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Author for correspondence:
Anna Papafragou
e-mail: anna4@sas.upenn.edu

Pragmatic communication and Theory of Mind

Anna Papafragou[1] and Myrto Grigoroglou[2]

[1]Department of Linguistics, University of Pennsylvania, Philadelphia, PA 19104-6228, USA
[2]Department of Linguistics, University of Toronto, Toronto, ON, Canada, M5S 3G3

AP, 0000-0001-5435-1058; MG, 0000-0003-3881-618X

A foundational assumption in theoretical models of communication is that the derivation of pragmatic meaning involves the calculation of speaker intention and hence relies on a form of Theory of Mind (ToM). Recent theorizing, however, has challenged the conclusion that ToM is required for all types of pragmatic processing. Here, we provide a theoretical synthesis of a wide-ranging but seemingly conflicting set of empirical findings on the role of ToM in pragmatic processing in children and adults, focusing on two key phenomena, reference and implicature. We argue that the state of the art offers no reason to abandon the hypothesis that both adults and children rely on ToM for the computation of pragmatic meanings. We propose that, across these and other pragmatic phenomena, apparent differences in ToM involvement can be attributed to principled and predictable outcomes based on how ToM is applied to the context in hand. We conclude by outlining new ways of studying the contributions of ToM to pragmatic interpretation.

This article is part of the theme issue 'At the heart of human communication: new views on the complex relationship between pragmatics and Theory of Mind'.

1. Introduction

Conversational, or pragmatic, inferences are required for a hearer to understand the intended meanings of utterances, even when these are not literally conveyed. A foundational assumption in theoretical models of human communication is that the derivation of pragmatic inferences involves the calculation of speaker intention [1,2]. On these classic pragmatic models, Theory of Mind (ToM), the ability to compute others' mental states [3], should be critical for the computation of conversational inferences, since interpreting an utterance (or any other kind of communicative symbol) is constrained by what the speaker had in mind and intended to communicate.[1]

Several pieces of evidence have provided support for the role of ToM in pragmatic processing. For example, the assessment of the speaker's epistemic state affects pragmatic computations in both adults and children in the process of learning language (for reviews, see [9–12]). Furthermore, neuroscientific evidence suggests that cortical regions linked to ToM, most notably the right temporo-parietal junction [13] are activated during the comprehension of several pragmatic phenomena (e.g. metaphors [14,15]; indirect requests [16]; indirect responses [17]; implicatures [18]; irony ([19]; cf. [20]); jokes [21]). Relatedly, lesions in ToM regions in the brain lead to impairments in different types of pragmatic processes (e.g. metaphors [22] and jokes [23]).

However, other research has challenged the conclusion that ToM is required for all types of pragmatic processing. One source of evidence has traditionally come from individuals assumed to have poorer ToM abilities (as in Autism Spectrum Disorders, ASD) but who sometimes have similar pragmatic comprehension to neurotypical individuals (e.g. scalar implicatures

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[24–26]; indirect requests [27,28]; metaphors [29,30]; word learning [31]). Such findings can be taken to suggest that ToM is not required in these types of pragmatic processing. Yet, such data must be interpreted with caution: in some cases, what has been assumed to be difficulty with ToM in ASD has been reinterpreted as difficulty with word knowledge (metaphors [29,30,32]; cf. [33]; see also [26,34] on implicatures). In other cases, the diversity of ASD profiles complicates the conclusions about the link between experimental performance and underlying representational mechanisms [35,36].

Another source of evidence comes from studies of neurotypical adult participants who—to some extent—fail to take into account an interlocutor's perspective in language processing, and instead interpret language from their own egocentric view, at least during initial stages of language processing [37–41]. The idea that communicators are (initially) egocentric (i.e. they focus on their own knowledge and informational needs, while ignoring the perspective of others) has a long history in psychology, with classic developmental views considering children as predominantly egocentric reasoners [42,43] and assuming that overcoming this initial egocentrism takes a lot of cognitive effort. Egocentrism has also been taken up by more recent linguistic-pragmatic accounts that challenge the standard view that a computation of the speaker's perspective is required for all types of pragmatic processing (e.g. [24,44–50]). For example, following Sperber [51], Kissine [45] suggests that pragmatic *processes* (e.g. implicature derivation) are distinct from pragmatic *strategies*, which may be more or less egocentric, taking into account the speaker's epistemic state to a lesser or greater degree, depending on the context, with adults switching between strategies as required (cf. [27,52]).

