5.   Acquiring implicatures

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Abstract: Children begin to acquire the ability to make inferences based on expectations of speaker co-operativity – implicatures – from the fourth year of life, but gaining adult-like proficiency in more complex communicative situations seems to take several more years. In this chapter we review what is known about children's developing ability to derive quantity, relevance and manner implicatures, and identify some key ingredients of this development: acquiring knowledge about communication, the world, and vocabulary and grammar; learning the inferencing process itself; and developing social cognition. We suggest that integrating these skills and types of knowledge in conversation is a key challenge faced by children, and outline directions for future research.

1.   Introduction

1.1.   The puzzle of implicature

The puzzle driving much recent research on the acquisition of implicature and other pragmatic phenomena, such as metaphor and irony, has been this: Why are children so adept at some skills that are foundational to pragmatics at an early age, yet apparently often so poor at inferring the speaker's communicative intention beyond what he or she literally said? From infancy, children demonstrate the ability to understand something about others' desires and intentions, track shared knowledge, and harness pragmatic assumptions for word learning (for an overview see Tomasello 2003, Clark 2009, and Ambridge and Lieven 2011). Yet their ability to perform in an adult-like way in tasks that test their pragmatic inferencing of implicatures seems to develop later, at age 5 or above.

Following Noveck's (2001) findings that 'children are more logical than adults', researchers have sought to disentangle an *apparent* delay in implicature acquisition from a real one. Are young children unable to infer that *Sam ate some but not all of the sweets* when they hear *Sam ate some of the sweets*, for example, because the demands of the task are too high, belying their true pragmatic competence? Or do they gradually learn the necessary knowledge and pragmatic processes, so that deriving implicatures emerges later as part of their communicative capacity? In this chapter, we will see, unsurprisingly perhaps, that the answer so far seems to include both aspects.

1.2.   What is implicature?

When speakers communicate, they convey more than just the literal meaning of their utterances; hearers derive pragmatic inferences to understand speakers' intended meaning, of which implicature is one type. Grice's (1975) model of rational communication has been foundational for both theoretical and empirical research on implicature. His proposal of an over-arching heuristic that guides human communication, the Co-operative Principle, was fleshed out with four maxims – quality, quantity, relevance and manner – which can be paraphrased as:

Maxim of quality: Be true.[1]
Maxim of quantity: Be as informative as you can, but no more informative.
Maxim of relevance: Be relevant.
Maxim of manner: Be clear, brief and orderly – use linguistic forms in a conventional way.

Interlocutors assume that they are following these maxims in their communicative exchange. When speakers appear not to adhere to them, given the literal content of the utterance, hearers are able to infer their intended meaning – or derive an implicature – on the assumption that they are in fact doing so. In the following examples, if Speaker A assumes that Speaker B is in fact being as informative, relevant or clear as possible in response to the explicit question, then she can reason to Speaker B's intended meaning:

(1) A: Did you clean the house?
     B: I cleaned the kitchen.
     ↛ I didn't clean the whole house[2].

(2) A: What shall we have for breakfast?
     B: We've got no milk.
     ↛ We can't have cereal; we'll have to have something else.

(3) A: How did John react?
     B: He turned the corners of his lips slightly upwards.
     ↛ He didn't exactly smile; he tried to smile; he feigned a smile.

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[1]   We do not consider the Maxim of quality at length here, as it is often taken to be foundational, and, furthermore, on some theoretical approaches is key for metaphor and irony, each of which have their own chapter in this volume; although see Section 3.3 on the Epistemic Step.

[2]   ↛ indicates the speaker's intended meaning.

Crucially, we can see here how the situational context, the discourse context – including the Question Under Discussion (Roberts 1996) – and the utterance itself all have to be taken into account by the listener. Change the context, and the implicature is different. For example, if the reply *We've got no milk* is in answer to the question *What can I get from the shop?,* it might instead implicate that the speaker wants the addressee to get some milk. On a Gricean approach, these kind of inferences, firstly, involve non-deductive and presumptive reasoning based on arguments from ignorance – the hearer's inference is derived based on lack of evidence to the contrary, but could be cancelled if new relevant information becomes available. Secondly, they are elaborative inferences based on background knowledge about the world and what is typically the case, which provides a cohesive link between what is said and how it is relevant (Cummings 2005: 91–103). And thirdly, in the case of quantity (1) and manner (3), they involve reasoning about alternatives – what the speaker could have said but did not. For instance, in the case of (1), the hearer assumes that the speaker is being fully informative (following the maxim of quantity) and is knowledgeable about the situation; he depends on background knowledge about the world, that a kitchen is a part of a house; and he reasons that the speaker could have said the stronger alternative 'the house', but did not.

In addition, note that these are *verbal* inferences about communicative intentions, dependent on lexical and grammatical forms – a fact that is easily taken for granted when thinking about adults' competency with implicature (in their first language, at least), but important to bear in mind when considering children, whose lexical and grammatical knowledge is developing along with their pragmatic abilities. This also differentiates implicatures, as inferences about *communicative* intentions, from other inferences that young infants can make about others' desires and actions (e. g., Behne et al. 2005).

Subsequently, other theorists have streamlined Grice's maxims, or adjusted where the line between literal and inferred content is to be drawn (or, indeed, how many lines there are). For instance, Horn (1984) proposes just two opposing principles, Q and R, while Relevance theorists put forward Relevance as a single motivation for pragmatic enrichment (Sperber and Wilson 1995, Wilson and Sperber 2012). Some particular implicatures, like scalar implicatures, have been recategorised as 'explicatures' (e. g. Carston, 2008), or as a primarily grammatical phenomenon involving a covert exhaustifier operator (e. g. Chierchia et al. 2001; Chierchia, Fox and Spector 2008). These differing theories are relevant to the question of children's acquisition to the extent that they provide models of adult pragmatic competence – the supposed endpoint of acquisition. However, the focus of this chapter is on what children do and why. We therefore concentrate on the empirical evidence about children's pragmatic development, assuming a context-driven, Gricean approach to implicatures, rather than following in detail these debates that have concerned pragmatic theory and, to some extent, adults'

processing of implicature. We also assume that this Gricean model primarily represents a theory at the computational level of analysis, and not a processing account (for a fuller exploration of this debate, see Geurts and Rubio-Fernandez 2015, and Franke and Jäger 2016).

