (<i>Pan troglodytes</i>), and children (<i>Homo sapiens</i>)	Children	–	No	Call (2001)
The sources of skill in seriating cups in children, monkeys and apes	Children	–	No	Fragaszy et al. (2002)
Referential understanding of videos in chimpanzees (<i>Pan troglodytes</i>), orangutans (<i>Pongo pygmaeus</i>), and children (<i>Homo sapiens</i>)	Children	–	No	Poss and Rochat (2003)
Can chimpanzee infants (<i>Pan troglodytes</i>) form categorical representations in the same manner as human infants (<i>Homo sapiens</i>)?	Infants	Infants	Yes	Murai et al. (2005)
Mental rehearsal in great apes (<i>Pan troglodytes</i> and <i>Pongo pygmaeus</i>) and children	Children	–	No? ^h	Dunbar et al. (2005)
Causal knowledge and imitation/emulation switching in chimpanzees (<i>Pan troglodytes</i>) and children (<i>Homo sapiens</i>)	Children	–	No ⁱ	Horner and Whiten (2005)
Copying results and copying actions in the process of social learning: chimpanzees (<i>Pan troglodytes</i>) and human children (<i>Homo sapiens</i>)	Children	–	No	Call et al. (2005)
Self-awareness in human and chimpanzee infants: What is measured and what is meant by the mark and mirror test?	Infants	Infants	No ^j	Bard et al. (2006)
Altruistic helping in human infants and young chimpanzees	Infants	Young	No	Warneken and Tomasello (2006)
Do chimpanzees (<i>Pan troglodytes</i>) and 2-year-old children (<i>Homo sapiens</i>) understand double invisible displacement?	2-year-old children	–	No	Collier-Baker and Suddendorf (2006)
Cooperative activities in young children and chimpanzees	Young children	–	No	Warneken et al. (2006)
Tracking the displacement of objects: A series of tasks with great apes (<i>Pan troglodytes</i> , <i>Pan paniscus</i> , <i>Gorilla gorilla</i> , and <i>Pongo pygmaeus</i>) and	Young children	–	No	Barth and Call (2006)

Table 1 (continued)

Title	Human Life History	Ape Life History	Matched on Life History Stage?	Source
young children (<i>Homo sapiens</i>)				
Apes' and children's understanding of cooperative and competitive motives in a communicative situation	Children	–	No	Herrmann and Tomasello (2006)
Faithful replication of foraging techniques along cultural transmission chains by chimpanzees and children	Children	–	No ^k	Horner et al. (2006)
Push or pull: Imitation vs. emulation in great apes and human children	Children	–	No ^l	Tennie et al. (2006)
Learning from others' mistakes? Limits on understanding a trap-tube task by young chimpanzees (<i>Pan troglodytes</i>) and children (<i>Homo sapiens</i>)	Children	Young	Yes ^m	Horner and Whiten (2007)
Reliance on head versus eyes in the gaze following of great apes and human infants: the cooperative eye hypothesis	Infants	–	No	Tomasello et al. (2007b)
Spontaneous altruism by chimpanzees and young children	Young children	–	No	Warneken et al. (2007)
Observational learning in chimpanzees and children studied through 'ghost' conditions	Children	–	No	Hopper et al. (2008)
Rational tool use and tool choice in human infants and great apes	Infants	–	No	Buttelmann et al. (2008)
How young children and chimpanzees (<i>Pan troglodytes</i>) perceive objects in a 2D display: putting an assumption to the test	Young children	–	No	Leighty et al. (2008)
Tracking and inferring spatial rotation by children and great apes	Children	–	No ⁿ	Okamoto-Barth and Call (2008)
Prelinguistic infants, but not chimpanzees, communicate about absent entities	Prelinguistic infants	–	No	Liszkowski et al. (2009)
Spatial construction skills of chimpanzees (<i>Pan troglodytes</i>) and young human children (<i>Homo sapiens sapiens</i>)	Young... children	–	No	Potí et al. (2009)
A competitive nonverbal false belief task for children and apes	Children	–	No ⁿ	Krachun et al. (2009)
The structure of individual differences in the cognitive abilities of children and chimpanzees	Children	–	No	Herrmann et al. (2010)
Reaching around barriers: the performance of the great apes and 3–5-year-old children	3–5-year-old children	–	No ^o	Vlamings et al. (2010)
Two-year-old children copy more reliably and more often than nonhuman great apes in multiple observational learning tasks	Two-year-old children	–	No ^p	Tennie et al. (2010)
Executive function in young children and chimpanzees	Young children	–	No	Moriguchi et al. (2011)