Despite having been the topic of intense empirical scrutiny, at present, the contribution of ToM to pragmatic processing remains a matter of debate.[2] Here, we revisit the role of ToM in pragmatic processing in both adults and children with the goal of providing a theoretical synthesis of a wide-ranging but seemingly conflicting set of empirical findings. We focus on two phenomena, reference and implicature, for three reasons. First, these phenomena have long been at the core of experimental pragmatics and have contributed rich relevant experimentation and theorizing. Second, unlike metaphor and irony that have often been used to assess the role of ToM in pragmatic processing (e.g. [55–58]), the comprehension of reference and implicature relies less on elaborate world knowledge or complex linguistic skills. Third, both reference and implicature are acquired by children relatively early (i.e. during preschool years), thus allowing us to examine the influence of ToM on pragmatic processing beginning at the earliest stages of development.

Our main thesis is that the state of the art offers no reason to abandon the hypothesis that mentalizing supports the fast and fluent computation of pragmatic meanings during the comprehension of reference and implicature in both mature (adult) and developing communicators. We propose that, across these and other pragmatic phenomena, apparent differences in ToM involvement can be attributed not to strategies employed for different tasks but to principled and predictable outcomes based on how ToM is applied to the context in hand. For pragmatic research, of interest is less whether communicators have the general ability to read the minds of their interlocutors but whether and to what extent they use this ability when producing and comprehending language (cf. [11,59,60]). As we show in discussing reference and implicature, the distinction between *having* the general ability to use ToM in pragmatic communication and *implementing* it in specific tasks is critical for explaining the pattern of results we see across tasks, linguistic phenomena and different developmental stages. Towards the end of the article, we outline new ways of studying the contributions of ToM to pragmatic interpretation suggested by this integrated picture.

2. Reference

(a) The role of Theory of Mind in reference assignment

Referring to objects, events and other entities is a foundational communicative act. On standard pragmatic views [1,61,62], successful referential communication requires speakers to distinguish the features that set apart the target referent from other possible referents in the context and choose referring expressions that vary in their specificity (e.g. *the blue pen*/*the pen*/*it*) based on the perspective and knowledge of their listener. Similarly, listeners interpret speakers' ambiguous referential expressions (e.g. *Give it to me*) by assuming that speakers are maximally informative and produce messages tailored to the listeners' knowledge and communicative needs. Evidently, this view of communication requires communicative partners to engage in ToM by taking the perspective of their interlocutor, in order to build and maintain a model of their interlocutor's knowledge and beliefs.

Perspective-taking in referential communication has been studied since the 1960s using the highly influential referential communication task (e.g. [63–66]). In this task, participants give and take directions about how to move objects on a visual display. In critical trials, two (or more) of the objects contrast along (at least) one dimension, so that, in order to disambiguate between them, one has to use a modified description (e.g. 'Pick up the big duck', in the presence of a small and a big duck). In some paradigms, one of the objects in the visual display is visible to one of the interlocutors but not the other. This creates a misalignment in the visual perspectives for the speaker and the listener, which needs to be taken into account when producing or interpreting instructions. Decades of research using variations of the referential communication task have provided consistent evidence that both adults and children regularly take into account their interlocutor's knowledge.

At the first level, communicators are sensitive to the visual perspective of their communicative partner from a very young age. In one study, 2-year-old children were more likely to name a hidden toy, mention its location or point towards it when a parent had not witnessed the toy's hiding compared to when the parent was present during hiding [67]. Relatedly, in a series of referential communication tasks, adult and 3- to 6-year-old speakers with visual access to two contrastive objects (e.g. a big duck and a small duck) were more likely to use an adjective to modify their object descriptions when their listeners had visual access to both objects (e.g. by saying 'Pick up the *big* duck'), but used unmodified descriptions when the listener could see only

one of the two objects (e.g. they said 'Pick up the duck'). Similar findings have been documented in comprehension: child and adult listeners, upon hearing a referential expression that was ambiguous from their perspective (e.g. 'Pick up the duck', in cases where they could see both a big and a small duck), looked quickly at the object that was in common view with the speaker and ignored the object that was in their own privileged view [68–75].