1.3.   Aims of this chapter

In the second section of this chapter we outline what is known about the timeline of children's developing comprehension of implicature (most of the work to date has focussed on comprehension, though for a production corpus study of scalar implicature, see Eiteljörge, Lieven and Pouscoulous 2018, and for an example of related work on informativity and reference in production, see Davies and Katsos 2010). While the overwhelming majority of studies – concerning pragmatic theory, adult processing and first language acquisition – have focussed on a particular type of quantity implicature known as scalar implicature (SI), we will attempt to give equal weight to quantity, relevance and manner, as focussing narrowly on SIs may skew our understanding of children's development of implicatures in general (see Katsos 2014, Zufferey 2015, and Papafragou and Skordos 2016, for overviews of SI acquisition). We will see that many factors in acquisition are common to the different types of implicature, and furthermore, as suggested by Verbuk and Shultz (2010: 2311), that developmental trajectories are likely to be linked to smaller subclasses of implicature and the characteristics of each conversational exchange.

In the third, more lengthy, section, we identify some specific aspects of implicatures that children have to acquire to bridge the gap between early pragmatic competence in infancy and adult-like performance for implicatures in late childhood and adolescence. We suggest that the acquisitional challenges for children include a) learning knowledge about vocabulary and grammar, about communication and about the world (Section 3.1); b) working out how to derive complex inferences (Section 3.2); c) developing social cognition (Section 3.3); and then d) integrating these processes and complex information in real life interactions (Section 3.4). While for each of these factors it is possible to identify aspects that develop earlier – facilitating implicature – or later – stalling some cases of implicature – no single one can be identified as the 'key'. However, it does seem that learning to integrate the different sources of information needed to derive an implicature could be the final step to adult-like competency. Finally, we end with some future directions for research.

2.   Children's comprehension of implicatures

2.1.   Quantity

Quantity implicature is the best understood type of implicature in children's acquisition, given the many studies across a wide age range and in many different languages besides English (e. g., Finnish – Loukusa, Leinonen and Ryder 2007; French – Pouscoulous et al. 2007; Greek – Papafragou and Tantalou 2004; Italian – Foppolo, Guasti and Chierchia 2012; Japanese – Okanda et al. 2015; and Spanish – Miller et al. 2005). These studies have also employed a variety of experimental designs: truth value judgement tasks, felicity judgement tasks, picture-matching, and action-based activities, to name a few.

Most of these studies have concentrated on scalar implicatures, for which the inference depends on a particular word in the utterance that can be said to lie on a scale with its stronger alternatives: a stronger alternative on the scale entails the weaker term that was uttered. For example, on the scale <all, most, many, some>, *some* is entailed by the stronger alternatives <all, most, many>. Upon hearing *Sam ate some of the sweets*, the listener may infer that the speaker would have used the stronger alternative on the scale *all* if that were the case, assuming that the speaker is fully knowledgeable about the situation; as the speaker did not, the negation of the stronger alternative (*but not all*) must hold. A few studies have also considered ad hoc quantity implicatures, where the stronger alternative is dependent entirely on the context: for instance, hearing *On the correct box, there is a car* (Grosse et al. in prep.) in a context where there is also a box with a car and a doll, the listener makes an exhaustive inference, *only a car*.

Given the evidence so far, it seems that children learn to derive SIs later than ad hoc quantity implicatures. For example, 5-year-olds and even older children respond with more 'logical' than 'pragmatic' answers for SIs than adults do, in truth value judgement tasks (e. g., Guasti et al. 2005; Foppolo, Guasti and Chierchia 2012) and eye-tracking tasks (e. g., Huang and Snedeker 2009). However, with an action-based or picture-matching task even some 4-year-olds begin to approach adult-like rates of inference, though not to the same extent of 5- or 6-year-olds (Pouscoulous et al. 2007; Horowitz, Schneider and Frank 2018). Three-year-olds, though, tend to perform at worse-than-chance levels with <all, some> inferences (Horowitz, Schneider and Frank 2018; Wilson, 2017; Grosse et al, in prep.).

In contrast, Stiller, Goodman and Frank (2015) found that 3-year-olds were able to make simple ad hoc inferences with a performance that was approaching adult-like. They presented children with an array of three objects, for example smiley faces: one with nothing extra, one with glasses, and one with glasses and a hat. Children were asked to choose which belonged to a toy animal, who said, for example, *My friend has glasses*. Children in the 3.5- to 4-year-old age range picked the face with only glasses significantly more than chance (70 %

compared to 50% chance), and 3- to 3.5-year-olds were also tending in that direction.

Still more convincing evidence comes from studies that have examined scalars and ad hocs together. Grosse et al. (in prep.) used a design similar to Stiller, Frank and Goodman (2015), in which the child had to find the location of a sticker which was described using either a scalar or ad hoc weaker term. When the description included the weaker term, 3-year-olds made the pragmatic inference at a rate of 81% for ad hocs (above chance), compared to 49% for scalars (at chance), whereas 5-year-olds did so at 97% and 69% respectively (both above chance). Similar results have been found in other picture-matching tasks (Horowitz, Schneider and Frank 2018; Wilson 2017), and in eye-tracking experiments (Yoon and Frank 2019).

Besides scalar and simple ad hoc implicatures, there are other kinds of quantity implicature, as we saw in our first example, *I cleaned the kitchen*. These rely on other lexical or contextual alternatives, such as whole-part relations. The limited evidence so far tentatively indicates that, when appropriate examples are chosen according to children's world knowledge, children are able to derive such inferences later than simple ad hocs and around the same time as or slightly earlier than SIs (Papafragou and Tantalou 2004; Verbuk and Shultz 2010). However, Verbuk and Shultz's (2010) study relies on both a binary judgement and a metalinguistic comment on the judgement with only three items, so may not be accurately tapping into children's pragmatic skills; Papafragou and Tantalou (2004) use a reward-based design and find that 4–6-year-olds correctly withhold a prize 70% of the time, but test only 10 participants with a three year age range. This is therefore an area where future work is needed to fill in the picture.