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Table 1 (continued)

Title	Human Life History	Ape Life History	Matched on Life History Stage?	Source
<i>(Pan troglodytes)</i> : Evidence From a nonverbal dimensional change card sort task				
Different social motives in the gestural communication of chimpanzees and human children	Children	–	No	Bullinger et al. (2011)
Nonhuman primates do declare! A comparison of declarative symbol and gesture use in two children, two bonobos, and a chimpanzee	Children	–	No? ^a	Lyn et al. (2011)
Comparing children's <i>Homo sapiens</i> and chimpanzees' <i>Pan troglodytes</i> quantity judgments of sequentially presented sets of items	Children	–	No	Beran et al. (2011)
Carryover effect of joint attention to repeated events in chimpanzees and young children	Young children	–	No	Okamoto-Barth et al. (2011)
Comparing the performances of apes (<i>Gorilla gorilla</i> , <i>Pan troglodytes</i> , <i>Pongo pygmaeus</i>) and human children (<i>Homo sapiens</i>) in the floating peanut task	Children	–	No ^b	Hanus et al. (2011)
Collaboration encourages equal sharing in children but not in chimpanzees	Children	–	No ^k	Hamann et al. (2011)
Children, but not chimpanzees, prefer to collaborate	Children	–	No	Rekers et al. (2011)
A comparison of temperament in nonhuman apes and human infants	Infants	–	No	Herrmann et al. (2011)
Differences in cognitive processes underlying the collaborative activities of children and chimpanzees	Children	–	No	Fletcher et al. (2012)
Majority-biased transmission in chimpanzees and human children, but not orangutans	Children	–	No	Haun et al. (2012)
Direct and indirect reputation formation in nonhuman great apes (<i>Pan paniscus</i> , <i>Pan troglodytes</i> , <i>Gorilla gorilla</i> , <i>Pongo pygmaeus</i>) and human children (<i>Homo sapiens</i>)	Children	–	No	Herrmann et al. (2013)
Understanding communicative intentions and semiotic vehicles by children and chimpanzees	Children	–	No	Zlatev et al. (2013)
Remembering in tool-use tasks in children and apes: The role of the information at encoding	Children	–	No	Martin-Ordas et al. (2014)
Younger apes and human children plan their moves in a maze task	Children	Younger	No	Völter and Call (2014)
Prospective memory in children and chimpanzees	Children	–	No	Perdue et al. (2014)
Children, but not chimpanzees, have facial correlates of determination	Children	–	No	Waller et al. (2014)
Differences in the early cognitive development of children and great apes	Children	–	Yes	Wobber et al. (2014)

Table 1 (continued)