Referential communication is also sensitive to information shared with interlocutors in prior discourse. For instance, once adult speakers have started using a specific referring expression to describe an object in conversation with a partner, they continue using the same expression in their subsequent conversations with the same partner but do so less when in conversation with a new partner [76,77]. Similarly, children as early as 2 years of age are more likely to use informative expressions to refer to a character (i.e. full noun phrases vs. pronouns) when their partner had not mentioned the character in prior discourse than when the partner had mentioned the character [78]. Similarly, in comprehension, both adult and child listeners interpret instructions faster when the speaker uses the same term to refer to a given object but slow down when the speaker uses a new term to refer to the same object [79–83].

Finally, communicators also adjust their communicative behaviour based on general background knowledge shared with communicative partners [61,64,84,85]. For example, when interlocutors were asked to arrange pictures of New York City landmarks, experts used less words per trial and more bare proper names when talking to other experts, as opposed to novices [64]. Similar effects have been found with other types of expertise: medical experts were more likely to use technical language when talking to addresses whose vocabulary choices indicated some level of medical expertise, as opposed to addresses who used non-technical language [84]. Children are also sensitive to information shared within a cultural community, with 5-year-olds differentiating their interpretation of ambiguous instructions (e.g. 'Can you give him to me please?') based on a partner's knowledge or ignorance of a culturally familiar character (e.g. Santa Claus) [86].

(b) Challenges and a synthesis

The studies reviewed so far suggest that adults and children, at least since age 2, are sensitive to information available to a specific communicative partner in a conversation and can use this information to modify their referential behaviour. However, other research has shown that adults and children do not always integrate their communicative partner's knowledge in referential communication. For instance, the developmental studies mentioned above also reveal rampant failures of perspective-taking: in many cases, children only successfully adapt their referential productions to their partner's perspective in less than half of the critical trials [68,73,87], while other work shows that children's referential production is persistently underinformative until the age of 8 or 9 [88,89]. Egocentric patterns in language production have also been found in adults, with certain studies showing that adults do not take into account the perspective of their listener at initial stages of message planning, but only later (if at all) as a repair for failed communication [39,90]. Contradictory evidence is also found in comprehension, with certain referential communication paradigms similar to the ones described above, showing that child and adult listeners, upon hearing ambiguous instruction, frequently failed to integrate the speaker's perspective in their interpretation [38,40].

How can these divergent findings be explained? Following prior suggestions [11,40,60,91], we propose that seemingly contradictory findings can be reconciled by drawing a distinction between *having* the ability to use ToM in referential communication and *implementing* this ability in specific tasks. Thus, even though massive evidence suggests that both children and adults can use ToM in referential communication, this ability may not always be manifest across contexts. We argue that the contexts of difficulty are predictable and rest upon three broad factors: the complexity of the experimental task, the cognitive demands of implementing ToM in the context at hand and the communicative conditions of the experiment.

The first factor affecting the extent to which adults and children integrate their communicative partner's visual perspective in reference comprehension has to do with the complexity of the experimental task [70,92,93]. In the studies reviewed above, paradigms with simpler arrays of objects and easy-to-interpret instructions tended to show more successful incorporation of a partner's perspective [70,73,87] than tasks with more complicated arrays and occasionally misleading instructions [38,40]. For instance, in one study showing more limited incorporation of a partner's visual perspective [38], 4- to 12-year-old children and adults were presented with a visual array with three contrastive objects (e.g. big, medium and tiny toy trucks), instead of the most typical two-object array used in other studies [70,72,73,87]. In critical trials, two of the trucks were visible to both the participant and the speaker (i.e. big and medium truck), while the third one (i.e. small truck) was visible only to the participant. Eye-tracking data showed that both adults and children, upon hearing ambiguous instructions (e.g. 'Move the small truck above the glue', when they could see two trucks that could qualify as 'small') tended to look first at the truck that was visible only to themselves (i.e. the smallest truck) and not the truck that was also visible to the speaker (i.e. the medium-sized truck). Adults, at later stages of online processing, correctly looked at the object that best matched the speaker's perspective but 4- to 12-year-old children often never recovered from their egocentric processing. These and similar findings were interpreted as evidence that comprehenders initially do not integrate the speaker's perspective [40,94]. However, given that the critical instruction (i.e. 'Move the small track') best matched the truck in participants' privileged view, it is more likely that these apparent failures to account for the speaker's perspective occurred due to the task set up creating lexical competition between the two potential referents. In fact, paradigms that eliminated such confounds found no evidence of an initial egocentric stage of language processing [70,72]. Instead, this line of research shows that listeners establish reference by actively weighing different types of available information (including the perspective of both oneself and others) in a principled and predictable way [70,72,95,96]. In this sense, the above-mentioned limitations in perspective-taking are mere experimental artefacts, resulting from the fact that competitor referents were better matches for the instruction given to participants.