It seems, though, that even simple ad hocs where the alternatives are visually presented in context are too hard for 2-year-olds. The youngest group were performing randomly in Stiller, Goodman and Frank's (2015) study, even in a simplified pilot version specially designed for 2-year-olds. Likewise, Yoon and Frank (2019) found in their eye-tracking study that 2-year-olds actually looked more to the distractor item, possibly due to salience. In other words, there is positive evidence for a 'gap' between early foundational skills for pragmatics, and an ability to derive quantity implicatures even in simple contexts.

2.2.   Relevance

Children seem to begin to derive relevance implicatures from 3 years, although again this depends on the precise nature of the implicature. For example, 3-year-olds responded in a pragmatically appropriate way at above chance levels (75%) with examples like (4), as they also did when the question and intention matched, with the response *I like elephants* (at 98%):

(4) A: Should [child] give you the elephant?
    B: I don't like elephants.
    ↠ Give me another item.
    (Schulze, Grassmann and Tomasello 2013: 2082; see too Tribushinina 2012)

In this case, the knowledge that provides the cohesive link between the utterance and the intended meaning is arguably readily available: preference strongly indicates desire. More complex inferences based on background knowledge about an unfulfilled condition are also understood at that age (5), but those based on a fulfilled condition are not (6):

(5) A: Do you want the cereal or the roll? [for breakfast]
    B: The milk is gone.
    ↠ I want the roll

(6) A: Do you want the cereal or the roll? [for breakfast]
    B: I bought milk.
    ↠ I want cereal
    (Schulze, Grassmann and Tomasello 2013: 2087)

In other words, while it seems that the ability to derive relevance inferences is available from 3 years in general, whether a child understands a particular implicature is variable, depending on the background knowledge required for the elaborative inference, as we will discuss more in Section 3.1.2. However, more research is needed to chart children's developing abilities with relevance implicatures, and to establish whether such inferences are possible below 3 years as well.

2.3.   Manner

Like quantity and relevance, manner implicatures have been taken to be part of an adult speaker's pragmatic toolbox, and therefore part of the acquisition challenge faced by the child. Their distinguishing characteristic is that the speaker's meaning is conveyed by way of the form of the utterance: the use of a marked form where there is a less marked alternative with similar semantic content can convey a marked meaning of 'not usual'. Admittedly, though, while some theorists have built on Grice's proposals for manner (e. g. Levinson 2000; Franke 2009), much less is understood about manner implicature in theory and in adult processing than for other implicatures, and many of the oft-cited examples turn out to be hard to tease apart from quantity (for a full discussion, see Wilson 2017). Consequently, we are also only beginning to understand when and how children are able to derive manner implicatures.

Like quantity implicatures, manner implicatures fall on a spectrum of potentially more or less conventionalised cases: from those where there is a systematic relationship between the form of an utterance and its alternative, to those where the relationship is ad hoc and completely dependent on context. An example of the more conventionalised, or generalised type in English involves causative verbs: given a systematic relationship between a periphrastic verb phrase (e. g., *cause to open*) and the alternative related verb (e. g., *open*), using the periphrastic verb phrase can trigger a manner implicature. Antoniou and Katsos (2017) tested Greek-speaking 6–12-year-old bilinguals and bidialectals on such inferences in a picture selection task. In the task, children saw pairs of pictures, for example an illustration of a man opening a door in the normal way (by turning the handle) and another illustration of a man opening a door in an unusual way (by kicking it). They had to choose the picture that was being described when they heard an utterance such as:

(7) In this picture a man made the door open.

They found that children performed comparably for manner implicatures, scalar implicatures and metaphor comprehension. Due to the wide age range, however, it is difficult to tell much about the developmental trajectory of this kind of manner implicature from this study.

Some researchers have noted the similarity between manner implicatures and the strategies that children use in word learning, in particular word learning by exclusion (Gathercole 1989; Brosseau-Liard and Hall 2011; de Marchena et al. 2011; for more general comparisons between implicature and word learning: Huang and Snedeker 2009; Barner, Brooks and Bale 2011; Katsos and Bishop 2011; Sullivan and Barner 2011; Bale and Barner 2013; Morisseau, Davies and Matthews 2013; Katsos and Wilson 2014; Stiller, Goodman and Frank 2015). In the typical word learning by exclusion paradigm, the infant is presented with two objects, one known and one novel, and told *point to the dax* (e. g., Diesendruck and Markson 2001). Even infants as young as 16 or 17 months have been shown to choose the novel object upon hearing the novel word at above chance levels (e. g., Graham, Poulin-Dubois, Baker 1998; Halberda 2003). One influential explanation for this behaviour – though by no means the only explanation – is a pragmatic one: the Principles of Conventionality and Contrast (e. g., Clark 1990, 2009). The Principle of Contrast, by which "speakers assume that any difference in form must signal a difference in meaning" (Clark 2009: 22), enables young word learners to infer the intended reference of a novel word along the following lines of reasoning: had the speaker been referring to the known object she would have said [known word]; she did not say [known word] but instead [novel word]; she must be intending not to refer to the known object; she must be intending to refer to the novel object. Word learning by exclusion and implicature can thus be

said to share pragmatic prerequisites – such as joint attention and attribution of intention – and also a similar inferential process. Like manner implicature, the word learning by exclusion inference involves reasoning about the form of the utterance, an awareness of conventional language use, and generating and negating an alternative (Grassman 2013; Katsos and Wilson 2014). It is crucial for word learning by exclusion that the child knows and can produce the form associated with the known object (Grassmann, Schulze and Tomasello 2015), and appreciates the conventionality of word use.

However, there are important differences between manner implicature and word learning by exclusion. For instance, in the typical word learning by exclusion situation, the need for disambiguation is obvious; the relevance of the alternative is clear; and linguistic and inferential demands are arguably simpler than in an implicature task (for further discussion of differences, see Morisseau, Davies and Matthews 2013: 27). Moreover, the emerging picture from studies on word learning is of changing and developing strategies over infancy and childhood, and so it is possible that children's very early demonstrations of word learning by exclusion are reliant on different mechanisms or heuristics from the word learning strategies they use later (Hollich, Hirsh-Pasek and Golinkoff 2000; Kalashnikova, Mattock and Monaghn 2014). The precise nature of both word learning by exclusion and manner inferences, as well as their similarity over development, is therefore a topic that merits further research. It does seem, though, that word learning by exclusion and manner implicature cannot be said to be one and the same inference without qualification.

