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Talking about the absent and the abstract: Referential communication in language and gesture

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Abstract

Human language permits us to call to mind objects, events, and ideas that we cannot witness directly, either because they are absent or because they have no physical form (e.g., people we have not met, concepts like ‘justice’). What enables language to transmit such knowledge? We propose that a referential link between words, referents, and mental representations of those referents is key. This link enables us to form, access, and modify mental representations even when the referents themselves are absent (‘absent reference’). In this review we consider the developmental and evolutionary origins of absent reference, integrating previously disparate literatures on absent reference in language and gesture in very young humans and gesture in non-human primates. We first evaluate when and how infants acquire absent reference during the process of language acquisition. With this as a foundation, we consider the evidence for absent reference in gesture in infants and in non-human primates. Finally, having woven these literatures together, we highlight new lines of research that promise to sharpen our understanding of the development of reference and its role in learning about the absent and the abstract.

Human language permits us to call to mind objects, events, and ideas that we cannot witness directly (e.g., Deacon, 1997). We learn and reason about people we have never met, about time that hasn’t yet passed, and about abstract concepts, such as justice or abelian groups¹ (e.g., Freyd, 1983; Jackendoff, 1997). We readily communicate about such phenomena, learn new information about them, and when (and if) these phenomena ever become perceptually available, we successfully identify them using the knowledge acquired through language.

This ability, which appears to be uniquely human, has long been the focus of inquiry among psychologists, cognitive scientists, and philosophers – from Plato’s early work connecting objects, words, knowledge and knowers (see Scolnikov, 2006, for a review) to Frege, Locke and Russel’s inquiries into how we can possibly acquire new knowledge from language alone, in the absence of perceptual information about the referent(s) (e.g., Frege, 1948; Locke, 1847; Russell, 1905). Despite the long and productive history of this inquiry

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¹An abelian group is an algebraic object – a group in which the group operation is commutative – named after Norwegian mathematician Niels Abel (see e.g., Fuchs, 2015).

among thinkers and empirical researchers, it remains an open question what cognitive capacities give rise to our ability to learn, reason, and communicate about absent or abstract phenomena from language alone.

We propose that at the heart of this problem is the capacity for linguistic reference² – *a three-way referential link between words, their referents (if they are real-world phenomena), and mental representations of those referents*. By establishing a referential connection between language and mental representations, this link that permits us to form, access, and modify representations on the basis of language input alone, with no perceptual access to the communicated information (for a discussion on the development of linguistic reference, see L. Bloom, 1993; Clark & Wilkes-Gibbs, 1986; Luchkina & Waxman, 2021; Luchkina & Xu, 2021; Trueswell et al., 2016; Ünal & Papafragou, 2020; Waxman & Gelman, 2009).

In this review, we use the terms ‘referents’ and ‘representations’ to distinguish between real-world entities, on the one hand, and mental representation of those entities, on the other. This terminology is consistent with the psychological literature on the problem of reference, but differs from that in linguistics and philosophy (e.g., Carnap, 1988; Church, 1940; Frege, 1948; Russell, 1905). In Box 1, we articulate the correspondence between the terminology here and to that in linguistics and philosophy.

In reviewing the development of linguistic reference in infants, we focus specifically on *communication about absent phenomena* (or, ‘*absent reference*’). We focus on absent reference because a link between a word and a referent when the referent itself is not observable – either because it is abstract (‘freedom’) or hidden from view (a puppy inside a neighbor’s home) – cannot depend upon an association between a word and co-present referent. Instead, successful communication about absent objects or events requires a link between a word and a mental representation (see Figure 1). Thus, although experimental paradigms in which words and their referents are co-present have shed considerable light on infant word learning, they do not address whether and when infants’ referential capacities permit them to move beyond perceptually available information alone to link words and mental representations.

In recent years, there have been substantial advances in our understanding of infants’ ability to establish absent reference (Spelke, 2022 provides a review). This is especially true in the developmental and language sciences, where innovative research paradigms have been harnessed to explore how and when infants develop this capacity. There has also been substantial new evidence on the communicative power of gesture in humans and non-human primates. However, because connections between these two research streams remains scant, *there remain gaps in our understanding of whether absent reference is unique to language, whether it is present in non-human communication, and how it develops*.

To address these gaps, we bring the evidence on absent reference in infant language into closer alignment with evidence on reference in the gesture of human infants and apes. This

²We treat ‘linguistic reference’ as synonymous to ‘verbal reference’. The term ‘linguistic’ is used here to contrast reference in language with reference in other human and non-human communicative systems, such as gesture.

review opens new avenues for advancing our understanding of absent reference, and its downstream effects on learning and reasoning about the absent and the abstract.