Title	Human Life History	Ape Life History	Matched on Life History Stage?	Source
Cross-species variation in gaze following and conspecific preference among great apes, human infants and adults	Infants, adults	–	No ^f	Kano and Call (2014)
Public information use in chimpanzees (<i>Pan troglodytes</i>) and children (<i>Homo sapiens</i>)	Children	–	No	Vale et al. (2014)
Differences in the nonverbal requests of great apes and human infants	Infants	–	No	van der Goot et al. (2014)
Human children rely more on social information than chimpanzees do	Children	–	No	van Leeuwen et al. (2014)
All great ape species (<i>Gorilla gorilla</i> , <i>Pan paniscus</i> , <i>Pan troglodytes</i> , <i>Pongo abelii</i>) and two-and-a-half-year-old children (<i>Homo sapiens</i>) discriminate appearance from reality	Two-and-a-half-year-old children	–	No	Karg et al. (2014)
The origin of representational drawing: A comparison of human children and chimpanzees	Children	–	No	Saito et al. (2014)
Children conform to the behavior of peers; other great apes stick with what they know	Children	–	No? ^{q1}	Haun et al. (2014)
Coordination strategies of chimpanzees and human children in a Stag Hunt game	Children	–	No	Duguid et al. (2014)
Differences in the ability of apes and children to instruct others using gestures	Children	–	No	Grosse et al. (2015)
Looking ahead? Computerized maze task performance by chimpanzees (<i>Pan troglodytes</i>), rhesus monkeys (<i>Macaca mulatta</i>), capuchin monkeys (<i>Cebus apella</i>), and human children (<i>Homo sapiens</i>)	Children	–	No	Beran et al. (2015)
Chimpanzees (<i>Pan troglodytes</i>) and human children (<i>Homo sapiens</i>) know when they are ignorant about the location of food	Children	–	No	Neldner et al. (2015)
Focusing and shifting attention in human children (<i>Homo sapiens</i>) and chimpanzees (<i>Pan troglodytes</i>)	Children	–	No	Herrmann and Tomasello (2015)
Communication about absent entities in great apes and human infants	Infants	–	No	Bohn et al. (2015)
The effects of being watched on resource acquisition in chimpanzees and human children	Children	–	No ⁿ	Engelmann et al. (2016)
Comprehension of iconic gestures by chimpanzees and human children	Children	–	No	Bohn et al. (2016)
Sensitivity to relational similarity and object similarity in apes and children	Children	–	No	Christie et al. (2016)
	Children	–	No	

(continued on next page)

Table 1 (continued)

Title	Human Life History	Ape Life History	Matched on Life History Stage?	Source
Children's and apes' preparatory responses to two mutually exclusive possibilities				Redshaw and Suddendorf (2016)
Great apes and children infer causal relations from patterns of variation and covariation	Children	–	No	Völter et al. (2016)
Young children, but not chimpanzees, are averse to disadvantageous and advantageous inequities	Young children	–	No	Ulber et al. (2017)
Prelinguistic human infants and great apes show different communicative strategies in a triadic request situation	Prelinguistic ... infants	–	No	Gretschler et al. (2017)
Preparatory responses to socially determined, mutually exclusive possibilities in chimpanzees and children	Children	–	No	Suddendorf et al. (2017)
Chimpanzees, bonobos and children successfully coordinate in conflict situations	Children	–	No ^k	Sánchez-Amaro et al., (2017)
Children, chimpanzees, and bonobos adjust the visibility of their actions for cooperators and competitors	Children	–	No ^k	Grueneisen et al. (2017)
Testing differential use of payoff-biased social learning strategies in children and chimpanzees	Children	–	No	Vale et al. (2017)
Learning the rules of the rock–paper–scissors game: chimpanzees versus children	Children	–	No	Gao et al. (2018)
Preschool children and chimpanzees incur costs to watch punishment of antisocial others	Children	–	No	Mendes et al. (2018)
Chimpanzees and children avoid mutual defection in a social dilemma	Children	–	No ^k	Sánchez-Amaro et al. (2019)
Human children but not chimpanzees make irrational decisions driven by social comparison	Children	–	No ⁿ	Herrmann et al. (2019)
The “sh-ape bias” in non-linguistic categorization: Comparisons between children and other apes	Children	–	No	Vonk and Rastogi (2019)
Helping in young children and chimpanzees shows partiality towards friends	Children	–	No	Engelmann et al. (2019)
Chimpanzees monopolize and children take turns in a limited resource problem	Children	–	No	Knofe et al. (2019)
Spontaneous categorization of tools based on observation in children and chimpanzees	Children	–	No	Gruber et al. (2019)
Chimpanzees help others with what they want; children help them with what they need	Children	–	No	Hepach et al. (2020)
Children, but not great apes, respect ownership	Children	–	No ^k	Kanngiesser et al. (2020)
How chimpanzees and children perceive other species'	Children	–	No	Gao and Tomonaga (2020)