3.   Aspects of implicature acquisition

We turn now to some specific aspects of implicature inferences which are key challenges in the acquisition process. They form part of the explanation for why we see a gradual development of this pragmatic skill, with some types of implicature achievable before others and high variability in performance depending on context. We consider the specific types of knowledge that children require for implicatures; the inferencing process itself; and children's developing social cognition. We suggest that the final challenge is acquiring the ability to quickly integrate these different skills and sources of information in conversation.

3.1.   Knowledge and implicatures

In order to be able to grasp implicatures, children need to acquire knowledge about communication, about the world and about vocabulary and grammar – we consider each in turn.

3.1.1.   Knowledge about communication

Firstly, children must acquire knowledge of what it means to be communicatively co-operative, and the understanding that being co-operative is a shared expectation. In other words, they must learn to assume that speakers are, for the most part, informative, relevant and conventional, and recognise what this looks like in communication. This kind of knowledge enables a hearer to be sensitive to which utterance or speaker is more co-operative in a particular context, as is tested, for example, in a felicity judgement task (Chierchia et al 2001; Foppolo, Guasti and Chierchia 2012, Experiment 5), or a Conversational Violations Test (Siegal, Iozzi and Surian 2009; Foppolo, Guasti and Chierchia 2012, Experiment 4). In Foppolo, Guasti and Chierchia's study, children heard an under-informative description of a story from one puppet, and a maximally informative description from another puppet, and had to judge which could 'say things better' (2012: 384). They found that the same children who performed poorly on SIs in a truth value judgement task (in which they had to say whether a speaker was right or not in describing a scene) were at ceiling in the felicity judgement task (in which they had to choose between two utterances to describe a scene). This suggests that knowledge about communication is a necessary but not sufficient step towards acquiring the ability to actually derive implicatures.

This knowledge emerges from infants' early ability to participate in a joint attentional frame with their interlocutor and recognise that others have intentions, and specifically communicative intentions. This begins around the age of 9 months, and is seen in second year of life in preverbal communication with pointing and gestures (for an overview, see Tomasello 2003, 2008; Tomasello, Carpenter and Liszkowski 2007). From 18 months, infants are able to infer an interlocutor's social goal and understand non-verbal indirect communicative acts (Schulze and Tomasello 2015). Later, specific pragmatic expectations about co-operative communication become evident: by three years, children are sensitive to whether an utterance is relevant or not (Lewis 2013) and whether a referential expression is ambiguous and therefore under-informative (Morisseau, Davies and Matthews 2013). However, it is not until age 5 that children begin to be sensitive to over-informativeness where there is no ambiguity in a referential context (Morisseau, Davies and Matthews 2013).

Once children have begun to be sensitive to informative, relevant and conventional utterances (and, conversely, under-informativeness, irrelevance and non-conventional language use), they must learn to extend this knowledge and apply it in new situations. It has been observed that, while in a binary judgement task children display much lower levels of pragmatic inferencing than adults, in a reward-based task with a scale of three or more potential prizes for the speaker, they show more adult-like performance. One proposal to account for these differences is the notion of pragmatic tolerance: children are less quick to penalise

under-informativeness than adults (Davies and Katsos 2010; Katsos and Bishop 2011). Various explanations for this phenomenon have been proposed, such as an inability to express nuanced judgement or uncertainty about language use. Another plausible option is that children differ from adults in their expectations of co-operativity in new situations, especially ones which lack contextual information or collaborative interaction, as is the case in many experimental designs. In other words, children may not expect the same level or kind of informativeness from the speaker in the communicative context created by a binary judgement task as adults do, and therefore fail to derive an implicature in the same way. Such situations are not just a quirk of experimental contexts: the amount of contextual information available to interlocutors varies in naturalistic settings too, where it can sometimes be extremely impoverished. Children might have to learn what a 'default' level of co-operativity is, or build up enough experience of different situations, in order to infer the speaker's intended meaning.

One intriguing finding from a study that, unusually, tested SIs throughout childhood and into adolescence, is an inverted U-shaped curve in 'pragmatic' responses with increasing age (Scrafton and Feeney 2006). The proportion of pragmatic responses increased from the youngest children, aged 5, to the middle group, aged 12, who were practically at ceiling. But then the rate decreased again in the 15-year-old and adult groups. This was more marked for a truth value judgement task with no context (based on Noveck 2001) than a story-based task with enriched context. There are many potential explanations for this progression, but one could be that a growing experience and increasing knowledge of co-operativity in communication allows the listener to gauge whether the literal meaning or a pragmatic enrichment is the most likely intended meaning. This study also highlights the fact that homing in on the first emergence of implicatures in children aged 3–5 years leaves a gap in our knowledge about the intervening years before adulthood – a period when many other pragmatic skills, like irony and metaphor comprehension, are known to be still developing.

3.1.2. *Knowledge about the world*

Secondly, learning to derive implicatures requires learning knowledge about the world, and learning to retrieve that knowledge appropriately. This is most obvious for relevance inferences, but is true of other implicatures too. In the simplest cases we saw earlier, where 3-year-olds inferred from an utterance like *I don't like elephants* that the speaker did not want the elephant, they had to use the fact that people tend to want or choose things that they like. Similarly, in the breakfast scenario, the listener must know that people typically have cereal with milk, in order to infer that the speaker does want cereal (*I bought milk*) or not (*The milk is gone*). Indeed, there is evidence that world knowledge does correlate with children's competence with relevance implicatures (Anagnostopoulou et al. 2017).

Likewise, quantity implicatures can rely on knowledge about the world. For instance, what are sometimes called 'encyclopaedic', 'pragmatic' or Hirschberg scales (Hirschberg 1991; Papafragou and Tantalou 2004; Verbuk and Shultz 2010; Verbuk 2012) have a contextually defined ordering relation, to take an example we have encountered already:

(8) A: Did you clean the house?
    B: I cleaned the kitchen.
    ↛ I didn't clean the whole house.
    (cf. Verbuk 2012: 1693)

Here the knowledge, albeit basic, that the kitchen is just one part of the house is required to infer that the speaker did not clean the whole house[3]. Similarly, in this next example, the knowledge that Stansted is closer than London facilitates the inference that the speaker did not cycle to London.