The development of absent reference in language

Infants' ability to establish absent reference appears to emerge by the end of infants' first year and to become increasingly sophisticated over the next two years of life (see Luchkina & Xu, 2022, for a discussion about its developmental mechanisms). By 12 months, when the capacities required to support absent reference are in place (see Box 2), infants successfully *retrieve* a mental representation, even when the referent of a word is hidden from view.

Most of the empirical evidence on infants' command of absent reference comes from an elegant behavioral paradigm: an infant is first introduced to a novel object and its name (e.g., "Look! A *dax*") and then, when the object is hidden, is asked to locate it ("Where is the *dax*?"). Although infants as young as 12 months comprehend such requests, their ability to carry them out is still fragile: they succeed only when visual 'anchors' – perceptually present reminders that are associated with the hidden object – are present (e.g., the bucket in which the object appeared before being hidden from view; Gallerani et al., 2009; Ganea, 2005; Osina et al., 2013, 2014).

At 14 months, infants use properties of hidden objects, such as their color (Saylor, 2004) as anchors, and point towards those anchors upon hearing the objects' names (Ganea & Saylor, 2013; Saylor & Baldwin, 2004). Fourteen-month-olds also use linguistic cues to interpret ambiguous requests for absent objects (e.g., "*my ball*" to refer to a particular ball when more than one ball is shown; e.g., Saylor et al., 2011; Saylor & Ganea, 2007). Moreover, 14-month-olds begin to identify absent referents if the word-referent pairing is highly familiar to them. For example, Hendrickson and Sundara (2017) used a visual priming paradigm, in which 12- to 14-month-old infants were first shown images of familiar objects for which they already knew the name (e.g., ball; shoe). The objects then disappeared from view and infants listened to a story in which some of these familiar objects were mentioned. Finally, when the images re-appeared (presented in silence), infants looked longer to the images of objects that had been mentioned in the story than those that had not. This evidence of representational capacity, although impressive, does not address the mechanism by which infants accomplish this task, and whether their success is restricted to already established referential links.

By 16 months, however, infants' comprehension of absent reference is more robust and no longer requires perceptual support. In addition to *retrieving* an already-established mental representation, 16-month-olds successfully *modify or update* their representations on the basis of language input alone. For example, Ganea et al. (2016) showed 16-month-olds an image of a scene including a table, chair, cat and dog. After the image was removed, infants heard about a change in the scene (e.g., "Now the dog goes on the table"). Subsequently, a scene was revealed, and infants looked longer if it did not match the description. This suggests that they had updated their mental representation based on language input alone. At 16 months, infants also spontaneously retrieve mental representations of familiar objects after hearing them mentioned in a story, without seeing the images until the test phase

(Luchkina et al., 2020). Advances in absent reference comprehension, such as this one, have been linked to advances in infants' representational capacity (Galazka & Ganea, 2014; Ganea & Saylor, 2013b; see also Box 1).

By 16 months, infants also show the first evidence that they can *form* new object representations using language input alone. For example, Luchkina and Waxman (2022) used both semantic priming and ostensive labelling to assess whether infants could successfully imagine an object they had never before seen and learn its name. Infants saw a series of four labeling events. In the first three, the objects and their names were highly familiar, and all belonged to the same semantic neighborhood (e.g., fruits). On the fourth trial, an object was also introduced and labeled ("Oh, a modi!") but the experimenter's body (seemingly accidentally) occluded the object, so that infants never saw it before the test. At test, infants viewed two novel objects simultaneously, one from the same semantic neighborhood (e.g., a novel yellow fruit) and the other a perceptually similar but semantically distant object (e.g., a yellow ottoman). When asked to find the referent of the novel label ("Where is the modi?"), infants looked to the novel object from the same semantic neighborhood. This suggests that by 16 months, the link between words, referents, and mental representations is in place. Infants successfully form object representations, learn object names on the basis of linguistic information alone, and recognize those objects when they later become perceptually available.

