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Mental files: Developmental integration of dual naming and theory of mind

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ABSTRACT

We use mental files theory to provide an integral theory of children's diverse dual naming problems and why these problems are overcome when children pass the false belief test. When an object is encountered under different appearances or given different verbal labels, two distinct representations (mental files) may be deployed for that single object. The resulting files refer to the same object but capture different perspectives on the object. Such coreferential files can thus be used to represent people's differing perspectives (e.g., belief). Typically the existence of different files indicates the existence of two separate objects. To mark that only a single object is involved, coreferential files need to be linked. Development of the ability to link files provides a powerful developmental explanation for success on dual labelling and perspective tasks at the same age, around 4 years: processing identity statements, overcoming mutual exclusivity (accepting different labels for an object), visual perspective taking, and understanding differences of belief. Mental files also provide a new framework for understanding conceptual pacts and their relation to mutual exclusivity in children and adults.

Introduction

How we label an entity, a person or object, can have far reaching consequences. The realization that entities can be labelled differently undergoes striking developmental changes that are reflected in quite different fields of investigation. Our objective is to present a cognitive theory of mental representation that provides a common framework for labelling phenomena that apparently undergo a common development. We thereby draw on the conceptual framework of mental files in philosophy of mind and discourse referents in linguistics. Within this framework we will summarise key phenomena related to labelling and theory of mind, and account for their associated development.

One of these phenomena is the formation of "conceptual pacts" (Brennan & Clark, 1996). Language users converge on a consistent set of terms for objects in a conversation. If a speaker uses a new label for a previously labelled object, comprehension is slowed or impaired. Adherence to such apparent pacts has been documented in children as young as three years (Matthews, Lieven, & Tomasello, 2010). In fact, young children find it difficult to provide an alternative name (e.g., flower) for items that have already been named (e.g., rose), even when explicitly instructed to do so and when they are quite familiar with both terms (Doherty & Perner, 1998). For these children 'rose' and 'flower' seem to be mutually exclusive terms. This restriction dissolves around the age of four years, when other problems with dual labelling are solved.

Another phenomenon is the 'mutual exclusivity bias.' Faced with a familiar object, for which they have a label (e.g., "banana"),

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and a novel object, children from seventeen months (Halberda, 2003) assume that a novel label ("fendle") refers to the novel object. This has been widely investigated as a helpful strategy for word learning (Markman & Wachtel, 1988; Lewis, Cristiano, Lake, Kwan, & Frank, 2019). Whether this is a lexical constraint (each object can only have one name: Markman, 1989) or a pragmatic constraint (use the known name for a known object: Bloom, 2000; Diesendruck & Markson, 2001) has been hotly debated. The bias persists through adulthood. What changes developmentally is how difficult the bias is to overcome. For instance, despite manifest pragmatic cues that the speaker uses a new term for a familiar object, children adhere to the bias until about four years (Haryu, 1991; Gollek & Doherty, 2016).

Flavell (1988) and Markman (1989) speculated that the mutual exclusivity bias might have a deeper root in young children's difficulty understanding a single entity can have different identities. To overcome the mutual exclusivity bias children have to consider that the banana and the fendle might be the same thing.

This ability is also required for a number of potential identity problems that are all resolved around age four. Children distinguish appearance from reality (Flavell, Flavell, & Green, 1983). When discovering that a small piece of rock is actually made of sponge, they become able to state that it *really is* a piece of sponge but *looks like* a rock. Children realise that a drawing can be ambiguous, e.g., an animal in a drawing can be a duck and a rabbit (Gopnik & Rosati, 2001; Wimmer & Doherty, 2011). They also understand identity statements (Perner, Mauer, & Hildenbrand, 2011), e.g., "Mr Mueller is the firefighter," said to help find the owner of a lost bag (Mr Mueller) by pointing out that Mr. Mueller is identical with the person earlier identified as 'the firefighter.' All these tasks depend on children being able to understand that a single object can have different identities and are mastered around the age of four years. Without this ability younger children have problems with different labels for a single object.

Choice of label relates to differences in perspective, allowing speakers to conceptualise the same things in different ways (Clark, 1997). Relating word choice to conceptualization and perspective is particularly intriguing since children, again around four years, start to appreciate differences in visual perspective (Level 2: Masangkay et al., 1974; Hamilton, Brindley, & Frith, 2009) and cognitive perspective (understanding false beliefs: Wellman, Cross, & Watson, 2001) even though dual labelling is not involved in these tasks.

In sum, there is an important change taking place with wide ramifications at about 4 years of age. The younger children are captured by *mutual exclusivity* of names: they strictly adhere to *conceptual pacts,* cannot overcome the mutual exclusivity bias, and are unable to provide familiar alternative names for objects. This adherence to exclusivity has been seen as an inability to acknowledge that an entity can have more than one "identity" and to draw the *appearance-reality* distinction. Children's problems with dual labels also relate to their ability to account for differences of *visual* and *cognitive perspective* (belief). To explain why these different aspects are related we need to answer some fundamental questions:

(1) Exclusivity: Why do different labels for the same entity create an opposition so that one treats them as mutually exclusive?
(2) Identity: What does it mean for an entity to have different identities?
(3) Perspective: Is the notion of perspective in the context of dual labels the same as in the context of visual or cognitive perspective?
(4) Development: What is the cognitive change around 4 years that allows children to consider differences of perspective, conceptualization, or identity, which is beyond the capabilities of their younger peers?

Mental files theory (Recanati, 2012) provides the conceptual tools and a cognitive structure to answer these questions.

Mental files

Mental files theory (Murez & Recanati, 2016) aims to unify research in which the notion of a mental file has been used under different guises: "notion" or "file" in philosophy (Perry, 2002; Strawson, 1974), "discourse referent" in linguistics (Karttunen, 1976), "object file" in psychological research on attention (Kahneman, Treisman, & Gibbs, 1992), object search (Treisman, 1982), and object tracking (Pylyshyn, 2000); short term memory and object individuation in infancy (Xu & Carey, 1996; Scholl & Leslie, 1999).

A mental file can be characterized by the following features (based on Recanati, 2012):

(1) *Representation*: A file is a conceptual[1] representation of a particular object, its referent.

(2) *Reference*: Information about a referent, via perception or verbal testimony, causes a file to be created. In formal terms: a file is tokened if it stands in an epistemically rewarding causal relation to its referent. This relation fixes the file's referent.

(3) *Function*: A file's function is to (a) *track* its referent over time and (b) *acquire* and *update knowledge* about its referent. This knowledge is registered on the file, thus (c) *binding* the object's properties to the object, and (d) making the information available for thinking and action.