(9) [Context: discussing a trip from Cambridge.]
    A: Did you cycle to London?
    B: I cycled to Stansted.
    ↛ I didn't cycle to London.

Our knowledge about the world of course develops across the lifespan, and as children increase in their world knowledge through growing experience and cognitive capacity, the breadth of implicatures that they are able to comprehend also increases.

3.1.3. Knowledge of vocabulary and grammar

We highlighted in the introduction (Section 1.2) that implicatures, in a broadly Gricean conception, are essentially verbal – they are inferences about communicative intention beyond the literal meaning of what the speaker *says*. Children therefore need to have at least some knowledge of vocabulary and grammar in order to derive implicatures. Much debate about the role of lexical knowledge

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[3]   Two inferences are actually possible here: one which relies on a contextual scale, on which <house, kitchen> are ordered with an entailment relation, and the stronger alternative *(whole) house* is negated. The other is more like an ad hoc inference, in which the mention of *house* activates alternatives like *bedroom*, *bathroom* and so on, which are then negated to derive the implicature *I cleaned only the kitchen (not the bedroom, not the bathroom, etc)*. Which inference is made depends on which alternatives might be salient in context.

has concerned SIs, and so we consider this in some depth here, before turning to knowledge about grammatical constructions and prosody.

The focus on children's acquisition of SIs reflects the corresponding debate in the theoretical and adult processing literatures on their nature: do children perform poorly on SIs because they have not yet acquired both the scalar terms and the scale to which they belong, or is there a more general explanation? Proposals that SIs are generated by default (Levinson 2000) or through a grammatical exhaustivity operator (e. g., Chierchia, Fox and Spector 2008; see also Chemla and Singh 2014a, 2014b), lead to the hypothesis that children's apparent lack of success with scalar inferences is due to the need to acquire lexical scales (e. g., Tieu et al. 2015). Thus SIs are harder than ad hoc implicatures, and acquired later, because for SIs the listener has to know and access the appropriate scale, whereas for ad hocs the alternatives are often available in context, and no special lexical knowledge is required. This idea seems plausible given studies in which children seem to have a good grasp of the stronger alternative, such as *all*, but still perform at less than adult-like rates with under-informative *some* (e. g., Noveck 2001, Experiment 3; Pouscoulous et al. 2007). Note, though, that a lexical or grammatical theory of SIs could, in principle, lead to the opposite prediction for acquisition: hypothetically, it could be that implicatures that 'only' depend on linguistic knowledge are likely to be easier than those that depend on background knowledge (as proposed by Verbuk 2012).

Barner, Brooks and Bale (2011) tested directly whether the challenge of SIs is learning that *some*, for instance, belongs together on a scale with *all*. They employed a truth value judgement task with pictures in which either some or all of a group of animals have some property. Their procedure differed from other similar studies though, in that the children were asked questions rather than given statements to evaluate, for example: *Are some of the animals sleeping?* Given that question environments usually do not license scalar implicatures, this means that this design does not test implicature derivation per se. However, the goal of the study is still addressed, thanks to the two manipulations that Barner and colleagues carried out. Children were asked a question either with the quantifier *some* or with animal labels (e. g. *the dog and the cat*), with or without the explicit operator *only*. There was an interaction between these four conditions: as expected, children strongly tended to answer 'yes' to the questions without *only* for both *some* and *the dog and the cat,* when all three animals in the picture were sleeping. However, for the questions with *only* they still answered 'yes' for *some*, but not for the labelled animals. That is, they apply the exhaustive meaning of *only* in the case of *only the dog and the cat (and not the cow)*, but not in the case of *only some of the animals (and not all of them)*. Based on the assumption that *only* requires similar reasoning to SIs in terms of generating and negating alternatives, and presupposing that these 4-year-olds have fully grasped the meaning of *only*, the results can be interpreted as evidence that children know *some* and *all* but do not yet know that they occupy

the same lexical scale. Acquiring this knowledge might be a special challenge in learning to understand scalar inferences.

The focus on SIs with the scale <all, some> may mask an important characteristic of children's acquisition of implicature, namely that different scales may be acquired at different points or at different rates over development. Obviously, the acquisition of scales depends on acquiring the meaning of the scalar items themselves, which may be easier or harder depending on more general cognitive development – epistemic modals <must, may>, for example, are likely to be acquired later (Ozturk and Papafragou 2015). In addition, we know that for adults scales seem to vary in how robustly they trigger implicatures, with <some, all> actually perhaps being an exception, rather than the rule (van Tiel et al. 2016). This raises some interesting questions: how does this pattern emerge developmentally? Is there continuity from childhood into adulthood? Do children show similar patterns of variability?

This brings us to a more general point about knowledge of vocabulary: it is clearly required for all types of implicature, so that the listener can both comprehend the literal meaning and derive the inference. There are links to the need for background or world knowledge here, but we can think of cases where it is specifically semantic knowledge that is required. To take another quantity implicature as an example, in the following case one needs to know the meaning of *parent* and *mum*; how the two are conceptually related to each other; and how they are related to what could be considered as an alternative, *dad*.

(10) A: Did Jane meet his parents?
    B: She met his mum.
    ↛ She didn't meet his dad.

If that semantic knowledge is not in place, then what potentially results instead is a relevance inference from a perceived evasive answer, comparable to:

(11) A: Does Jane like orange juice?
    B: She likes apple juice.
    ↛ She doesn't like orange juice. / I'm not sure whether she likes orange juice.

Here the listener either derives a strong inference, that Jane does not like orange juice, or a weak one, that the speaker does not know whether Jane likes orange juice (see Bale and Barner 2013: 247–248 for discussion). Likewise, the hearer in the *parent*s case would infer either that the speaker met his mum, but not his parents (paradoxical though that is), or that the speaker is unsure whether Jane met his parents. Whether children sometimes defer to a relevance strategy instead of an informativeness one due to lack of lexical or semantic knowledge has yet to be addressed. However, it is plausible, given their fairly early ability to derive

relevance implicatures (e. g., Schulze, Grassmann and Tomasello 2013) and under-
stand evasive answers (Sullivan, Davidson, Wade and Barner 2019), and the fact
that such inferences do not require the generation and selection of relevant alter-
natives (Bale and Barner 2013: 248).