By 18–19 months, children not only successfully access, modify, and form new representations of objects based on language alone, but can rely on language input to acquire new *knowledge*. For example, Ferguson et al. (2014) presented infants with a novel word when no images were available. Nineteen-, but not 15-month-old, infants successfully used the surrounding words to infer the properties of the novel word's referent (from "the *dax* is crying" infants inferred that the 'dax' must be an animate object because the verb 'to cry' requires an animate object) and identify it when it becomes visible. By 22 months, children successfully update representations of absent objects based on language input alone. For example, after being introduced to a toy frog Lucy and told that Lucy got wet while she was away, 22-month-olds correctly chose a wet toy over an identical-looking dry one when prompted to find Lucy (Ganea et al., 2007). By 30 months, children use language alone to learn detailed information – including habitat and physical traits – about novel creatures they have never seen and go on to recognize those creatures during test (Saylor et al., 2016). Finally, by 36 months, children have also begun to master the meaning of words referring to abstract concepts, such as "believe" or "think" (Gleitman et al., 2005; Papafragou et al., 2007; Henry M. Wellman & Karen Bartsch, 1995; Bergelson & Swingley, 2013; de Villiers, 2021). In sum, the capacity to use linguistic information alone to retrieve and modify an already-established representation, and to establish an entirely new representation is present by 16 months. This provides the foundation for learning new information from language alone, without requiring direct perceptual access to any objects or events. It is also instrumental for linking words to abstract ideas, such as mental states, belief states or abstract concepts. But what remains unknown is whether children's remarkable success in establishing absent reference is a feature of language only, or evident in other rich communicative systems, like gesture.

Gestural reference in human infants

Gesture, like language, is a powerful communicative tool. In humans, gesture often complements or amplifies the information conveyed in speech³ (e.g., Goldin-Meadow & Alibali, 2013). But does gesture also convey absent and abstract reference? To address this question, we first summarize the development of gestural communication in infancy and then address the possibility that gesture supports reference to absent and abstract entities.

Infants begin to *comprehend gestures* in the first year of life (Ger et al., 2018; Goldin-Meadow & Alibali, 2013; Iverson & Goldin-Meadow, 2005; Liszkowski et al., 2012; Matthews et al., 2012). Infants as young as 12 months recognize the symbolic, intentional, and communicative nature of deictic gestures (see Box 3), such as pointing (Krehm et al., 2014; Liszkowski et al., 2004, 2007a, 2007b; Rodrigues et al., 2021; R  ther & Liszkowski, 2020; see Liszkowski, 2008, for a review). At 12 months, infants also begin to comprehend gestures that refer to hidden and absent objects. For example, Behne et al. (2012) showed that when adults point to the location of a hidden object, 12-month-old infants search for that object in the indicated location. In a different experimental paradigm, Jart   and Liszkowski (2021) demonstrated that infants at 14, but not 8⁴, months expect that an object, which they had never seen before, will appear behind an occluder to which the experimenter pointed. Using a similar procedure, Gliga and Csibra (2009) found that infants expect a previously hidden object to appear in the location indicated by the experimenter's pointing and to correspond to the name she provided.

Moreover, infants in the first year of life *produce* distinct classes of pointing gestures, for different communicative purposes. Protodeclarative pointing serves to draw others' attention to something, while protoimperative pointing serves to communicate a desire, a request, or intention with regard to something⁵ (Bates et al., 1975; Behne et al., 2012; Gliga & Csibra, 2009; Kovacs et al., 2010; Salomo & Liszkowski, 2013; Tomasello et al., 2007). By 12 months, infants reliably produce both types of pointing gestures to communicate about absent objects. For example, Bohn et al. (2015) showed that 12-month-olds use *protoimperative* pointing to indicate the former location of their preferred toy (colorful balls) to request them again. Other work suggests that 12-month-old infants produced *protodeclarative* points to the location of the object that was shown but is currently hidden (Liszkowski et al., 2007b; Osina et al., 2013; Saylor, 2004).

³Some suggest that gestural communication in humans may be innately specified. Gesture produced by congenitally blind children lend support to this proposal (Iverson & Goldin-Meadow, 1997, 2001).

⁴There is some evidence that 8-month-old infants may recognize the referential nature of pointing and how it serves as a cue to the location of a hidden object. Gredeb  ck et al. (2010), for example, showed 8-month-olds a visual sequence in which an object appeared in one of two empty boxes on a screen. The object subsequently disappeared, after which a hand pointed to one of the boxes. Infants exhibited an event-related potential (ERP) component P400, which is associated with incongruent outcomes, when they saw pointing to the box that had not contained any object before. It is not clear, however, if 8-month-olds fully appreciate the social nature of gesture. Tummeltshammer et al. (2014), for example, showed that 8-month-olds have similar expectations about locations cued by the human face orientation and gaze and by an arrow.

⁵Some also proposed that in addition to protodeclarative and protoimperative pointing, infants produce interrogative pointing, which serves the goal of requesting new information about something (e.g., Kov  cs et al., 2014; Southgate et al., 2007). For example, infants point to inform adults about object locations they are looking for (Liszkowski et al., 2006) and to inform adults about something out of their view (Liszkowski et al., 2007b).