(4) *Tracking*: To fulfil a file's tracking function three processes are needed:

(i) *Recognition*: the information on the file is used to re-identify an encountered object as the file's referent.
(ii) Attention: Once (re-)identified the object will be tracked by an attentional mechanism (e.g., Pylyshyn, 2007, fingers of instantiation: FINSTs) and need not be continuously re-identified.
(iii) *Tracking Constraint*: Some mechanism is required to prevent potential confusion that could result from mixing different conceptualisations of objects within the same conversation. We propose that only one file is allowed to track an object at a particular

[1] In the infancy literature conceptual files are distinguished from object files, which do not individuate an object under a concept. As this paper focuses on the interplay of perceiving objects and talking about them, we are only concerned about conceptual files.

time[2].

(5) *Conceptuality*: Mental files are constituents of thought, hence conceptual representations. They *represent* their referent *as* something.

We illustrate these features with a concrete example in Fig. 1. An object is perceived by an observer. Perception being an epistemically rewarding relation, a file is deployed for the object. As the observer sees the object as a die the file is marked with "die"[3]. Besides perceptual information, also conceptual information about the die is stored on the file, which among other uses is important for re-identifying this die as the file's referent at a later time.

We now elaborate on some of these features and their consequences of particular relevance for our present purposes.

File management

(a) **Deployment**: Mental files are deployed when an object comes to attention, either through being perceived or talked about. This epistemic relation establishes the file's referent.

(b) **Tracking**: Once an object has gone out of attention and later enters anew, we assume that no new file is automatically deployed. Rather, a suitable existing file is first sought. For this the recognition criteria of existing files are checked and if there is a matching file the object is re-identified as that file's referent. This is important for linguistic discourse, e.g.: "The dog jumped over the fence. The girl ran after the dog." The second mention of "the dog" should not trigger a second dog-file. Rather, existing files are checked for a match to this referential expression. The information about the dog in that sentence is then recorded on that file. Only if no match is found, will a new file be deployed. Files track objects for the duration of a conversation, or for the period the object is attended to.

(c) **Multiple filing**: It would be most straightforward if there could only ever be one file for each object. However there are many occasions when coreferential files are deployed for a single referent. This occurs in (i – iii), enables (iv), and needs to be constrained (v):

(i) Re-identification failure: failure to re-identify a die as the original one results in a new file that happens to be about the same object.

(ii) Input modality: Being verbally informed about a die, if there is no indication that it is the perceived or earlier-mentioned die, may lead to a second file for it.

(iii) Conceptualisation: Certain labels (sortals) individuate the referent under a specific concept. This is particularly important for ostensive reference. When pointing somewhere and saying, "This is nice", the "this" does not clearly establish what one is talking about; it could be the die or a face of the die, or its pattern of dots, or its movement. It becomes clear by adding a label: "This *die / dot / spin* is nice" (see Perner & Leahy, 2016). Since the use of a particular sortal determines what "this" refers to, it is a sensible strategy for a basic language interpretation system to open a new file whenever a new label is used. This strategy is advisable even in the case where "this" happens to refer to the same object as on a previous occasion, e.g., "This is a rabbit," and "This is an animal," just in case the speaker does mean different objects. In a second step one can determine whether the speaker did mean a different or the same object. The strategy pays even when the same object was meant because different labels put a different perspective on an object, as we will explain.

(iv) Perspective: Coreferential files for the same referent capture Frege's (1892/ 1970) famous distinction between sense and reference. The different files provide different senses for the same referent (Recanati, 2012, chapter 3) or different perspectives on the referent. Different labels exploit this perspective difference further. For instance, if a big mouse is individuated as *mouse* one can say of it that it is *big*, whereas, when individuated as *animal* even a big mouse is considered *small*.

The label also puts the referent into a different inferential field. If an animal is individuated as a *bird*, one is prone to infer that it can fly; if it is individuated as a *penguin* one realizes that it cannot do so. So, different files and their associated labels capture nicely the use of labels to create different perspectives, as advocated by Clark (1997) or Tomasello (1999). The fact that labels create different perspectives provides another good reason to generate different files for different labels.

(v) Tracking Constraint: The advantage of representing different perspectives with multiple files can have deleterious consequences unless constrained. Mixing perspectives within a conversation is a sure way to confusion. Mixing perspectives can be avoided by the simple constraint of allowing *only one file to track an object at a particular time*. We refer to this as the *tracking constraint*.

Consider Heinz's eraser, a popular item for some experiments (Apperly & Robinson, 1998). It is made of rubber, is cube shaped, and has dots on each of its sides. Unfortunately it is not very good as it smears the pencil marks. However, it makes up for its shortcoming when serving as a die for gambling. This duality gives rise to a die- and a coreferential eraser-file. The tracking constraint ensures that only one file is used at any one time, meaning (1) that only perspective/context relevant information goes onto the appropriate file: "being not very good" onto the eraser-file and "excellent" on the die-file, and (2) that in conversation one does not confuse one's partner by hopping from file to file and talking about the 'excellent' die that is 'not very good.'

The constraint works in two ways for an object being tracked by a mental file. The original file will typically continue to track it,

[2] This is an addition to Recanati (2012) account and is a weaker, more temporary form of what Recanati (2012, 41) refers to as "the Strawson-Lockwood constraint 'one object – one file' (Lockwood, 1971; Strawson, 1974).

[3] The functional significance of this "label" is best thought of as associating the object with relevant script knowledge, e.g., what a die is used for and what one typically does with it.

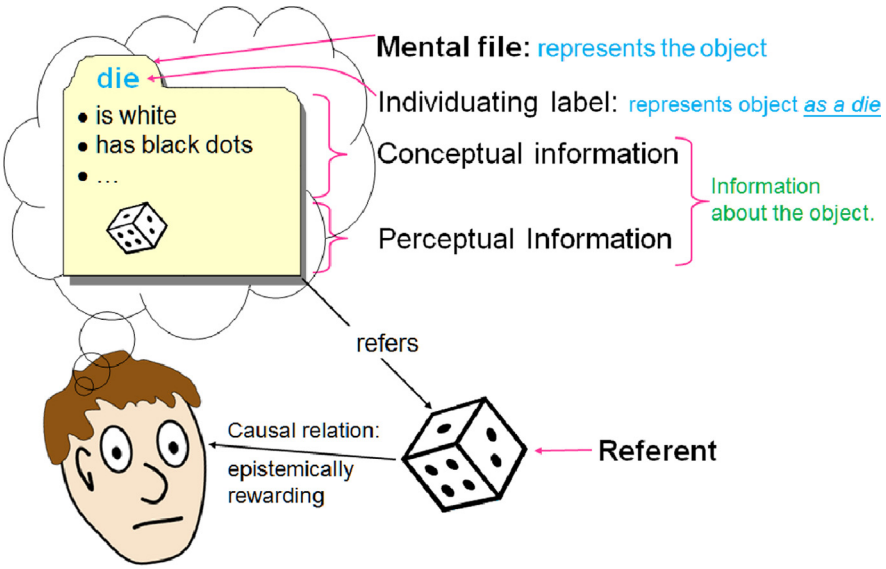

Fig. 1. Essential features of a mental file.

and further files cannot track the object, except through being linked to the original file (see below). Alternatively, the second file will replace the first file, which then no longer tracks the object. This involves a reindividuation of the object. Which of the two ways will occur depends on context.