Relatedly, the likelihood of taking into account an interlocutor's perspective in communication often depends on the cost of engaging ToM in a specific task, based on the type of perspective information that communicators have to track. Specifically,

incorporating information about an interlocutor's visual perspective, especially when it involves inhibiting one's own perspective (as in typical referential communication tasks), requires constant monitoring and updating and may be more costly to incorporate than information shared between interlocutors in prior discourse or within a community [97–100]. Support for this possibility comes from studies that have examined how interlocutors adjust their communicative behaviour to different types of information shared with their communicative partners. In one study by Brown & Dell [90], speakers were asked to retell stories involving actions performed with typical or atypical instruments (e.g. stabbing a man with a knife vs an icepick) to listeners who could either see pictures representing the actions or not. Results showed that speakers regularly adjusted their utterances to include information that would be considered unpredictable within the community (e.g. by mentioning atypical instruments more often than typical ones), but this adjustment was not affected by their particular listener's visual perspective (i.e. by whether the listener could see the pictures of the actions or not). Developmental studies show that these effects are even more pronounced in children [100–103]. In one study using a version of the Brown and Dell paradigm [100], 4- to 5-year-old children who were asked to describe videotaped events of actions involving typical and atypical instruments (e.g. watering plants with a watering can/hat) to a listener with or without visual access to the events mentioned instruments infrequently and, unlike adults, did not mention instruments more frequently for a listener without visual access to the events. Nevertheless, children did adjust their communicative behaviour to include atypical instruments more than typical ones. These adaptations were not made for the sake of a specific addressee—since they did not depend on whether the child's interlocutor could see the events or not; rather they appeared to be adaptations that would benefit any generic listener.

These patterns of results can be explained by the different cognitive costs of 'particular' and 'generic' adaptations. Maintaining and updating highly 'particular' and dynamic representations of a partner's perspective (i.e. present, moment-by-moment representations of an exchange), especially when these involve constantly suppressing one's own visual perspective to incorporate the perspective of the interlocutor, pose higher cognitive demands compared to 'generic', more stable representations (e.g. knowledge shared in the community/generally known facts, or memories of physical or linguistic co-presence) [100]. The cost of these adjustments might depend on individual differences in higher-order cognitive abilities: children and adults with stronger executive functioning (e.g. working memory, inhibitory control) and better mentalizing skills (e.g. ToM) are more likely to take into account their interlocutor's perspective in referential communication [74,80,104–108].

Finally, the nature of the conversational exchange itself may affect the likelihood of successful ToM involvement in referential communication for both adults and children [100,102,109–111]. For example, in a replication of Brown & Dell's [90] study that asked people to retell stories with instruments to naive listeners (instead of confederates), speakers were more likely to mention atypical instruments when the listener lacked access to the pictures depicting the events in the story compared to when the pictures were visible [110]. This effect arose presumably because speakers unconsciously thought that naive listeners (unlike the confederates in the original Brown and Dell study) had genuine informational needs. In a further series of studies, we tested the effect of the listener's profile on speakers' perspective-taking in a more systematic way [100,102]. In this line of work, we used confederates instead of naive listeners (to avoid providing corrective feedback) but critically manipulated how interactive the listener appeared in the task. In one version of the experiment [100], 4- and 5-year-old children and adults performed a referential communication task where they had to describe one of two contrasting pictures depicting typical and atypical instrument events (e.g. a woman sweeping with a broom vs. a tree branch) to a listener who appeared as a passive bystander (as is typical in many referential communication studies); in another version of the experiment, participants performed the exact same task but described the events to an interactive listener who offered some minimal input before and after each trial (e.g. *Tell me, which one is it? Ok, I think I got it!*) and had a specific goal (i.e. to guess which of the two pictures was the 'right one'). Results showed that both 4- and 5-year-old children and adults were more likely to disambiguate between the two instrument events when communicating with the interactive, collaborative partner compared to the more passive listener. These results clearly show that both adults and children are more likely to integrate the perspective of a communicative partner when they perceive that their informational needs are genuine and the interaction, thus, more psychologically rewarding (for similar findings with children using monetary incentives see [111]).