There are two more areas to mention where acquiring implicature hangs on
acquiring aspects of grammar. Firstly, it is not only knowledge of words, but also
phrases and grammatical constructions that children need to learn as a basis for
implicature, especially for manner inferences.

(12) A: How did John react?
    B: He turned the corners of his lips slightly upwards.
    ↝ John didn't exactly smile / John feigned a smile.

(13) The man made the door open.
    ↝ The man opened the door in an unusual way.

Here, the listener needs to know that *smile* is a plausible alternative that the speaker
chose not to use in the first example, and that there is the simple verb *open* that
alternates with the periphrastic causative *make X open* or *cause X to open*, in the
second. Crucially, it is not just a productive knowledge of lexical items or gram-
matical constructions as alternatives that it is needed, but also of how phrases
or grammatical constructions are typically used – that is, sociolinguistic value,
frequency, complexity, or any of the other features that might contribute to 'mark-
edness'. This is obviously knowledge that depends on linguistic experience, which
we would expect to contribute to a gradual development of manner inferences.

Secondly, children's knowledge of prosody, and especially contrastive focus
intonation, is known to interact with their acquisition of implicature. Children
aged 4 or above, and indeed adults as well, derive more scalar implicatures when
the quantifier carries a contrastive accent (Miller et al. 2005; Cummins and Rohde
2015), e. g.:

(14) Make some faces HAPPY
    Make SOME faces happy
    (Miller et al. 2005: 394)

One suggested explanation for this effect is that the focal accent highlights the
Question Under Discussion that the utterance is relevant to (Cummins and Rohde
2015) – which is especially valuable in controlled experimental situations with
impoverished context. However, this is only available to children as a cue to the
speaker's intended meaning once they have developed sensitivity to and under-
standing of contrastive stress. At the age of 3 years, contrastive focus intonation
has only a limited facilitative effect for SIs, which, as Yoon and Frank (2019)

point out, is likely to reflect children's developing and fragile sensitivity to stress. It seems that in the preschool years children are still learning the abstract meaning of contrastive stress, and so only show an adult-like comprehension when it is supported by context, even drawing on other pragmatic strategies to infer the speaker's intention in using contrastive stress (Sekerina and Trueswell 2012; Kurumada 2013). While the interaction between contrastive intonation and implicature is now better explored in adults (e. g., de Marneffe and Tonhauser 2015; Gotzner 2017), how children integrate prosodic knowledge into implicatures is a question still open to further research.

In summary, however 'simple' the implicature, some knowledge about vocabulary and grammatical constructions is crucial, and will determine which implicatures are accessible to young children: lexical, grammatical and prosodic knowledge all interact with and constrain children's pragmatic inferences, and this is true not just of scalar implicatures, but other quantity, manner and relevance implicatures as well.

3.2.   The inferencing process

Besides knowledge that facilitates sensitivity to co-operativity, children also need to acquire the inferential process itself in order to derive implicatures in context. In this section we pick out two inferential steps that seem to be particularly challenging for young children – generating alternatives and selecting relevant alternatives.

Firstly, children not only need to possess the vocabulary, grammar or background knowledge needed for an implicature, but to access this knowledge as part of the reasoning. In particular, for quantity and manner inferences, they must learn to generate alternatives – what the speaker could have said but did not. Studies in which the availability of the alternative is manipulated – for example by providing or cueing it in the experimental context – show that increasing its availability helps young children to derive implicatures at more adult-like levels. For instance, studies that give children a training phase emphasising informativeness (e. g., Papafragou and Musolino 2003) or where children hear the contrasting alternative before the critical utterance with the weaker term (Skordos and Papafragou 2016; Horowitz and Frank 2014; Grosse et al, in prep), find that children derive implicatures at higher rates with training or exposure to alternatives than when there is no training or exposure to alternatives.

Secondly, children need to learn to generate *relevant* alternatives. In other words, it is not just a matter of knowing that *all* can be an alternative to *some*, and accessing *all* when *some* is heard, but knowing that it is the relevant alternative given the context. In principle, the studies that found a facilitative effect of encountering the stronger alternative before the critical weaker term could be explained in two ways: it could be that providing the stronger alternative itself is what helps children perform in a more adult-like way – the developmental challenge is purely

learning and accessing alternatives. Or it could be that, in addition, mentioning the stronger alternative highlights quantity as part of the Question Under Discussion and so *all* is provided as a *relevant* stronger alternative in that context. Skordos and Papafragou (2016) teased apart these two options in their acceptability judgement task, in which 5-year-olds heard an utterance with *all* before a critical under-informative utterance with *some* in one of two conditions: either the utterance with *all* (for example, *all of the animals have scarves*) was false because, in the picture, only some of the animals had scarves, or it was false because all of the animals had hats, not scarves. That is, the implicit Question Under Discussion was either quantity or quality, and thus either consistent or inconsistent with the following critical trials with *some* where the implicit Question Under Discussion was to do with quantity. Where the Question Under Discussion was consistently quantity, children who were competent with the semantics of *some* and *all* performed indistinguishably from adults in detecting the under-informativeness of the critical *some* utterances (17 "passers" and 0 "failers"). But where the Question Under Discussion shifted from quality to quantity, the 5-year-olds performed more poorly (6 "passers" and 16 "failers"). This provides evidence that as children acquire implicatures, they are learning how to track the Question Under Discussion and to recognise and generate alternatives that are relevant.

It is worth noting that the findings from Barner, Brooks and Bale's (2011) study, described above in Section 3.1.3, might also be explained in terms of a general challenge of generating relevant alternatives (as suggested by Papafragou and Skordos, 2016): it could be that the negated alternative is more easily generated for ad hoc inferences (in their case, where the animals are labelled) because the set of alternatives is highlighted in the utterance by the labelling of the different animals. For SIs with *some*, the relevant alternative is less obvious, and this makes both SIs and sentences with the explicit exhaustifier *only* more difficult. This proposal can also explain why the contexts created by some experimental designs allow children to perform like adults with SIs: where *some* and *all* are both presented at the same time, either in utterances or pictures (such as in felicity judgement tasks or binary picture-matching tasks), they can be treated as relevant alternatives. This may even allow children to derive an inference without knowing and using a scale, but merely seeing the stronger term as a contrasting alternative (Sullivan, Davidson, Wade and Barner 2019; for examples of such studies, see Katsos and Bishop 2011; Horowitz and Frank 2018).