(d) **Linking**: Having two files for a referent means that, from one's own perspective, one is thinking of two objects. The files just happen to be of the same object. If one receives information that this is mistaken one could just drop one of the files. However, this has the negative consequence that one loses the information garnered about the referent under the dropped file's perspective. A better method is either to *merge* the information contained in both files into one file or *link* the two files. Linking allows the information of each file to be accessed from the other file (Perry, 2002) and has the advantage of preserving the different perspectives. The ability to link files is of particular relevance for us, since younger children's problems with dual naming and false beliefs can be traced back to an inability to link files[4].

Equipped with this mental files framework we can now tackle the challenge of answering our four fundamental questions (concerning exclusivity, identity, perspective, and development; see Introduction) and see how well we can account for relevant data.

Perspective

Our fundamental question about perspectives was: "Is the notion of perspective in the context of dual labels the same as in the context of visual or cognitive perspective?" Psycholinguists claim that a particular label or name for an entity puts a certain perspective on it. As Clark (1987, 1-2) put it:

"When speakers plan an utterance, they choose a specific PERSPECTIVE on what they wish to speak about. This perspective, marked by word-choice, allows them to present to their addressees a specific conceptualisation of an object, property, relation or event. Word choices allow speakers to conceptualise the same entities and events in different ways. And they therefore allow speakers to highlight properties pertinent to the goal of the discourse. … Depending on one's conversational goal, one might refer to a neighbour variously as *the cellist, the mother of three*, *my cousin* or *the Mayor*. "

We have argued that the difference of perspective can be captured by different co-referential files for the entity. The question is how this use of 'perspective' relates to the more familiar cases of visual perspective or belief, where no dual labelling occurs.

The literature distinguishes between two levels of perspective taking. Level 1 denotes the ability to distinguish *what* people can and cannot see from different vantage points (Masangkay et al., 1974; Flavell, Everett, Croft, & Flavell, 1981). Very young children can understand that, e.g., another person can see the dog on their side of the wall, but not the cat on the child's side (Masangkay et al., 1974), and orient objects so that others can see them (Lempers, Flavell, & Flavell, 1977). Level 2 additionally involves understanding

[4] We want to emphasise that 'linking" has a special technical meaning in this context. It only applies to linking coreferential files, which Recanati (2012) adopted from Perry (2001). It captures the identity of the files' referent. It does not provide information about the referent (other than that it is identical with itself, which is trivially true). Instead, it affects the mental organisation of how one thinks about the referent (Lockwood, 1971; Strawson, 1974), e.g., it enables use of information from either file (e.g., Mueller-file or firefighter-file) regardless of which file one uses to think about the referent. These features distinguish this use of linking from, say, predicating a relation between objects, e.g., "Mueller visits the doctor". This also relies on some sort of "link" between files, that relates different referents, here as one visiting the other. However, in this use of "link" no information flow between files is intended: what one knows about one person would not also apply to the other one. Moreover, the link provides information about the referents, namely that one visits the other.

how a scene looks to another. For example, if a drawing of a turtle is placed between two people, one may interpret it as standing on its feet, and the other as lying on its back. This distinction can be generalised beyond visual perspectives. For instance in Clark's example above, calling her neighbour *my cousin* or *the Mayor* does not connect her listener's mind to different people or different facts (the listener may well know that her cousin is the Mayor), but serves to get her listener to conceive of her neighbour in a particular way for the discourse.

The two levels also apply to mental states like knowledge and belief. There is good evidence of early ability to conceive of agents connected to objects or facts (level 1), which can be used to predict likely actions. For example, O'Neill (1996) found that 2- to 3-year olds, who needed their parent's help retrieving a toy, adjusted their information according to whether the parent had seen the toy in its new place or not. Younger children can understand that an agent will be more interested in a toy they have not yet seen or played with than a familiar one (Tomasello & Haberl, 2003; Moll & Tomasello, 2007; see also Sodian, Thoermer, & Metz, 2007). Knudsen and Liszkowski (2013) showed that 12- and 18-month-olds spontaneously warned an adult by pointing out to her an aversive object hidden in her way.

Infants communicative repairs may also be evidence of level 1 understanding (Golinkoff, 1986; 1993). When their requests are misunderstood or not satisfied by their carers, infants frequently repeat, or phonemically or semantically alter the original requests. Understanding that the carer is not engaged with an infant's desired object, for example, as suggested by persistent attempts to engage her, would be level 1. However, repairs have also been more leanly attributed to simple persistence to achieve a goal (being handed the object) or a desire to continue the interaction (Shatz & O'Reilly, 1990; Fagan, 2008). Consistent with this, Bosco, Bucciarelli, and Bara (2006) found that 3-year-olds were poor at recognising other people's communicative failures (shown in video clips), whereas older children became increasingly able to recognise them.

While level 1 allows thinking about agents in relation to objects or facts, it does not allow thinking about agents in relation to propositions. Predicting an agent's behaviour in relation to a proposition requires understanding that the agent can evaluate the proposition as either true or false. This is level 2, analogous to understanding that the proposition 'the turtle is lying on its back' will be evaluated as true or false by agents at different viewpoints. We will now argue that abilities that require a level 2 understanding emerge together, later than those requiring a level 1 understanding, between 3 and 4 years. For this we focus on the false belief task, as it provides a clear case of different perspectives and for which there is a rich developmental database.