Table 1 (continued)

Title	Human Life History	Ape Life History	Matched on Life History Stage?	Source
bodies: Comparing the expert effect				
Human children, but not great apes, become socially closer by sharing an experience in common ground	Children	–	No	Wolf and Tomasello (2020)
The strategies used by chimpanzees (<i>Pan troglodytes</i>) and children (<i>Homo sapiens</i>) to solve a simple coordination problem	Children	–	No	Duguid et al. (2020)
The contingency symmetry bias (affirming the consequent fallacy) as a prerequisite for word learning: A comparative study of pre-linguistic human infants and chimpanzees	Pre-linguistic ... infants	–	No	Imai et al. (2021)
Great apes and human children rationally monitor their decisions	Children	–	No ^s	O'Madagain et al. (2022)
Joint attention in human and chimpanzee infants in varied socio-ecological contexts	Infants	Infants	Yes	Bard et al. (2022)
The structure of executive functions in preschool children and chimpanzees	Preschool children	–	No	Völter et al. (2022)

Notes: dashes (–) indicate that no life history stage was listed in title. Question marks (?) indicate that a confident classification could not be made.

^a Tests were conducted on the author's daughter and systematically compared with the apes' performances in Köhler (1925).

^b Matched on "maturation level" (p. 782), although the human children were substantially older than the chimpanzees.

^c On balance, the apes were older than the children, with some overlap in ages.

^d The apes were older than the human children, but the longitudinal design created significant overlap in ages between the apes and the children.

^e One learning-delayed group of human children was not matched on chronological age with the apes.

^f All apes described as juveniles, but no ages given.

^g Four of five apes were age-matched to human children.

^h Ages of two chimpanzees not given, orang-utans described as 'adults' in text.

ⁱ Partial overlap: humans 2–4 years, chimpanzees 2–6 years.

^j Partial overlap: oldest human infants and youngest chimpanzee infants = 24 months.

^k Information in supplementary material.

^l Youngest apes' ages not given ("... younger than 8 [years]" (p. 1161).

^m Chimpanzee age range (2–7 yrs) > human age range (3–6 yrs), completely overlapping childrens' ages.

ⁿ Some overlap in age.

^o Oldest children might overlap youngest apes.

^p "... six juveniles (up to 6 years)..." (p. 339).

^q Ages not specified.

^r Ages of human adults and adult great apes overlapped considerably, but no infant apes were included in this study.

^s Ages not specified, but not matched (Cathal O'Madagain, personal communication, July 7, 2022).

infant chimpanzee socio-cognitive skills are evident long before 22 months of age; it is, therefore, somewhat inaccurate to refer to apes raised under a standard nursery care regime in a biomedical research center as "human-raised." However, throughout the 1990s and 2000s, there were numerous claims of apes' deficiencies in understanding visual attention that, often implicitly, were built on the assumption that standard nursery care in institutional settings was not detrimental to the apes' performances in experimental settings (e.g., Povinelli and Eddy, 1996; Povinelli et al., 1997; Tomasello and Carpenter, 2005). Institutionalised apes who have limited daily interactions with their human caretakers have not had the same opportunities to learn to read the nonverbal signalling conventions of those humans, compared to captive apes who have enriched, daily interactions with their caregivers, such as language-trained apes or home-raised apes. Institutions, themselves, vary in their reasons for having great apes in captivity (entertainment, biomedical research, cognitive research, and so on) and will, thus, vary quite a lot in how much opportunity they provide to interact with humans. Clearly, those apes who have less interactive experience with humans will be less well-prepared to interpret human signals (e.g., Bard and Leavens, 2014; Leavens and Bard, 2011), and this has been borne out in virtually all studies that have statistically controlled for this factor of interactive experience (e.g., Bard et al., 2014; Lyn et al., 2010; Russell et al., 2011). Most published claims of a great ape incapacity to follow deictic cues completely ignore the impact of early experience on later testing (see, e.g., Bard and Leavens, 2014; Bard et al., 2022; Leavens et al., 2019, for extended discussions and evidence pertaining to chimpanzees).