Manner inferences also involve the generation of relevant alternatives, but there is potentially an extra step in the inference: the relevant alternatives are relevant not only because they are a less marked corresponding form, but also because they are typically used to convey a stereotypical or usual meaning – *he smiled* without further qualification implies *he smiled normally*. On this view, the prototypical manner implicature, incorporating some sort of 'unusual' meaning, is arrived at by negating not the corresponding form but its corresponding impli-

cated meaning. This extra step might make manner implicatures harder for young children than quantity implicatures, but as we saw above (Section 2.3) we do not yet know a great deal about adults' processing or children's acquisition of manner implicatures.

Generating relevant information is a key part of relevance inferences, too: children have to learn to make a cohesive link between what was said and the Question Under Discussion. This would involve efficient searching of background knowledge and recognising how the relevant fact provides the link (e. g., through cause, contingency, correlation, and so on). As we saw above (Section 2.2), Schulze, Grassmann and Tomasello (2013) found that 3-year-olds perform better for relevance inferences based on preference than those based on unfulfilled conditions, and in turn better than those based on fulfilled conditions. This provides tentative evidence that, as with quantity implicatures, children are aided when the relevant information is more available in the context. It would be instructive to examine the acquisition of relevance implicatures using experimental designs that have been developed for quantity implicatures, to see whether training on relevance or implicitly or explicitly cueing the cohesive link does aid children's inferential capacities in a similar way.

3.3.   Social cognition and implicature

Having outlined how acquiring implicatures depends on acquiring certain knowledge and inferencing abilities, we now turn to a final aspect: how implicature acquisition is contingent on developing social cognition. By social cognition, we have something different in mind from the communicative knowledge we discussed earlier in 3.1.1: social cognition involves the more general cognitive capacities of tracking and reasoning about others' desires, intentions and epistemic states, which are foundational not just for pragmatic phenomena but any social interaction.

The received view on a Gricean approach to pragmatics is that competence with deriving implicatures involves reasoning about the speaker's intentions and epistemic state, or Theory of Mind, which is "the capacity to attribute mental states to oneself and to others, and to reason on the basis of this information in order to interpret and predict others' behaviors" (Zufferey 2010: 6). On this model of reasoning, hearers reason about speakers' epistemic states as they make the assumption that the speaker is fully knowledgeable about the information in the utterance. Take our example of a quantity implicature again:

(15) A: Did you clean the house?
     B: I cleaned the kitchen

Without this assumption, the hearer can only make an ignorance inference that the speaker does not know whether she cleaned the house; assuming that the speaker

is fully knowledgeable allows the inference that she did not clean the whole house, only the kitchen. Indeed, adults do adjust the inferences they make depending on whether the speaker is knowledgeable or ignorant, deriving a quantity implicature less often if the speaker is ignorant or only partially knowledgeable about the situation being described (Bergen and Grodner 2012; Breheny, Ferguson, Katsos 2013; Goodman and Stuhlmüller 2013). However, there are also alternative views that pragmatic inferences do not always require reasoning about the speaker's epistemic state, either throughout the lifespan or specifically in development (Breheny, 2006; Jary, 2013; Kissine 2016; Andrés-Roqueta and Katsos 2017).

In children, developing Theory of Mind abilities have traditionally been measured by tests of their ability to attribute false beliefs to others, such as the Sally-Anne change-of-location task (Baron-Cohen, Leslie and Frith 1985) or unexpected contents task (Perner, Leekham and Wimmer 1987)[4]. Typically, children only pass these tests at age 4, with some variation depending on the exact procedure (Wellman, Cross and Watson 2001). Given that we see some competence with implicatures emerging from age 3, this could be taken to indirectly suggest that implicature inferences are possible without full Theory of Mind, at least in development. However, more recent implicit tests of false belief provide evidence that these skills may already be in place in the second year of life (e. g. Onishi and Baillargeon 2005; Mascaro and Sperber 2015), in the which case they could be supporting implicature acquisition in the fourth year. A further scenario, based on the influential modular view of Theory of Mind (e. g., Baron-Cohen 1995) is that this cognitive capacity develops incrementally, and different types of pragmatic inference are correspondingly available at different stages. On the modular view, some abilities, like intentionality and eye-direction detection, are in place early, and later followed by shared-attention, and finally full Theory of Mind (see also Tomasello 2003, and Kissine 2016, for similar views). It could be that the types of implicatures that young children are able to understand do not require any notion of false belief, but only joint attention and intention reading. As children mature in their Theory of Mind throughout childhood, acquiring the ability to understand second order false beliefs, for example, they also acquire more adult-like competence with implicatures, in particular in situations where the speaker and listener do not share beliefs about a situation.

However, as we have already seen with knowledge of vocabulary and grammar and with generating alternatives, possessing the requisite abilities does not necessarily mean that they can be used in pragmatic inferences; we must consider cases

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[4]   In the Sally-Anne task, a story is acted out with two protagonists, Sally and Anne. Sally puts a marble in a box, before leaving the room; Anne then moves the marble into a basket, before Sally returns. The child is asked where Sally put the marble at the beginning, where it is now, and where Sally will look for it on her return.

where children demonstrate social cognition actually in their pragmatic inferences. There is evidence that the ability to monitor whether someone is knowledgeable or ignorant about something in a communicative situation develops early. For example, Grosse and Tomasello (2012) found that 2-year-olds are able to differentiate 'test' questions, where the speaker already knows the answer, from genuine questions. Likewise, children change their production and provide more information if their parent has not seen where an object was hidden (O'Neill 1996). Furthermore, by around 5 years, children are sensitive to ignorance and able to make inferences based on it. Hochstein et al. (2016) asked 4- and 5-year-olds whether a blindfolded, ignorant puppet or a seeing, knowledgeable puppet uttered a sentence such as *The bunny took a cup or plate*, when in fact the bunny had taken a cup *and* a plate. They found that 5-year-olds, but not 4-year-olds, were able to attribute the under-informative statement to the ignorant puppet at above chance levels (see too Papafragou, Friedberg and Cohen 2018, for a replication with SIs with *some*). In other words, children are able to track others' epistemic states and use this information to at least derive ignorance inferences from 5 years.