In the classic task (Wimmer & Perner, 1983) children are told about Mistaken Max who does not see that his chocolate is transferred into a new location. Children are then asked where Max will look for his chocolate. Below 4 years most children indicate the chocolate's new location, presumably because they do not yet understand that Max has a different perspective to their own on where the chocolate is. Mental files theory (Perner & Brandl, 2005; Recanati, 2012) assumes that this can be done by creating coreferential files for the objects on which different perspectives are taken. Mistaken Max's perspective can be captured by a *vicarious* file for the chocolate, indexed to Max. The vicarious file is co-referential with one's own *regular* file. On the regular file one registers everything that happens to the chocolate, on the vicarious file only events about which Max has information. Since he does not witness the transfer to the final destination his vicarious file shows the chocolate in its previous location. One then uses the vicarious file as if it were one's own file to reason vicariously for Max where he has—from his perspective—reason to look for his chocolate.

This analysis provides an answer to our fundamental question concerning perspective: Co-referential files provide a common interpretation of what is meant by 'different perspectives' and this interpretation applies to perspective tasks as well as dual naming exemplified by the alternative naming game. Doherty and Perner (1998; Perner, Stummer, Sprung, & Doherty, 2002) used pairs of alternative labels for an item that were familiar to the children, e.g., "bunny" and "rabbit". Using a character and a puppet, children were instructed as follows (Doherty 1994, Experiment 1):

"This is Tony, and he is going to tell us what these things are. But Puppet also wants to play but he doesn't want to say the same thing as Tony, so we are going to help him think of a different way of saying what these things are. Now, Tony says this is a rabbit. What could puppet say it is? I know, he could say it is a bunny, because it is a rabbit and it is a bunny. They are different ways of saying the same thing.

Test: Tony says: "this is a rabbit." What could Puppet say it is? < child's answer >

If Tony says "Rabbit", then, a child who says "Bunny" plays correctly. Three-year-olds typically fail this task; they most often repeat the word produced by Tony. Four-year-olds typically pass. Moreover, passing this test is strongly correlated with passing the false belief task.

Mental Files theory explains performance on the alternative naming task as follows (Perner & Leahy, 2016). When Tony first individuates the item with one sortal: "This is a *bunny*", the object of conversation is the item *individuated as* a bunny. For the child, who cannot yet link files, the 'bunny' and 'rabbit' files represent different entities; they are identical but children do not yet realize that. So when asked what else the item can be called, the child uses the 'bunny' file, since the item has just been individuated as a bunny by Tony, and the child stays within that perspective to think about this item. Within this perspective an item individuated as a bunny cannot be called anything but a bunny. So, children answer with "bunny", counter to the instructions given. This explains their difficulty and wrong answers in the alternative naming game. Older children succeed because they can link files. Linking makes the contents of each file mutually available. Now children can follow the instructions "to use a different label or name for the item" by consulting a coreferential file for the object in which the object has been given a different name.

Mental files theory also gives us a different and more detailed way of looking at children's and adults' performance in false belief tasks. The standard theory of mind analysis assumes that from the observed events, i.e., Max not witnessing his chocolate's transfer, we infer that he believes that his chocolate is still in the old location. From Max wanting to be where his chocolate is and believing that it is in the old location we use the practical syllogism (Gopnik & Meltzoff, 1988) to infer that he will try to satisfy his desire by going to the old location. The need to infer Max's belief has tethered the field to the question when children acquire the concept of

belief and to find the definitive method to detect this point in development. Use of vicarious files allows us to understand how children get an increasingly better understanding of Max's erroneous action without having to decide whether this requires an understanding of only 'belief-like states' (Butterfill & Apperly, 2013), the 'concept of belief,' or the 'full-fledged concept of belief' (including its aspectuality: Rakoczy, Bergfeld, Schwarz, & Fizke, 2015).

For proper use of Max's vicarious file for his chocolate children have to understand that not all events concerning his chocolate should be noted on the vicarious file, but only events *witnessed* by Max (Perner, Rendl, & Garnham, 2007; *registered* by Max, Apperly & Butterfill,. 2009; *experiential record* for Max, Perner & Roessler, 2010; *engaged* with by Max, Doherty, 2006). Once the vicarious file contains this information it can be used for figuring out what Max should do to get his chocolate in the same way as I will use my own files to figure out what I should do to get Max his chocolate. Max (from the perspective provided by his vicarious files) should go to the chocolate's original location, while I should go to its new location and bring it to Max.

These analyses show that children may entertain coreferential files long before they can solve these tasks, but they still lack the ability to link coreferential files. The emergence of this ability around 4 years explains why these tasks are mastered at this age and strongly correlate. This has been demonstrated in eleven published experiments, total N = 513, $0.53 \leq r \leq 0.77$; $0.29 \leq r_p \leq 0.59$ with age, or age and verbal IQ controlled (Diaz & Farrar, 2018; Doherty, 2000; Doherty & Perner, 1998; Gollek & Doherty, 2016; Perner et al., 2002; Wimmer & Doherty, 2011).

A tempting alternative explanation of these findings is that the false belief test and alternative naming may pose similar executive demands on children. In fact, constraints of working memory and inhibitory control have been argued to explain why children who fail the standard verbal false belief test show sensitivity to belief much earlier in nonverbal tests (e.g., Baillargeon, Scott, & He, 2010; Carruthers, 2013; Leslie & Polizzi, 1998; Leslie, German, & Polizzi, 2005: Setoh, Scott, & Baillargeon, 2016). This popular explanation has however come under varied criticism (Southgate, 2019, p 6–10; Westra, 2017, 238-240). Moreover, these factors also fail to account for the correlation between verbal false belief success and alternative naming. Working memory limitations in accessing an appropriate alternative or failure to inhibit the label provided by the experimenter cannot account for the fact that children had the same problems judging another's performance on the task, in which case both alternatives were provided by the experimenter (Judgement version: Doherty & Perner, 1998; Perner et al., 2002). Children had no comparable difficulties with the same task format when alternative colours of a two-coloured object had to be indicated, or a change between colour and name (Perner et al., 2002; Pearson, 2013), or if the task was to come up with a pretend identity (Doherty & Perner, 1998).