Thus, by 12 months, infants understand and produce pointing gestures, including those referring to absent objects. This suggests that pointing, like words, engages infants' capacity to imagine unobservable things, creating a placeholder representation of an object that they have not yet seen. However, pointing rarely achieves the referential specificity that is emblematic of naming. For example, although pointing to one of Chagall's mosaics will likely have a communicative effect, pointing alone (without accompanying language) cannot specify what it is about the mosaics that we mean to highlight – their location, their colors, or the abundance of art in the streets of Chicago. The same is true for young children: a pointing gesture alone (e.g., to a ladder) cannot specify the intended referent (the ladder itself, the cabinet above, the cookie jar inside; see Table 1).

This limitation in the referential precision of pointing, however, can be surmounted in representational gesture (see Box 3). Representational gestures are often iconic – resembling an aspect of its referent physically or metaphorically (Novack & Goldin-Meadow, 2017). They can indicate the shape of objects, capture elements of relational structure among physical entities or logical arguments (e.g., 'one the one hand, on the other hand'), and transmit information about the manner of a certain action (e.g., 'fast' or its repetitive nature).

Infants begin to produce and comprehend representational gesture between 12 and 15 months (e.g., Iverson et al., 1994; Puccini & Liszkowski, 2012; Rodrigues et al., 2021). In a now classic study, Acredolo & Goodwyn (1988) identified several types of representational gestures produced by infants from 11 to 16 months, including objects ('flower'), requests ('give food'), attributes ('all gone'), replies ('I don't know'), and events ('bye-bye'), each of which can convey greater referential specificity than pointing.

Although more precise than pointing, representational gesture typically does not attain the referential precision of language. For example, iconic gestures (e.g., a gesture for eating with a spoon, which imitates the motion of hand approaching a mouth) are often created 'on the spot', typically not conventionalized, and therefore do not have stable meanings and (e.g., Cartmill et al., 2012). As a result, when divorced from any surrounding linguistic and physical context, the referents of such gestures remain underspecified. In some instances, an iconic gesture may evoke transparently its referent (e.g., 'glasses'), but typically, in the absence of any such transparency (e.g., 'praise', 'company'), referential ambiguity remains.

Notably, some representational gestures become conventionalized (see Box 3; see also Fusaro & Vallotton, 2011; Iverson & Goldin-Meadow, 2005; Özçalı kan & Goldin-Meadow, 2011). Examples of conventional gestures include the handshake for 'peace' and the circling index finger produced near the temple for 'cuckoo'. When gestures are conventionalized, their function is akin to protowords or holophrastic words (see e.g., Dore, 1975; Menn, 2013) and they convey more precise information than pointing. However, even conventional gestures rarely convey the nuanced meanings or abstract ideas that are so readily conveyed with language. For example, it would be hard to interpret a handwave, like those used in greetings, to convey a more abstract meaning, such as 'we were grateful for a very warm welcome from the Italian government'.

In sum, in humans, gesture is a strong communicative device that engages some of the same capacities as language and can enable reference to absent objects and people. However, for the most part, gesture lacks referential precision and depth⁶ (see also Meyer et al., 2015; Meyer & Gelman, 2016). Nevertheless, the possibility remains that because it emerges prior to language, gesture may pave the way for linguistic reference. There is evidence that infants and young children use gestures to communicate about concepts in advance of learning words to describe them (e.g., Goodwyn & Acredolo, 1998). Moreover, there is evidence that gestural communication in infants predicts later language outcomes, including vocabulary size (Rowe et al., 2008) and the advent of combinatorial speech (Iverson & Goldin-Meadow, 2005). In older children and adults, there is evidence that gesture supports comprehension of complex ideas, including mathematical operations (Goldin-Meadow, 2009; Goldin-Meadow & Alibali, 2013; Novack, Congdon, et al., 2014; Ouwehand et al., 2015). Thus, although limited in its referential specificity in communicating about present, absent, and abstract phenomena, human gesture is an effective communicative system that complements language.

Importantly, among humans, gesture serves as communicative system that complements language. Perhaps, then, the representation precision and power of gesture is capped in humans because of its auxiliary status to language and rarity of its independent use. To address this possibility, we consider gestural communication in other great apes (hereafter, ‘apes’) – a highly social, communicative species who invoke gesture and vocalizations, but not language, to communicate.