3. Implicature

(a) The role of Theory of Mind in implicature computation

Implicatures are pragmatic inferences that arise when the speaker blatantly violates one (or more) of the conversational maxims and wants the listener to perceive this violation, in order to infer the speaker's intended meaning [1]. Scalar implicatures are a type of conversational implicature that arises when the speaker uses a weaker scalar item from a scale of items organized in terms of semantic strength. Such scales can be lexically defined (e.g.<*all*, *most*, …, *some*>,<*and*, *or* >,<n, ..., *three*, *two*, *one*> ,<*must*, *should*, *might*>; see [112,113,114], for more examples of *lexical* scales) or contextually defined (e.g. <*John and Mary, Mary*>; see [115] for more examples of such *ad hoc* scales). On a Gricean [1] account, scalar implicatures (e.g. 'Some of my kids love art') arise because the listener realizes that the speaker did not use a stronger, more informative term that would have been relevant (thus violating the Maxim of Quantity); the listener thus needs to infer that the speaker was not in a position to offer a more informative alternative involving a stronger scalar item (e.g. the speaker knew that not all of her kids love art). According to classic pragmatic accounts, the derivation of scalar implicature engages a rich computational process that integrates the speaker's epistemic state [1,2,116–120]. The hearer typically reasons that the use of an informationally weaker statement means that the speaker either does not know that the stronger scalar statement is true or knows that the stronger statement is not true [112,117–119,121–123].[3] Although this idea remained underexplored in early experimental work, a growing body of

research shows that both adults and children can and do consider different types of speaker knowledge in scalar implicature computation.

Adult comprehenders regularly take into account the speaker's perspective when processing scalar implicatures. In one study [127], participants read scenarios told from a first-person perspective. Introductory sentences established whether the speaker had full or partial knowledge of an issue (e.g. 'At my client's request, I meticulously compiled the investment report/At my client's request, I skimmed the investment report'), followed by critical sentences that included the weak quantifier *some* (e.g. 'Some of the real estate investments lost money') and continuations that referred to the complement of the set mentioned in the critical sentence ('The rest were successful despite the recent economic downturn'). Results showed that participants took longer to read sentences with *some* when it was established that the speaker had full—compared to partial—knowledge of the issue (presumably because the speaker generated the implicature *not all* in the full knowledge condition). Furthermore, participants in the full knowledge condition were faster to read the continuation sentence compared to participants in the partial knowledge condition (presumably because the generated implicature had already evoked the complement set).

Adult listeners also use information about a speaker's visual perspective when deriving scalar inferences, even if this perspective contradicts their own [50,128–130]. For instance, in an eye-tracking study [128], participants watched videos of a woman putting objects (e.g. forks, spoons) inside two boxes and heard descriptions of the woman's actions by a confederate speaker who was also watching the same videos on a separate computer screen. In critical trials, the video depicted the woman putting a spoon in each box, and then a fork in only one of the boxes. In such trials, the speaker's description 'The woman put a spoon in the box' could trigger the ad hoc scalar implicature that 'The woman put a spoon in the box and nothing else', thus leading listeners who have computed the implicature to look at the box with only the spoon. However, the study manipulated the speaker's visual access to the video, such that the speaker was either fully knowledgeable about how the event unfolded (i.e. watched the woman putting a spoon in each box and a fork in one of the boxes) or partially knowledgeable (i.e. watched the woman putting only spoons in the boxes). Results showed that although listeners were fully knowledgeable, they computed the implicature and looked at the target box (that contained only the spoon) only when the speaker was knowledgeable but did not compute an implicature (as evidenced by a lack of anticipatory looks to the target box) when the speaker was ignorant.