Mental files theory also offers a potential explanation for why children show sensitivity to belief in their looking behaviour before correctly answering the test question of the standard belief test. Clements and Perner (1994) found a dissociation between correct anticipation of the agent's mistaken action in looking and wrong prediction in response to the standard test question. Despite their correct looking children were convinced of the correctness of their wrong verbal response (Ruffman, Garnham, Import, & Connolly, 2001). Correct visual anticipation could be shown just before children's third birthday but not earlier. All of seven replication reports confirmed these findings (Kulke & Rakoczy, 2018). Evidence of much earlier competence came from similar studies that avoided any verbal interaction. Children had to infer what the agent wanted from repeated successful retrieval of the target object. Using looking time to measure violation of expectation yielded evidence around 14 months (Onishi & Baillargeon, 2005; Surian, Caldi, & Sperber, 2007, and many others). Correct anticipatory looking was found at two years (Southgate, Senju, & Csibra, 2007) or 18 months (Neumann, Thoermer, & Sodian, 2008; Thoermer, Sodian, Vuori, Perst, & Kristen, 2012) provided the target object was removed from the scene (disappear condition) to eliminate any distraction by the object's real location (and—presumably—application of basic teleology). The replicability of this early evidence has, however, come under sustained criticism. Across several different study paradigms only about half the studies found the effects (Kulke & Rakoczy, 2018).

The nature of findings and the volatility of replicability can be accommodated by postulating "unlinked vicarious files" (Perner, 2016). Before passing the standard false belief test children are able to form vicarious files but cannot link them. This gives infants information about another agent's perspective in their vicarious file. So, when they happen to track the object with that file its information takes hold of their practical reasoning. However, as that file is not linked to their regular file they cannot use it when tracking the object with their regular file. This leads to haphazard use of the vicarious file sufficient for above chance performance but not intentional use of this file as an alternative to their own perspective.

Several suggested biases could influence which perspective is taken. A cooperative bias (Helming, Strickland, & Jacob, 2016; Westra, 2017) leads children to focus on where Max's chocolate is to help him find it.[5] Also several referential biases may be operative. Removing the chocolate from the scene reduces the likelihood that the "chocolate" in the test question "Where will Max look for his chocolate?" will pick out the child's own regular chocolate file since it has lost its location information (Disappear condition, Wimmer & Perner, 1983; Southgate et al., 2007; but see Russell, 1996). Also, the experimenter's test question shifts attention away from Max's perspective to the common ground of child and experimenter, who both know where the chocolate really is (Helming et al., 2016). Mention of Max's desire highlights the chocolate's actual location since Max wants to go where his chocolate is and not where he thinks it is (Perner et al., 2007; Rubio-Fernández & Geurts, 2013, 2016). All these biases are conceived as making the standard verbal false belief test more difficult than the non-verbal alternatives. The mental files theory of unlinked vicarious files (Perner, 2016) leaves open how these biases might sway young children one way or the other. However, the theory explains why older children give the right answer in the standard verbal false belief task, despite all these biases supposedly working against the correct answer: children become able to link coreferential files. This allows them to remain aware of Max's perspective in the vicarious file even when they think about the chocolate using their regular file.

[5] See Perner (2016) for a summary of problematic data for this suggested bias.

To sum up, co-referential files provide a unified notion of level 2 perspective that is applicable to dual naming phenomena as well as more typical perspective cases like false beliefs. The developmental synchrony of mastering these different tasks can be explained by the ability to link files emerging around 4 years of age.

Exclusivity

Our principal question about exclusivity was: Why do different labels for the same entity create an opposition so that one treats them as mutually exclusive?

A wide range of phenomena suggest that co-referential terms cause difficulties. When a speaker uses different terms for the same referent, listeners often react with consternation. Similarly, children appear to have difficulty acknowledging that objects can have more than one label. Both phenomena could reflect assumptions about common ground and speaker intentions. Alternatively, the developmental phenomena could be specific to word learning. By contrast, mental files theory can account for both sets of phenomena in terms of pragmatically sensible processes for managing perspective differences. In older children and adults these can be moderated by more deliberative metacognitive processes. Younger children are limited to the file management processes. This yields specific developmental predictions.

Conceptual pacts

As discussed in the Introduction, participants in a conversation converge on a consistent set of terms for objects in the conversation. Breaking this "conceptual pact", e.g., by using a new label for a previously labelled object, results in slowed or impaired comprehension. For example, Metzing and Brennan (2003) had participants play a game moving objects, for which terms were established (e.g., "the shiny cylinder") after which a speaker broke the established precedent by using an alternative expression (e.g., "the silver pipe"). This made listeners slower to respond, particularly when the alternative expression was used by the original speaker rather than a new speaker. Metzing and Brennan suggest that in conversation people form partner-specific 'conceptual pacts', temporary agreements to view objects in a particular way. New speakers are not part of this pact, and therefore are not expected to adhere to the agreed terms.

These phenomena have both rich and minimalist interpretations. The rich view is that participants constantly monitor what they take to be common ground (what the other knows that I know, etc.) to resolve reference. In the example above, the first label is known to the first speaker and participant, but not necessarily to the second speaker. This makes it readily understandable why the second speaker might use an alternative label, but not the first speaker. The minimalist view is that such considerations are not used in the early stages of utterance processing. In mental files terms, file management simply creates a 'shiny-cylinder' file, with which the listener tracks the object. The tracking constraint then makes it difficult for the newly deployed 'silver-pipe' file to take over tracking the object. Considerations of common ground may feature later in processing, particularly if the basic linguistic processing is ambiguous. This suggests a two-stage model of the observed reaction times: a fast acting rejection of alternative names according to the minimalist view, followed by a slower deliberative phase in the spirit of the socio-pragmatic view.

A recent meta-analysis by Kronmüller and Barr (2015) strongly supports such a two-stage model. Following the basic logic of Metzing and Brennan (2003) task, the tasks analysed included eye tracking after a speaker used an alternative label. The previously used label is considered to 'preempt' the alternative label, causing listeners to attend away from the target. In the first few hundred milliseconds (reliably from ~400 ms) after hearing the alternative term, this preemption occurs regardless of whether the speaker is new or old, suggesting no use of extra-linguistic knowledge (including common ground, speaker intentions, etc.). The difference between speakers occurs between about 800 and 1200 ms. This is consistent with an early automatic effect independent of speaker, and a later more reflective effect that is speaker-dependent. Kronmüller and Barr argue for the 'recovery-from-preemption' hypothesis according to which in the later effect "listeners use perspective information to recover from a partner-independent preemption effect", or, in other words, try to figure out why the speaker used a different label. This is straightforward for a new speaker, who has no reason to use the established term, but not for the old speaker. Kronmüller and Barr (2015, p. 15) conclude that "listeners expect to hear descriptions conforming to established precedents due to factors that are unrelated to common ground or speaker-specificity, but the field is currently lacking a good explanation for what might give rise to this pragmatic effect."

The absent explanation can be supplied by mental files. Initial reference to an object creates a file bearing the referential expression that tracks the object. Further files created by new referential expressions will be prevented from tracking the same referent by the tracking constraint, i.e., allowing only one file to track an object at a particular time to avoid mixing of perspectives. This hypothetical constraint is automatic, so will occur rapidly after hearing the expression.