Gestural reference in greater apes

Communication among apes includes gesture, facial expression, and vocalizations. The latter two appear to serve communicative functions primarily about affect (Seyfarth & Cheney, 2003) or predation (Zuberbühler, 2005). Moreover, facial expressions and vocalizations tend to be broadcasted to the group, rather than to a specific recipient (Arbib et al., 2008). In contrast, gestures appear to serve communicative functions like reference (e.g., Leavens et al., 2004), and to be directed toward specific communicative partners (Gillespie-Lynch et al., 2014; Pollick & de Waal, 2007; see Tomasello & Call, 2019; Arbib et al., 2008, for reviews) to achieve specific goals, like receiving food or grooming (Byrne et al., 2017; Genty & Zuberbühler, 2014; Pika & Mitani, 2006; Sievers & Gruber, 2016). If the goal is not achieved, apes have been observed to ‘rephrase’ their signals⁷ (Byrne et al., 2017), either producing sequences of synonyms to clarify the message (Cartmill & Byrne, 2010; Hobaiter & Byrne, 2011) or combining gestures to convey new meanings (e.g., Crockford et al., 2012).

⁶Importantly, this is not a limitation of the visual-manual modality itself: speakers of sign languages certainly communicate about absent and abstract phenomena and use non-linguistic gesture to augment linguistic communication (e.g., Goldin-Meadow & Brentari, 2017), just like speakers of verbal languages, who begin to combine gesture with speech around the middle of their second year (Capirci et al., 1996; Iverson et al., 1994).

⁷The motivation for this behavior (rephrasing) remains under debate. Some propose that apes understand the beliefs or desires of others, and tailor their gestures accordingly (Warren & Call, 2022); others remain skeptical of apes’ capacity for mentalizing⁷ (Seyfarth & Cheney, 2003).

The repertoire of *deictic* gestures (see Box 3) in apes appears to resemble that of human infants (Gillespie-Lynch et al., 2014; Kersken et al., 2019), with one exception: apes produce primarily *imperative* pointing (see Tomasello & Call, 2019), with scant evidence of *iconic* or *representational* gestures (e.g., Cartmill et al., 2012; but see Perlman et al., 2014, for an alternative account). Nevertheless, apes appear to have established a sizeable repertoire of mutually understood gestures with relatively stable (perhaps conventionalized) meanings (Graham et al., 2017). The source this stability, however, may differ from that of word meanings. Words are arbitrary, bearing no necessary relation to their referents, and must therefore be learned. In contrast, many of the mutually understood gestures among apes appear to stem from phylogenetic ritualization (Hobaiter & Byrne, 2011; but see Halina et al., 2013, for an *ontogenetic* ritualization account). Moreover, for those cases in which the meaning of a particular ape gesture is learned, the evidence suggests that it may be understood by only one participant in the communicative episode (e.g., a mother interprets her infant's gesture; Byrne et al., 2017), and not shared within the broader group. Interestingly, conventional gestures of apes appear to convey information primarily about actions (Byrne et al., 2017; Tomasello et al., 1997). In contrast, human infants' earliest lexicon includes a preponderance of names for objects and object category names (e.g., Bergelson & Swingley, 2012, 2015; McDonough et al., 2011; see Perszyk & Waxman, 2018, for a review). In sum, although strong convergences exist between ape gesture and human language, there are also compelling differences in communicative functions and specificity of each.

Nevertheless, apes do appear to have mastered several capacities that underlie the establishment of absent reference (see Luchkina & Waxman, 2021). For example, apes use gesture to communicate intentionally and to represent the location of *absent* objects (e.g., Albiach-Serrano et al., 2010; Barth & Call, 2006). To see whether these advances enable apes to use gesture produce and comprehend absent and abstract reference, we turn to experimental investigations of ape communication.

Absent reference in ape gesture

Like 12-month-old human infants, apes *produce* gestures intentionally and purposefully to request absent food, pointing to an empty plate that previously contained that food (Bohn et al., 2015). In addition, apes continue to point to the location of a previously shown banana, even after the banana was hidden (Leavens et al., 2004). Liszkowski et al. (2007) went further to distinguish between *absent* vs. *hidden (occluded)* referents. In this experiment, all apes watched a demonstration, in which one human actor, the requester, verbally requested a desired food item (displayed in one of two containers) from another human actor, the giver, who delivered it to the requester. Apes were then assigned to one of two conditions. In the *occluded-referent* condition, they observed the giver hiding a desired food item inside one of two containers. In *absent-referent* condition, they observed the giver begin, but ultimately fail, to complete the action. During test, apes in both conditions viewed two empty containers. Only those in the *occluded-referent* condition pointed to the container in which the food was last seen. This outcome stands in contrast to 12-month-old human infants who, when tested in a similar procedure (but with toys instead of food), pointed to the former location of the toys in both conditions.

Despite apes' successful *production* of deictic gestures to request displaced food items (as we just reviewed), there is little evidence that they *comprehend* the deictic gestures of others (humans or conspecifics; (e.g., Itakura et al., 1999; Tomasello, 2020; Tomasello et al., 1997). Moreover, apes' comprehension of deictic gestures appears inferior to that of human-reared dogs and wolves (e.g., Agnetta et al., 2000; Hare & Tomasello, 1999; Kaminski et al., 2012; Virányi et al., 2008), despite that apes can track the locations of hidden items substantially better than dogs (Rooijakkers et al., 2009).