Finally, adults, when processing implicatures, also consider the knowledge a speaker holds as a member of a particular linguistic community. For instance, a series of studies has shown that adult comprehenders judged under-informative sentences containing a weak scalar term (e.g. 'Some elephants have trunks') more leniently when the sentences belonged to non-native compared to native speakers, presumably because non-native speakers are less aware of the meaning of their linguistic choices [131–133]. Interestingly, listeners draw different social inferences depending on whether under-informative sentences are used by a native or non-native speaker. Specifically, under-informativeness in non-native speakers is more likely to be attributed to inability to abide by the maxim of quantity rather than unwillingness [131]. Furthermore, non-native speakers who use under-informative sentences are less likely to be considered untrustworthy and unappealing than native speakers who commit the same 'sin of omission' [133].

Turning to developmental findings, there is currently evidence that young children can successfully integrate a speaker's visual knowledge when computing scalar implicatures [129,130,134]. In one study, 4-year-olds, 5-year-olds and adults saw pairs of pictures showing the same person sitting across a table behind a two-compartment box containing identical objects (e.g. a spoon and a bowl). In one picture, the person in the picture could see the contents of both compartments in her box (e.g. both the spoon and the bowl) but in the other, she could only see the content of one compartment (e.g. only the spoon) because the other compartment was blocked for her. Participants heard either a strong statement (e.g. 'I can see a spoon and a bowl') or a weak statement (e.g. 'I can see a spoon') and had to match the statement to the appropriate picture. Even 4-year-old children were highly successful in matching weak statements to the pictures where the person had limited access to the contents of the box (such that, e.g. she could only see the spoon); 5-year-olds, just like adults, were at ceiling. This is remarkable since, from the perspective of the participants, both boxes had identical contents (always two objects).

More recent evidence suggests that the ability to take into account speaker knowledge in pragmatic inference extends to forms of ostensive communication beyond language. A further study [134] adopted the same paradigm but replaced utterances with drawings: in response to a question about what she saw, the person in the pictures held up a drawing of either one object (the spoon) or two objects (the spoon and the bowl), and participants had to choose which box she had in mind. It was found that 5-year-olds and adults (but not 4-year-olds) expected drawings, like utterances, to be informative in accordance with their creator's knowledge. Notice that, for 5-year-olds to succeed on this task, they had to derive pragmatic inferences from pictorial symbols but do so from the epistemic perspective of a communicator that was sometimes different from their own (see also [135], for evidence that even 3-year-olds can apply pragmatic expectations to both utterances and pictures in a simpler task).[4] We conclude that the ability to engage ToM to compute implicatures extends beyond language to other communicative stimuli, just as classic pragmatic accounts would expect [1,2].

(b) Challenges and a synthesis

The above evidence suggests that both adults and young children incorporate speaker knowledge in scalar implicature computation. Despite these successes, however, children's performance in tasks that require epistemic reasoning appears fragile and task-dependent [24,48,130]. In one relevant study [48], children were presented with two action figures, one blindfolded and one with full visual access. The action figures watched as an animal stole an object and announced 'Look, an orange and a banana! Look what I'm taking!' and were asked what happened. Results showed that 4-year-old children presented with disjunctive sentences (e.g. 'He took an orange or a banana') failed to compute non-scalar 'ignorance' implicatures (i.e. they failed to match the disjunctive statement to the blindfolded speaker and thus to reason that only a speaker who lacks

knowledge is pragmatically justified in producing a disjunctive statement), despite succeeding in a matched ad-hoc implicature task in which the epistemic aspect was removed. It was concluded that 4-year-olds have substantial difficulty with the epistemic aspects of implicature derivation and even potentially compute scalar implicatures in the absence of epistemic reasoning (cf. [24]). Other recent studies of implicature have shown limits to the degree to which even adult listeners fully consult the viewpoint of the speaker when it contradicts their own [50,147].

How should we interpret these results? As with referential communication, a distinction needs to be drawn between *having* the ability to use ToM during pragmatic processing and *using* the ability in specific tasks and contexts. For instance, in the case of the developmental studies showing limitations in children's ability to incorporate information about a speaker's epistemic state, there are good reasons to believe that factors beyond children's mentalizing abilities, such as task differences, affected performance. Specifically, in the Barner *et al*. [48] study mentioned above, children had to watch lengthy scenarios while tracking the epistemic state of multiple speakers and the actions of multiple agents. These high task-specific cognitive processing demands may have masked 4-year-olds' ability to incorporate epistemic state into scalar implicature derivation (see [130] for discussion of this possibility; cf. also [145]).