However, it seems that they may not be able to take into account the speaker's epistemic state to appropriately derive or not derive an implicature until later in development. Wilson, Lawrence and Katsos (2018) used a version of the director task in which children had to follow a speaker's instructions to select from an array of picture cards, one of which the speaker could not see. They found that, unlike adults, children aged 5–6 years were unable to not derive an ad hoc quantity implicature when the speaker was ignorant of the relevant information. This was despite the children's adult-like ability to derive an implicature when the speaker's epistemic state was not at stake, and their competent explicit reasoning about the speaker's epistemic state (passing a Theory of Mind false belief task, and accurately stating which cards the speaker could and could not see). This suggests that the remaining challenge for children could be integrating the two skills, of the pragmatic inferencing process and reasoning about others' beliefs.

3.4.   Integration of multiple sources of knowledge and processes

We have seen that acquiring implicatures is a considerable challenge in children's communicative development: understanding a speaker's intention by deriving an inference draws on different types of knowledge, inferential processes, and more general social cognitive skills. While some of these skills and knowledge are acquired in infancy, many appear only gradually and later in childhood. Furthermore, they are all independently necessary for implicatures, but they must also be integrated at speed in conversation in order for an implicature to actually be derived.

Papafragou and Skordos (2016) propose that what is common across the acquisition of different pragmatic phenomena is the gradual development of the ability

to integrate linguistic and non-linguistic sources of information. Similarly, others have proposed that there are multiple 'routes' to deriving an implicature, and children are restricted in which they can use. Given that language processing in general is known to be massively interactive, Snedeker (2016, see also Huang and Snedeker 2009) suggests that there are two possible routes by which a hearer can derive an enriched meaning: bottom-up or top-down. Bottom-up reflects the traditional Gricean model, whereby the literal meaning of an utterance is first interpreted, and then the implicated meaning calculated based on the literal meaning, contextual information and assumptions about the speaker. On the other hand, top-down processing is possible when the context allows the hearer to predict the meaning that the speaker might communicate, and even to pre-encode how this might be said. This could happen, for instance, when a hearer has sufficient time to look at all the pictures in a picture-matching task before hearing the speaker's utterance. The suggestion is that computing an implicature is effortful without pre-encoding, and that children have difficulty using top-down cues and so pre-encode less than adults in contexts that permit it. This results in difficulty with implicatures that reduces over development as they become more able to process multiple cues.

These two proposals can be integrated: the top-down route, which enables adults to be fast and flexible in implicature inferencing across contexts, requires early integration of multiple sources of information – knowledge stored in long-term memory, and information in short-term or working memory from the immediate discourse and visual context. The bottom-up route, on the other hand, can rely on the literal meaning of the utterance to cue the search for other relevant pragmatic information (as could be happening in word learning by exclusion, or felicity judgement tasks), although this is likely to be more effortful and potentially slower, or altogether unsuccessful. Both proposals were made specifically for SIs, but it is possible to see how they can be extended to other types of implicature as well.

4.   Future directions

Our understanding of how children acquire implicatures, and other pragmatic skills, has grown hugely over the past two decades. Here we highlight some additional questions and avenues for future research.

Firstly, recent research suggests that listeners adapt their expectations of informativeness, relevance and conventionality in a speaker-specific way (Pogue, Kurumada and Tanenhaus 2016; Yildirim, Degen and Jaeger 2016). We know that children are also sensitive to speakers' characteristics in word learning by exclusion: 3- and 4-year-olds are sensitive to their reliability or accuracy in naming (Sobel et al. 2012), and 4- but not 3-year-olds to their expertise about objects (Sobel and Corriveau 2010). However, we do not yet know how and when children learn to adjust their expectations of co-operativity in a speaker-specific way at different

rates for different aspects of co-operativity, when it comes to implicatures. We might expect, for example, that it would be harder to detect a speaker who is further from the norm of conventionality than one who is further from the norm of informativeness, because the former requires more linguistic experience to gauge and has potentially less severe consequences for communication. Borrowing experimental designs from the research on speaker-specific traits in word learning inferences could be a way forward to investigate children's response to speaker-specific traits for implicature comprehension.

Secondly, there is the question of how more general cognitive functions underpin the acquisition of implicature, especially Executive Functions, which include working memory, inhibition and cognitive flexibility. Specifically, it might be hypothesised that working memory is essential for understanding implicatures, as it requires manipulation of different pieces of information, such as the literal meaning and alternatives. Inhibition, too, might be needed to prevent salient interpretations, like the literal meaning, from being chosen as the intended meaning. Indeed, some links between working memory and implicature derivation have been found in adults, as increased cognitive load has been found to decrease implicature rates (e. g., De Neys and Schaeken 2007) although there is also evidence to the contrary (Scrafton 2009). However, no such link has yet been found in children for working memory (Scrafton 2009; Janssens, Fabry and Schaeken 2014; Antoniou 2015) or inhibition (Antoniou 2015; Nordmeyer, Yoon and Frank, 2016). Part of the challenge here is that Executive Functions are not simple constructs and nor is there just one accepted way to measure them, making correlational studies difficult to interpret.

Finally, much of the research on children's acquisition of implicatures has concentrated, as we have seen, on SIs and on comprehension. We still know relatively little about other types of implicature, and about children's production of implicatures, and how it relates to their developing comprehension. In addition, while SIs have been investigated in several different languages, more cross-linguistic work and studies of bilingual children might help us to identify the factors that are particularly important for different sub-types of implicature. They might also reveal other factors, such as cultural or educational factors, that affect children's acquisition of implicatures. Another less explored but potentially fruitful avenue is to look at implicatures alongside other types of inference. For example, children do not always succeed with entailment relations when these are tested alongside implicatures (Sullivan, Davidson, Wade and Barner 2019), suggesting that this prerequisite skill may not be in place for certain lexical relations. Nordmeyer, Yoon and Frank (2016) compared processing difficulty in children for negation, implicature and inhibition, where negation and implicature both require children to resist a salient interpretation, but found different developmental trajectories for each phenomenon. Likewise, Bill et al. (2014) compared presuppositions and SIs, but again found different developmental patterns for these two pragmatic phenomena.

There is still much to learn about the trajectory of children's acquisition of implicature, and its relationship with other pragmatic phenomena across development.

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