The second process, recovery from preemption, occurs when no other candidate object is suitable. Adults and older children may link the new file to the old file, and thus indirectly to the object. The decision to do this may be influenced by speaker perspective considerations, as Kronmüller and Barr suggest. If a child cannot link files, the new expression is likely eventually to lead to a process of reindividuation. The object is reconceptualized, after which a new file is created which tracks the object. The tracking constraint would simultaneously cause the original file to stop tracking the object. This should be independent of speaker.

Findings from the only relevant study with 3- and 5-year-olds pose a potential challenge to this explanation. Matthews et al. (2010) found that even children of mean age 3;5 showed a speaker difference, with faster recovery when a new speaker used an alternative expression compared to the original speaker. This suggests that the 3-year-olds were able to link files. It would pose a problem because (a) we claim that success on tasks requiring an understanding of different perspectives, e.g., false belief tasks, marks the onset of the ability to link files; and (b) typically three-year-olds fail such tasks. However, performance on false belief tasks varies

considerably between studies. The metaanalysis by Wellman et al. (2001) shows that about 45% of children at this age pass the false belief test. Factors influencing success, including social background and verbal mental age, are not known for Matthews et al.'s sample. Thus it is unknown how many of these children would fail false belief tasks, and whether Matthews et al.'s study constitutes data against our claim.

It is interesting to note that in their protests children did not distinguish between speakers: nearly a third of children protested the change in label at least once, and protests were in fact slightly more frequent for the new speaker than the old speaker. Although the number or pattern of protests did not seem to differ between age groups, Matthews et al. note that 3-year-olds "seemed just as indignant when a new term was used by a new partner as by an old partner who could have known better … the younger children probably did not engage in a fully adult like process of inference" (p. 755–6).

The mutual exclusivity bias

Exclusivity when studied in children is frequently attributed to a lexical principle that word extensions are mutually exclusive. This Mutual Exclusivity assumption reduces the number of possible meanings children must consider for a novel word. For most basic level categories the assumption holds, and so is plausibly a useful word-learning heuristic (Carey & Bartlett, 1978; Dockrell, 1981; Dockrell & Campbell, 1986; Markman, 1989; Merriman & Bowman, 1989; Golinkoff, Hirsh-Pasek, & Bailey, 1992).

Clearly children do learn overlapping terms, and know and use many by the age of 3 or 4 years (Waxman & Hatch, 1992; Deák & Maratsos, 1998) or earlier (Clark, 1997). It has been argued that children relax the bias given enough information that it does not apply in a particular case. The bias is taken to be relaxed for specific words, rather than abandoned entirely (Markman, 1989, p. 215). This implies that the bias is lifelong, being relaxed for new words as they are learned. Existing data indicate that adults continue to conform to the predictions of the mutual exclusivity bias unless evidence suggests it is inappropriate.

There are a number of potential consequences of this assumption. The most studied is the disambiguation effect (Markman & Wachtel, 1988), where children assume a novel word must refer to something they cannot yet name. Another related phenomenon is children's tendency, when taught two novel words for a single unfamiliar object, to accept only the first name *tested* as the valid label for the object (Savage & Au, 1996). This phenomenon has no generally accepted name. Here we refer to it as the *dual name teaching effect*.

The disambiguation effect.

The most commonly studied method for the hypothesised bias is 'the disambiguation task'. Typically, children are shown a familiar and an unfamiliar object (e.g., a banana and a whisk) and asked (for example), "which one is the *fendle*?" where 'fendle' is a novel word. Preschool children select the novel object, typically in around 80% of trials (e.g., Markman & Wachtel, 1988, Expt. 1). The effect can be observed from infancy on using eye-tracking (Halberda, 2003). A recent meta-analysis of the disambiguation effect (Lewis, Cristiano, Lake, Kwan, & Frank, 2019) finds that from infancy until 5 years the strength of the bias increases. Lewis et al. attribute this increase to independent effects of vocabulary size and of age.

What needs to be explained is how the disambiguation effect happens, and why it increases in strength. Traditional lexical principle explanations claim that children assume that or behave as if word extensions do not overlap. How this assumption is instantiated is not specified.

The mental file account provides a potential way of instantiating it, explaining both how the disambiguation effect comes about and why it increases in strength. We assume that children create a mental file bearing the familiar label and use this to track the familiar object. For the period the object is tracked this file will preempt tracking by alternative files via the tracking constraint. This explanation assumes that seeing an object can activate its label. This is plausible: Mani and Plunkett (2010) found that children as young as 18 months implicitly name visually fixated images. Further, Grassmann, Schulze, and Tomasello (2015) showed that when the label was in the child's receptive vocabulary but not productive vocabulary (so children could not name it to themselves) disambiguation did not occur.

On this account, the increase in strength of the bias results from an increased likelihood of spontaneously creating mental files bearing known labels. One factor influencing this is the strength with which familiar words are known. Larger productive vocabularies correspond to common words being better learned. Lewis et al. (2019) also provide direct evidence that the strength with which recently taught names are known affects their likelihood to cause the disambiguation effect when the object is paired with a novel object (Au & Glusman, 1990).

The dual name teaching effect.

A smaller number of studies have examined another mutual exclusivity effect, in which children are taught two novel words for an unfamiliar object by different speakers, for example *lemur* and *primate* (Savage & Au, 1996). Children are then asked to select referents for the novel names. Typically they successfully choose the target for whichever name is tested first, suggesting both names have been learned. For the second name tested, children frequently choose a distractor (Savage & Au, 1996; Frank & Poulin-Dubois, 2002; Karadaki & Doherty, 2017). One might object that the repeated questioning produces pragmatic artefacts. Asking for the same object using a different label could be misinterpreted as a request for a different referent, or that the child's first response was incorrect. Both misinterpretations would lead to choosing a distractor. Separating requests for the same object by requests for other objects should diminish these misinterpretations. However, intermingling the requests for the target with requests for other objects

does not affect performance (Frank & Poulin-Dubois, 2002), nor does performance differ when requests take place in the context of a game, which arguably distracts from the salience of repeated labelling (Kalashnikova, Oliveri, & Mattock, 2018; Kalashnikova, Mattock, & Monaghan, 2015). These studies also had different speakers test the word that they themselves introduced, more pragmatically natural than Savage and Au's original procedure in which a single experimenter tested both words.