Also instructive is the handful of case studies with language-trained apes, indicating that apes may, in principle, have the requisite capacity to represent absent objects and abstract concepts, and to communicate about them (Call, 2011; Premack, 2014). For example, Sarah, a language-trained chimpanzee, acquired symbols for the abstract concepts 'same' and 'different', and also appeared to have interpreted if-then hypotheticals like 'If Sarah take apple, then Mary give chocolate to Sarah' (Premack & Premack, 1972). Another language-trained ape, the bonobo Kanzi, understood complex requests to manipulate certain objects and used pictograms to communicate about them with his trainers, but never with other bonobos (Savage-Rumbaugh et al., 1993). However, because observations like these come from only a few individuals and only with language-trained apes raised by scientists, it remains an open question whether apes raised in natural environments spontaneously develop such abilities.

In sum, apes' ability to communicate about absent and abstract reference remains inconclusive. On the one hand, it is unclear whether apes' communication about absent objects engages the same cognitive capacities as in humans (see Box 2). Do apes use gesture to access mental representations, or do they simply produce pointing behaviors to achieve a desired outcome? On the other hand, apes' intentional production gestures about absent referents for specific communicative partners, coupled with evidence that at least some language-trained apes can communicate about abstract concepts, suggests is similar to human language in its communicative function. This evidence is also consistent with proposal that apes' gestural communication and human language may share evolutionary origins (e.g., Arbib et al., 2008; Gillespie-Lynch et al., 2014; Pollick & de Waal, 2007). Even so, humans and apes differ considerably in their ability to attribute of communicative status to arbitrary stimuli. For example, infants flexibly attribute communicative properties to a wide range of signals (Ferguson & Waxman, 2016; Tauzin & Gergely, 2018) and learn to constrain this range to words and gestures by 12 months (May & Werker, 2014; Namy & Waxman, 1998; Novack, Henderson, et al., 2014; Suanda & Namy, 2013). Further, there appears to be no evidence of a link between gesture and other aspects of cognition in apes (e.g., Novack & Waxman, 2020). In contrast, human language, including sign language, facilitates categorization in human infants as early as 3 months of age (Perszyk & Waxman, 2018). It might be due to this difference that apes gestural communication does not reach the same depth and complexity as human language, enabling learning about absent and abstract phenomena. Additional evidence will be required to investigate this possibility.

Absent reference in humans and apes: summary and (still) open questions

We have proposed that the capacity for absent reference is a critical test for the link referential between words (or gesture), and mental representations. Integrating evidence from human infants and apes, we showed that children link words to mental representations by 16 months, and soon after begin learning new facts from language alone. We also showed that gesture is less effective than language in enabling absent reference. This is likely because gesture lacks referential precision, which is a distinct feature of language and a constituent component of linguistic reference. We proposed that this limitation may be due to gesture's auxiliary role in human communication. We then turned to literature on ape gesture to gain insight into the power and precision of absent reference in gesture when it is the primary form of referential communication. However, investigations of ape gesture, however fascinating, do not yet resolve whether gesture about absent referents is referentially more precise in apes than in humans, and whether apes use gesture for knowledge acquisition. These open questions require further empirical work to clarify the extent of apes' capacity for absent reference and the extent to which ape gesture can communicate information about absent or abstract referents.

New directions: the link between linguistic reference and abstract reasoning

The current review suggests that an ability to acquire knowledge about absent and abstract phenomena may be enabled uniquely by linguistic reference. Interestingly, without linguistic reference in place, non-human primates and prelinguistic humans appear to be limited *not only in their ability to communicate about abstract phenomena but also in their ability to reason about them* (Donlan et al., 2007; Penn et al., 2008). This observation raises the possibility that the acquisition of linguistic reference may support abstract cognition more broadly (see also Neuman et al., 2012, for a computational account supporting this possibility).

Some correlational evidence is consistent with this possibility. First, language skills in infancy and early childhood predict a range of abstract reasoning skills in later childhood (Hammer et al., 2017; LeFevre et al., 2010, 2010; Marchman & Fernald, 2008; Morgan et al., 2015; Peng et al., 2020; Slot et al., 2020; Socher et al., 2020). Second, children deprived of language input early in life, such as deaf children of hearing parents who lack access to sign language, have more difficulty in abstract reasoning tasks than their hearing peers (Socher, 2020). To further clarify the relation between linguistic reference and abstract reasoning, new systematic investigations are necessary.