It is by virtue of these pronounced effects of early rearing history that great apes can serve as animal models for the ability to follow the focus of attention of an interlocutor (receptive joint attention, also known as responding to joint attention) and to produce deictic signals, such as pointing (productive joint attention also known as initiating behavioral regulation or initiating joint attention). Being able to follow the attentional cues of an interlocutor and being able to direct the attention of another are, for great apes, acquired skills that are fostered in some, but not all environments. One of the significant findings of the recent work by Bard et al. (2022) is that even the form of joint attention differs across cultures in both humans and great apes; for example, Western, postindustrial children experience significantly more joint attention interactions that are oriented to objects, rather than to social partners, compared with other human groups. Hence, while it may be true that cage-reared, institutionalised great apes, as a group, tend to display less facility in following human pointing gestures or gaze than, say, enculturated apes, this is not evidence that representatives of one species lack the cognitive adaptations of another species; rather, this is simply the unsurprising demonstration that cage-reared animals do not act very much like Western, middle-class children living in postindustrial environments.

In addition to the longstanding neglect of apes' developmental stage, confounding age differences with phylogenetic differences, direct ape-human comparisons have almost never matched the groups on task-relevant, pre-experimental learning opportunities, rarely have even similar protocols been administered to the different samples, virtually never have similar sampling regimens been deployed, and testing environments typically differ dramatically (e.g., testing apes in cages, but not testing humans in cages). In short, no claim of ape deficiencies in the kinds of attention-following and attention-directing skills that, in humans, support the acquisition of a lexicon in a language-speaking rearing environment, withstands scrutiny (e.g., Bard and Leavens, 2014; Boesch, 2007; 2012; Leavens, 2014, 2018; Leavens et al., 2019; Scheel et al., 2017). Moreover, where attempts have been made to control for the effects of differential rearing, age, species, or sex, no obvious deficiency in these attentional skills has been observed (e.g., Lyn et al., 2010; Russell et al., 2011).

4. The object choice task and its confounds

Probably the most widely used protocol for assessing the ability to follow deictic cues is a family of tasks referred to as Object Choice Tasks (OCTs: Anderson et al., 1995, 1996). In this protocol, desirable objects are placed covertly into one of two or more containers, then an experimenter provides a deictic cue to the object's location: gazing with head and eyes, pointing, and so forth (see Fig. 1). Joint attention skill as measured with the OCT exemplifies the kinds of confounds that have cast a haze of uncertainty over the empirical findings, considered in aggregate, over many different vertebrate species, including humans.

These confounding factors relate to measurement and procedures such as whether the trials were randomized or counterbalanced, whether the environment was indoors or outdoors, durations of cues, inter-object distances, and intertrial intervals (Table 2). Investigating how these factors interact and are reported in the descriptions of OCTs will significantly reduce the inherent ambiguities that characterise the contemporary literature. Nevertheless, most of the studies performed to date do not consider these confounding factors. These aspects together with methodological variability have made it difficult to interpret whether a pass or fail by, for example, chimpanzees in OCT performance results from the chimpanzees' natural