Furthermore, the type of scale used to test implicature derivation in children is highly critical in children's success in deriving scalar inferences. For instance, in studies by Barner and colleagues [24,48,49], showing that 4-year-olds fail to reason epistemically, the children were asked to compute implicatures involving disjunction, a lexical term that children of this age struggle with [148–150]. By contrast, the study by Kampa & Papafragou [129] that found successful incorporation of the speaker's epistemic state in implicature derivation used ad-hoc scales that rely only on children's pragmatic abilities and not on the semantics of logical connectives. Thus, children's failures in previous tasks are better explained by task-specific processing difficulties rather than insufficient development of epistemic reasoning ability.

Similarly, suggestions that epistemic reasoning may not be required for pragmatic processing in adults need to be interpreted with caution. In a recent study [50], adults had to compute ad-hoc implicatures to identify a referent (a card) by sometimes resolving differences in common ground between themselves and the speaker. The study presented participants with four cards depicting fruit, one of which was only visible to the participant but not the speaker, and were given instructions by the speaker about which card to choose. The study had four critical conditions: (i) a condition where choosing the correct card required participants to compute an ad-hoc implicature in common ground between speaker and hearer (e.g. 'Pick the card with pears', in the presence of a card with only pears and a card with pears and bananas), (ii) a condition where choosing the correct card required participants to take into account the perspective of the speaker but not compute an implicature (e.g. 'Pick the card with pears', when the listener could see two identical cards with pears and bananas but the speaker only one), (iii) a condition where choosing the correct card required participants not to compute an implicature because it clashed with the speaker's perspective (e.g. 'Pick the card with pears', in the presence of a card with only pears in the listener's privileged ground and a card with pears and bananas in common ground with the speaker), and (iv) a condition where choosing the correct card required participants to both compute an implicature and consider the speaker's perspective (e.g. 'Pick the card with pears', in the presence of two cards with only pears but only one in common ground). Participants were highly accurate (above 90%) in their choices in all conditions, but performance was significantly lower (around 75%) when the generation of an implicature clashed with the speaker's perspective. These results were interpreted as evidence that pragmatic inferences are not derived by listeners only when warranted by the speaker's perspective, as suggested by standard pragmatic accounts, but that the listener's egocentric perspective may also play a role in pragmatic inference.

We suggest that, alternatively, the drop in adult's performance in the condition where the derivation of the implicature clashed with the speaker's perspective can be explained by task-specific factors. First, although the study adopted the design of referential communication studies, it differed critically from many of them, in that it was fully computerized and conducted online with no real speaker present. As already discussed, the lack of a real speaker in true physical co-presence with the listener can account for listeners' egocentric pragmatic processing [102,109,151]. Second, it seems that, in this condition, the instruction given by the speaker (e.g. 'Pick the card with pears') better matched the card in the listener's privileged ground (a card with only pears) than the card in common ground (a card with pears and bananas), thus requiring the listener to suppress the generation of an implicature, something that was not required in the other critical conditions in the study. The difference in performance can thus be explained by the different demands that this condition posed on participants' cognitive resources. This condition requires ToM to be applied not only to interpret what is being said in the presence of the visual context (i.e. the four cards with fruit—which would lead to the generation of an implicature) but also when assessing the speaker's perspective (which clashes with the implicature interpretation). If these steps are executed in order and not at once, the generated implicature interpretation would have to be inhibited, thus further increasing the cognitive cost. On this analysis, participants' failures in this task do not necessarily constitute ToM failures but limitations with executive functions (e.g. working memory, inhibitory control).

4. Conclusion

A foundational assumption in theoretical models of communication is that the derivation of pragmatic meaning involves the calculation of speaker intention and hence relies on a form of ToM. Nevertheless, the role of mentalizing within pragmatic communication has been brought into question from several directions. Here, we reassessed the role of ToM in pragmatic processing in both adults and children to integrate a broad but conflicting set of experimental results. We focused on two key pragmatic phenomena, reference and implicature, that have contributed data both favouring and challenging the engagement of ToM. We have argued that the evidence, if properly assessed, offers no reason to abandon the assumption that mentalizing

supports pragmatic interpretation in each of these domains in both adults and children. Thus, even though the possibility that pragmatics does not necessarily rely on ToM remains open, the evidence that has been marshalled in favour of this conclusion is currently not compelling.