Savage and Au (1996) interpreted their findings in terms of a special case of the lexical principles account. They suggest that children temporarily hold both names in mind. The experimenter's first request forces them to commit to one name. They then abandon the other name, thus allowing them to maintain the assumption that word extensions are mutually exclusive. This account predicts that children would reject the supposedly abandoned word later. Savage and Au did not test whether children would do so. However, Karadaki and Doherty (2017) did. Shortly after the main task children were shown the original target and distractor and were only asked to select the referent of the second word. When this word had been presented immediately after the other word in the main task, younger children had applied it to the distractor. Nevertheless, when only this word was presented later, even most children who had previously chosen the distractor now selected the original target, refuting Savage and Au's assumption.

The mental file account of the dual name teaching effect does not require children to forget one of the words. In the learning phase children correctly learn both. This is clear, because children correctly identify the object using whichever word is used first in the experimental phase, and in the post-test also identify the referent using the second word. On hearing the first word in the experimental phase, children use a mental file bearing the first label to track the target. The second label causes the creation of a new file. This file cannot track the target, however, because the target is currently being tracked by the original file. So the new file is used to track the novel distractor. Older children are able to link the two files, and thus choose correctly. Files track objects only for the duration of a conversation. Thus, in the later retention test a file bearing the second label can track the target, so long as children do not spontaneously generate a file bearing the first label.

Other developmental dual labelling phenomena.

Clark (1997) found that children "readily apply multiple terms to the same objects or events" as soon as they have the necessary words. Even in their second year when they have a vocabulary of no more than 20 words they use different labels for the same referent, e.g., "basket" for a basket, but "hat" when it was put over the child's head. Clark also points out that on occasion children reject a second familiar label. Because the child already knows both labels these rejections are not evidence for rejections of multiple lexical entries. They are rejections of a perspective (Clark, 1997, p. 19). This is what the tracking constraint amounts to, as each coreferential file provides a different perspective on their referent. The important point for us is that these early spontaneous uses of different labels are not evidence for linking files but rather evidence for context induced switching of coreferential files.

Clark and Svaib (1997) showed children a series of pictures of animals in human dress carrying out various human activities. Even 2-year-olds could correctly answer "What is the rabbit?" [expected answer: a nurse], as well as, "Is this dog an animal?", or "What kind of animal is this?". Here it helps to distinguish between terms used to individuate objects (see Fig. 1: conceptualisation), and words used attributively to represent under which concept or concepts an object falls. In the sentence "Is this dog an animal?", for example, *dog* defines the object (as a dog) and puts a perspective on it; whereas "animal" is information that the already-individuated dog also falls under the concept "animal". It does not establish a second perspective. Thus situations like Clark and Svaib's only require a single mental file.

For situations in which there are two files, retaining information about the referent after switching to the second file would require the files to be linked. Three- to 6-year old children were recently tested for this ability with anthropomorphic animal characters similar to those used by Clark and Svaib (Huemer, Haslehner, & Perner, 2019). In the basic story the same referential term was used throughout. In one story the Gardener, who is a rabbit, loses his wallet while working. He goes to lunch with his friend the Bear. When they leave one of them cannot pay. Children are asked, "Who cannot pay, the Gardener or the Bear?" Over 80% of children correctly pointed to the Gardener, whether they failed or passed a false belief test. When the term Gardener changed to Rabbit after meeting up with the Bear, all children accepted the change in label. However, when asked, "Who cannot pay, the Rabbit or the Bear?" only 55% (not above the guessing level of 50%) of children, who failed the belief test, gave the correct answer. Still 91% of belief passers did. In line with the observations by Clark and Svaib, children who fail the belief test are perfectly able to accept different labels for the same referent. However, this does not mean that they can link files. Performance on the Gardner story suggests children had not linked their Gardener and Rabbit files, because the information about the lost wallet in their Gardener file was not available in their Rabbit file for answering the test question.

More challenging would be the finding that children as young as 3 years old can themselves name objects at multiple levels of a hierarchy under certain circumstances. Waxman and Hatch (1992) showed preschool children a picture of a rose and asked "is this a dandelion?" After children responded (e.g., "no, it's a rose"), the experimenter asked "is this a tree?" and "is this an animal?" Children frequently responded to these questions with correct names at the same hierarchical level, e.g., *flower* when rejecting *tree*, or *plant* when rejecting *animal*. Three-year-olds produced an average of 1.68 labels per object, and 4-year-olds 2.11 labels, a highly significant improvement with age. (See also McGregor & Waxman, 1998, and Deák & Maratsos, 1998[6], for similar procedures.)

[6] Deak and Maratsos's (1998) procedure may allow success using a single mental file. Children named an object (e.g., dinosaur), after which the experimenter elicited multiple names by asking, e.g., "What kind of thing is a dinosaur? Is it a plant?" Using the previously established name for the object in the probe question can be seen as an invitation to provide conceptual information. This information could be added to the file bearing the sortal dinosaur (e.g., "A dinosaur is an animal", "this particular dinosaur is a T. Rex", etc.) This would cause no issues with the tracking constraint. It

The findings could challenge the mental file approach. If the younger children were aware that they had changed their answer it would suggest they are able to link files. However, as discussed, performance among 3-year-olds is highly variable in other tasks that require the ability to link files, such as the false belief task, and it is unknown how this particular group would have performed. Further, repetitions of the misnaming procedure have not produced the original levels of multiple labelling, even with children old enough to be able to link files. McGregor and Waxman (1998) found that typically developing 5-year-olds produced a mean of 1.25 labels per object, 23% of which were errors. Gollek (2013) found that 4-year-olds produced an average of 1.14 labels per object, 5-year-olds an average of 1.31.

Predictions

The mental files explanation of mutual exclusivity effects generates novel predictions, some of which are being or have been tested. The basic notion is that the disambiguation and dual name teaching effects initially result from the inability to attach more than one file to a referent. Thus they should relate to other tasks that share this difficulty. These include the false belief task, as well as Doherty and Perner (1998) Alternative Naming task.

Potential relations with the disambiguation effect seem at first glance improbable, since there is little evidence of developmental change. Children show the effect from infancy (e.g., Halberda, 2003; Markman, Wasow, & Hansen, 2003) and adults will choose the novel object as the best first guess (e.g., Au & Glusman, 1990). However, the assumption that they always do so for the same reason may be incorrect, as indicated by a study by Haryu (1991; Haryu & Imai, 1999). She devised a version of the task that is sensitive to developmental change. Her 'word-only' condition followed the typical procedure, with children asked to identify the referent of the new word in the presence of a novel and a familiar object (e.g., a lipstick holder and an apple). In the novel 'pragmatic' condition children were told that a puppet "is hungry. I would like to give her [the] *heku* [a nonsense word in Japanese]", thus providing a clear indication that the intended referent was edible (i.e., the familiar apple). Three-year-old children nevertheless chose the inedible novel object about as often as in the standard disambiguation condition; about half the 4-year-olds and most 5-year-olds selected the apple, the pragmatically sensible object.