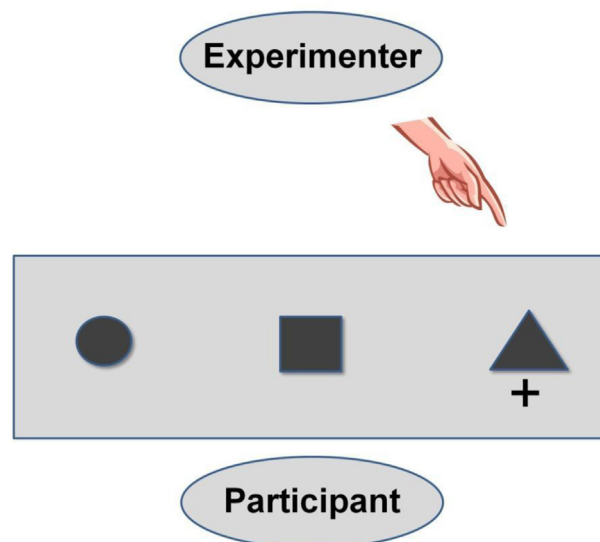


Fig. 1. Schematic of a three-choice object choice task, similar to those used in Call and Tomasello (1994), Tomasello et al. (1997), and many others. The triangular container has been baited by an experimenter, behind an occluding screen, and the participant is presented with a cue, in this case a pointing gesture. The plus sign indicates that selecting this container will result in delivery of the reward hidden there. (Figure and caption reproduced from Leavens, D. A., *The Plight of the Sense-making Ape*, in M. Cappuccio & T. Froese (Eds.), *Enactive cognition at the edge of sense-making*, 2014. U.K.: Palgrave Macmillan. Reproduced with permission of Palgrave Macmillan.).

Table 2

A list of confounding procedural and measurement factors that underlie the Object Choice Task.

Factors ^a	Considered categories
<i>Trial-related</i>	
Randomization	No randomization, pseudorandomized, randomized, semi-randomized
Counterbalancing	No counterbalancing, counterbalanced
Test-retest	No test-retest, test-retest
Practice	No Practice, practice
Intertrial interval	List interval between trials
Container type	
Container colour	White, blue, red, yellow, grey, clear, brown, black, green, orange, different colours, multicoloured, not stated
Interobject distance	Distance between containers
<i>Cuer-related</i>	
Cuer identity	Experimenter, owner, experimenter and conspecific, non-human object, conspecific and child or a combination of these identities.
Familiarity of cuer	Not familiar, familiar
Distance between the experimenter and subject	Distance between experimenter and subject
Cuer posture	Sitting, Standing, Kneeling, Crouching, Squatting, combination, other postures.
<i>Cue-related</i>	
Durations of cues	Sustained, Momentary
Momentary cues	Duration?
<i>Environment-related</i>	
Indoor or Outdoor	Outdoor, indoor
Testing	Park, Zoo, Lab, Research Centre, Training School, Aviary Pens, Sanctuary, Home, Daycare, Animal Shelter
Barrier	No barrier, barrier

Note: ^aFactors were derived from our previous analysis of uncontrolled factors (Clark et al., 2019); please see the references in that article and its associated supplementary information.

abilities or methodological factors that are not controlled. As a result, the investigation and characterization of joint attention in primates and canids via OCTs is compromised at present (Clark et al., 2019). To move forward in the knowledge about how different confounding factors interact on the performance of the OCTs is of utmost importance to reduce the heterogeneity and uncertainty in the existing literature. This future knowledge will help explain canid-primate performance differences, so that we can properly understand the roles of homologous and convergent factors in the cognitive evolution of the two most popular models of human attentional skill (dogs and great apes), as we build towards more accurate hypotheses of the evolution of component skills, such as joint attention, in language evolution (e.g., Arbib, 2005; Hauser et al., 2002).