One productive avenue would involve longitudinal investigations, taking advantage of individual variation in infants' command of absent reference to predict their subsequent abilities in abstract reasoning. If the relation is indeed causal, then the results of these investigations will inform the design of interventions aimed to bolster children's abstract reasoning skills and to mitigate language-related learning difficulties.

Another intriguing avenue would involve assessing whether individual variation in children's access to linguistic reference predicts variation in their abstract reasoning. The evidence from deaf children in Nicaragua may provide a case in point: every subsequent cohort introduced more elements of linguistic reference to the emerging sign language (see Goldin-Meadow & Alibali, 2013; Senghas & Coppola, 2001). A comparison of absent reference and abstract reasoning skills across different cohorts, as well as across broader deaf populations who had varying access to language input (e.g., native signers, late signers, home signers, non-signers with cochlear implants), may shed light on the possibility that linguistic reference is causal in shaping abstract reasoning.

Yet another new avenue is specifying the development of referential precision in language and gesture in humans and apes. For example, even young infants, who have only recently established linguistic reference, reliably use naming to guide their concepts of individual vs. category distinctions (e.g., LaTourrette & Waxman, 2020) and to identify which kinds of words (e.g., noun, verb) tend to refer to which kinds of referents (e.g., object categories, object properties, event categories (Perszyk & Waxman, 2018; Waxman & Booth, 2003; Waxman, 2004; Waxman & Lidz, 2006). It is an open question whether apes are capable of such nuanced interpretations of their communicative repertoires. Future cross-species investigations are needed to clarify the referential precision conveyed in apes' gesture and whether this precision supports conceptual learning.

Investigations like these, bridging laboratory studies with neurotypical populations to clinical and cross-species and ethnographic research, will help shed light on how linguistic reference shapes our ability to learn and reason about abstract phenomena. It will also move the field forward by advancing our understanding of the relation between language and cognition.

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Box 1.**Reference terms used in this paper and their correspondence to those in linguistics and philosophy****Words.**

Words are acoustic units that are not intrinsically bound to any specific real-world entity. Once meaning has been assigned, words become vehicles for accessing, forming, and modifying representations (i.e., pragmatic reference, see Abbott, 2010). Words can also be used to draw attention to a real-life entity. However, to identify what to attend to, one must rely on the word meaning to retrieve representations linked to the word. One then needs to compare present phenomena to those representations (in some cases, referential acts are accompanied with gesture, which helps constrain the set of phenomena to attend to).

Referents.

Referents are real-world phenomena and their properties when such phenomena and properties do exist. But not all words have real-world referents. In the case of abstract ideas or things one cannot perceive ('subatomic force'), referents are indistinguishable from representations. This is not a problem for linguistic reference under our definitions: even when there is no real-world referent or referent is volatile ('democracy', 'every American'), words can still be linked to representations, which preserve the possibility of meaning (see below) and communication.

Mental representations.

Representations are ideas, concepts, and stored mental images (but not percepts of real-world objects available during observation or experience with them). Here, we use the term 'mental representations' broadly to include representations of individuals (e.g., 'Fido'), categories of things (e.g., dogs, scientists), or a memory of a unique sensation (e.g., the pain of having stepped on a Lego part); we do not distinguish between perceptual and conceptual representations. This is because in most empirical findings that we review it is difficult (if at all possible) to distinguish between these types of representations. Some representations are sparse. For example, 'spacetime continuum' is hard to conceptualize or visualize, which may leave the representation corresponding to the words relatively sparse. Other representations are detailed and precise (e.g., one's own pet dog). The same referent can have multiple corresponding representations (e.g., the same three in the summer and in the winter).

Meanings.

Meanings are word-representation links believed to be shared by others, which requires awareness of pragmatic reference. Without users of language, words have no intrinsic meanings. In some cases, when word-representation links are believed to be shared widely, the meaning is relatively stable (e.g., dog). In other cases, it is volatile and depends on the context ("it"; see e.g., Clark & Marshall, 1981; Doran & Ward, 2019; Nunberg, 2004; Prince, 1992). Representations themselves can be sparse. What matters is the belief that others have corresponding representations and pair them with words. We

may have little idea of who Napoleon was, but we can form a representation based on how others use the word (e.g., it is embedded in expressions containing known words) that help us infer a widely shared meaning.