Two general observations further bolster the conclusion that ToM supports pragmatic meaning. First, individual differences in ToM have effects on pragmatic processing. In a study on a large sample of neurotypical English-speaking adults [152], the better a participant performed on tasks measuring ToM, the more likely they were to respond to the pragmatic meaning of scalar implicatures and indirect requests. Importantly, this association represented the unique influence of ToM, controlling for the role of executive functions (specifically, working memory). (For metaphors, there was no such unique effect for reasons related to the specific study materials.) This evidence suggests that mentalizing skills, as the present article has argued, are uniquely important for making pragmatic judgements.

Second, a speaker's pragmatic behaviour leads listeners to draw social inferences about the speaker—precisely because pragmatics rests on assumptions about the speaker's mental states, including their abilities and preferences. For instance, a speaker's adherence to, or violation of, pragmatic principles in conversation, as well as the reasons underlying these violations, affect the evaluation of the speaker's personality along core social dimensions such as their warmth or competence ([153]; see [131,154]).

Questions of how individual differences in ToM and assumptions about the speaker's social identity affect pragmatic communication are novel and promising avenues of future research. Given that ToM is a broad term for a collection of abilities relating to thinking about other people's internal states and can be measured with a great variety of tasks, it remains to be seen what particular components of ToM are involved in pragmatic communication [7,8]. Large-scale investigations of the effect of individual differences in ToM on pragmatic processing in adults and children across a variety of pragmatic phenomena are required to answer this question.

Finally, while research on pragmatics tends to be tested by using somewhat artificial tasks (e.g. referential communication paradigms) and isolated sentences presented out of context (e.g. as in implicature comprehension studies), in real life, pragmatic communication takes place within rich sociocultural contexts. A promising path for future research is to explore how truly interactive, naturalistic interactions affect reliance on ToM during pragmatic processing. We conclude that pragmatics is not a monolithic entity but a complex intention-recognition system that interfaces with both language and non-linguistic (including social) cognition in several interconnected ways.

Ethics. This work did not require ethical approval from a human subject or animal welfare committee.

Data accessibility. This article has no additional data.

Declaration of AI use. We have not used AI-assisted technologies in creating this article.

Authors' contributions. A.P.: conceptualization, writing—original draft, writing—review and editing; M.G.: conceptualization, writing—original draft, writing—review and editing.

Both authors gave final approval for publication and agreed to be held accountable for the work performed therein.

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Endnotes

[1]In the context of these models, the term ToM is used in its most general sense to refer to any appreciation of other people's internal states. Other terms such as *mentalizing* (the ability to understand the mental state of the self and others), *mindreading* (often used in the psychological and philosophical literature instead of ToM) and *perspective-taking* (the ability to consider the knowledge of a communicative partner in conversation) would fall under the same general category of skills. Here, we adopt this inclusive definition of ToM as a general ability that human communicators have—at least in some form—since early stages of development (for recent proposals and empirical findings see [4–6]). Admittedly, ToM is a highly variable and multi-dimensional construct, with recent studies suggesting that different ToM measures may be targeting different components of the ability [7,8]. For present purposes, we simply point out that general debates about the relationship between pragmatics and ToM should extend beyond individual pragmatic phenomena and stand alone ToM components.

[2]There is a separate issue of whether pragmatics relies on a domain-general mindreading mechanism that is also responsible for action interpretation ([3], a.o.) or whether it relies on a domain-specific mindreading module that is solely responsible for utterance interpretation [51]. At present, there is a paucity of studies that bear on this distinction, and early evidence in favour of the second possibility [53] has been reconsidered in light of better-controlled studies [54].

[3]Unlike these models, in certain neo-Gricean approaches of scalar implicature, listeners, upon hearing weak scalar terms such as the quantifier *some*, may compute an implicature automatically, without initially consulting the speaker's intention or knowledge [124–126]. According to such models, the speaker's intention might be consulted later, if the listener finds that the implicature is not warranted by context and thus needs to be cancelled. We do not discuss these models here in detail.

[4]From a more general perspective, the data by Kampa and colleagues [129,134,136] offer one of the earliest demonstrations of children's success with scalar implicature, especially from an epistemic perspective. Scalar implicature is typically thought to pose challenges to 5-year-olds and sometimes even older learners [137–141]. Our findings confirm the conclusion that the ability to compute scalar implicatures is task-dependent [139,142–146].

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