5. Attention direction in great apes

In terms of pointing production—the use of deictic signals to re-direct the attention of an interlocutor to a specific locus—great apes show a striking diversity in the frequency and form of pointing, depending on their early rearing histories (e.g., Leavens and Bard, 2011; Leavens et al., 2010). Wild apes rarely display deictic gestures (for examples by bonobos see Douglas & Moscovice, 2015; Veà and Sabater-Pi, 1998; by chimpanzees see Hobaiter et al., 2014; Pika and Mitani, 2006; and see Plooj, 1978 and Wilke et al., 2022, for referential use of a leaf-grooming gesture); pointing has not been reported to be a prominent part of their repertoires in their natural habitats (e.g., Graham et al., 2017; Hobaiter and Byrne, 2011; Knox et al., 2019). In contrast, pointing is commonplace among institutionalised great apes: in more than 15 published studies of gestural communication by over 130 captive chimpanzees, 50% of them displayed pointing gestures, either with their index fingers or their whole hands (Leavens and Bard, 2011, Tble 1, p. 15). Strikingly, 100% of enculturated apes (apes cross-fostered by humans) point (e.g., Krause, 1997; Krause and Fouts, 1997; Pedersen et al., 2009; Savage-Rumbaugh, 1986; Savage-Rumbaugh et al., 1998—reviewed by Leavens et al., 2010; Leavens and Bard, 2011). This pattern of systematic phenotypic variation in pointing as a function of rearing environment implicates environmental influences on communication development in great apes. This manifest sensitivity of the attention-directing behavior of great apes to environmental input suggests that the development of the capacity to use deictic signals to redirect the attention of others to specific loci does not require any human species-unique cognitive adaptations, because it emerges so easily in captive populations of great apes, in the absence of any explicit training (e.g., Leavens, 2004, 2021). In summary, when great apes are raised by language-using humans, they universally display pointing behavior, as do human children raised by language-using humans—if pointing was grounded in human species-specific cognitive adaptations, the prediction would be that apes would display less facility in the use of such attention-directing behavior, but its ubiquity among cross-fostered apes counters that prediction.

6. Conclusion

As we have argued, here, there are numerous reasons to doubt the widespread dictum that great apes are, somehow, deficient in their capacity to discern and manipulate visual attention in others. Great apes are perfectly capable of displaying

the kinds of skill in attention deployment that are evinced by human children in the earliest months of language acquisition. Because captive great apes easily acquire the abilities to follow and to deploy deictic signals that are not prominently displayed in the repertoires of apes living in their natural habitats, we argue that these capabilities are better understood as responses to specific environmental factors than as evolved, human-unique, domain-specific cognitive adaptations to support language acquisition. Rather, we think that because humans' nearest living relatives, the great apes, manifestly do not possess domain-specific, biologically given cognitive adaptations for the acquisition of speech, therefore, the most parsimonious interpretation of the ease with which they acquire joint attention skills is that domain-general learning capabilities can and do support the acquisition of these skills. The strength of this argument increases with the taxonomic distance between humans and the animals displaying joint attention competency (see, e.g., [Pepperberg, 1994](#)). Although [Gómez \(2007\)](#) has argued that pointing among humans is an evolutionary adaptation, but pointing by apes is an exaptation, we think that the ease with which apes adopt pointing gestures suggests that the ability to re-direct another's attention is a developmental adaptation to particular kinds of circumstances in which the signaler is reliant on others to act on the world for them, a situation that characterizes early human development and the captive environments of great apes, but not the environments of apes living in their natural habitats, where pointing is rare. We call this the *Referential Problem Space* (see [Leavens, 2021](#), for elaboration). The central theoretical implication of this ecologically situated perspective on the acquisition of these basic attention skills—which seem to be foundational to language acquisition—is that our hominin ancestors, who invented language, were already equipped with the domain-general learning abilities sufficient to support the shaping of their discernment of deictic intent in others and the adoption of deictic signaling, themselves (see also: [Gómez, 2009](#)).

Declaration of competing interest

All authors declare that they have no competing interests.

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