Referents	Mental representations	Meanings
• Extension (Carnap)	• Idea (Frege)	• Intension (Carnap)
• Denotation (Russell)	• Concept (Church)	• Meaning (Russell)
• Reference/denotation (Frege)	• Mental image	• Sense (Frege)

Box 2.**Requisite capacities of absent reference (see Luchkina & Waxman, 2021, for a more detailed review).****Establishing and retrieving mental representations.**

At least by 5 months, infants show evidence of remembering a recently hidden object, as well as its size and location (Baillargeon et al., 1989; Baillargeon & Graber, 1987; Spelke et al., 1992). At least by 6–9 months infants can store object and event representations over the span of months (Bauer, 2002; Bauer et al., 2000; Carver et al., 2000; Mandler & McDonough, 1995). At 9 months, infants also can build correct expectations about the identity of non-visible object after hearing its name (Parise & Csibra, 2012). This evidence suggests that by 9 months they successfully store object representations in long-term memory, map them to words, and retrieve them upon hearing the corresponding word.

Recognizing that the unobservable can be communicated.

Infants begin to recognize that others' actions are guided by their (unobserved) intentions around 6 months of age (Southgate & Vernetti, 2014). Soon after, between 6 and 12 months, infants begin to realize that speech is also driven by intentions and that it can communicate. They use contextual information to infer the goals communication, even if those goals cannot be observed directly (Cheung et al., 2012; Martin et al., 2012; Vouloumanos et al., 2012, 2014).

Referential precision.

Between 11 and 14 months infants become increasingly aware of different classes of words (e.g., nouns vs. adjectives) and appropriately map them onto different classes of phenomena (e.g., objects vs. properties; see (Booth & Waxman, 2009; Waxman & Booth, 2003). At this age they also comprehend the meaning of pronouns and use them to resolve referential ambiguity (Saylor et al., 2011). The referential precision of words enables language to communicate about various aspects of the same phenomenon, rather than just indexing it (e.g., Luchkina & Waxman, 2021).

Box 3.**Types of gesture.**

Deictic gesture (e.g., pointing) is pointing is analogous to deictic linguistic expressions (e.g., ‘that’). As deictic expressions, deictic requires contextual information to identify the intended referent (e.g., Clark & Marshall, 1981; Doran & Ward, 2019; Nunberg, 2004; Prince, 1992).

Representational gesture describes an object or an action iconically or metaphorically (see e.g., Novack & Goldin-Meadow, 2017). For example, such gestures can describe the shape of objects, capture elements of relational structure among physical entities or logical arguments (e.g., ‘one the one hand, on the other hand’).

Conventional gesture has a stable meaning, similar to words in human languages (see Goldin-Meadow & Alibali, 2013; Kersken et al., 2019; Liszkowski, 2008). Examples of such gestures include waving hello or goodbye or shaking one’s head in disagreement. Infants produce some conventional gestures by 16 months (e.g., Guidetti, 2002; Iverson et al., 1994).

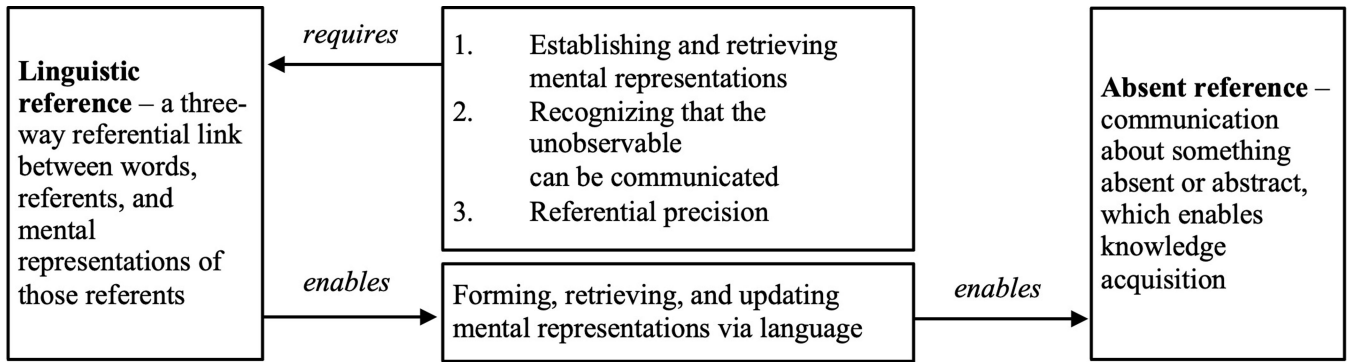


Figure 1.
Key constructs used in this paper.

Table 1.

Referential specificity of language and gesture (produced in isolation). Light grey checkmarks represent limited capacity.

Reference to absent and abstract phenomena	Language	Gesture
Reference to whole present objects/events	✓	✓
Reference to parts of present objects/events	✓	✓
Reference to states or aspects present of objects/events	✓	✓
Reference to previously observed but currently absent objects/events (including requests for desired actions)	✓	✓
Reference to never seen and currently absent objects/events	✓	✓
Reference to abstract notions	✓	✓