Younger children's inability to take the clear pragmatic cue into account suggests that until the age of about four years children are unable to avoid the disambiguation effect, even when it is not the pragmatically sensible option. According to the mental files account, children become able to avoid this once they can link files, here linking the *heku* file to the apple file tracking the object. This ability should associate with the false belief and alternative naming tasks.

This prediction was examined by Gollek and Doherty (2016), who simply gave 2- to 5-year-old children the false belief task, alternative naming task, and the pragmatic-cue version of the disambiguation task. All three were strongly associated over three experiments (all r between 0.40 and 0.69), even beyond common associations with age, verbal mental age, and inhibitory ability (all partial r between 0.35 and 0.53). Performances on the typical disambiguation task approached ceiling and were not associated with the other tasks.

The dual name teaching effect has also seldom been examined with more than one age group. Comparing experiments with different age groups, appropriate application of both labels to the target appears to be developing between 2- and 5-years (Frank & Poulin-Dubois, 2002; Kalashnikova et al., 2015, 2018; Savage & Au, 1996). Recently Karadaki (2019; Karadaki & Doherty, 2017) has given the task to preschoolers in this age range, also comparing performance with false belief tasks and Haryu's Pragmatic Cue task discussed above. Performances were significantly correlated (r values ranged between 0.66 and 0.82, age-partialled r values between 0.45 and 0.70, all $p < .001$) as predicted by the mental files approach.

Comparison to other approaches

The mental files account is pragmatic in nature, concerning word use rather than word learning. In this sense it potentially differs from accounts that take the ME bias to be specifically a lexical principle. Identifying the referent can be an important stage in learning a word. The tracking constraint performs this function in situations like the disambiguation task. Nevertheless, it is situation-specific, and does not operate across situations or act on the lexicon to maintain one-to-one word-object associations. This helps account for an old puzzle associated with the ME bias, that children treat words as mutually exclusive yet learn many alternative names by the age of 3- or 4-years. The tracking constraint does not prevent application of a new term to a familiar object unless the object is spontaneously tracked by a file with the familiar name. In the disambiguation paradigm, mental files may be spontaneously created for known objects about 60% of the time, given typically 80% choice of the novel object (60% plus half the random choices).

Thus, the tracking constraint performs at least one function of a lexical principle, but is more appropriately viewed as a pragmatic principle governing word use. It is therefore necessary to examine how it compares to other pragmatic explanations of the mutual exclusivity bias such as the sociopragmatic account. The account claims that children infer word meanings by judging others' communicative intentions (Bloom, 2000; Tomasello, 2000; Diesendruck & Markson, 2001). Disambiguation results from reasoning that if a speaker refers to the familiar object she would use its mutually-known name. Because she did not, she likely intends to refer

(*footnote continued*)
is also unclear that children did provide multiple terms. Referents were all dual-function objects (e.g., a dinosaur-eraser). Prompts included demonstrating the object's function and saying "what do you call a thing that does this?", for which the referent is the class of objects with the given function.

to something else, which is why children select the novel object.

On this reasoning, Diesendruck and Markson (2001) argued that disambiguation should occur for other situations in which a novel referring expression is used instead of an expression that is mutually-available and unambiguous. They provided support for this with a disambiguation effect for idiosyncratic facts. They told children about one of two novel objects, "my uncle gave this to me." Children were then asked "Can you give Percy the one my cat likes to play with?" Three- to 4-year-olds showed a clear disambiguation effect by handing Percy the previously unmentioned object.

This result was taken as evidence against lexical principle accounts of disambiguation, since apparently the same bias was shown in the fact condition without involvement of multiple labels. However, subsequent research calls this into question. Whereas adults show the disambiguation effect for labels (78%) they do not do so for facts (45%; Malone, Kalashnikova, & Davis, 2016). The two biases also develop differently. While levels of disambiguation for facts are similar to those for labels at around 4 years, they are lower at younger and older ages (Scofield & Behrend, 2007; Kalashnikova et al., 2015; de Marchena, Eigsti, Worek, Ono, & Snedeker, 2011). The correlation between them is close to zero ($r < 0.1$) for preschool children (Kalashnikova et al., 2015) and children with autism and matched controls (de Marchena et al., 2011).

The mental file account does not strongly predict that facts should cause disambiguation. A fact about a novel object causes a mental file to be deployed, and the fact recorded on it. The second fact could be added to the existing file for the first object. Alternatively, a new file could be deployed, which the tracking constraint would cause to track the other object. Which tactic a listener will choose cannot be readily predicted.

A clear difference to the mental files approach is that the sociopragmatic account requires a high level of mental state reasoning. In contrast, the tracking constraint is assumed to be a fundamental feature governing the pragmatics of reference, and operates without reasoning. Children are able to bypass some consequences of the constraint from roughly four years when they acquire the ability to link files. From this point they can be said to possess the mental state reasoning abilities posited by the sociopragmatic account. Until then, the pragmatic tendency to treat words as mutually exclusive is provided by an automatic constraint rather than judgements of speaker intent.

Exclusivity summary

Developmental phenomena related to exclusivity resemble preemption in conceptual pacts research: an established term for an object causes participants to attach a second term to a different object. The insights provided by eye-tracking research with adults provide reason to think the phenomena involved in pacts and mutual exclusivity may, indeed, not be fundamentally different. In both fields, early on (in development, or in processing) participants are not able to consider the original object as referent of the new term, and later (after 4 years or 1000 ms, respectively) they are able to do so.

Mental files theory offers a unified explanation, encompassing both pacts and mutual exclusivity: participants are initially unable to consider more than one term for an object because the tracking constraint does not allow more than one file to track an object. This will produce the disambiguation effect. Associated word learning benefits are provided by a pragmatically sensible system that minimises processing demands. Once children are able to link mental files they can take into account the complexities of speaker intention, what is mutually known, what is understood to be mutually known, and so on.

To address our initial question: Why do different labels for the same entity create an opposition so that one treats them as mutually exclusive? This is because different labels cause the generation of different mental files, and therefore different perspectives. Mixing perspectives in a single discourse would risk confusion about what and how objects are being talked about. Therefore, two files should not be allowed to simultaneously track the same object. People become able to stop treating different labels as mutually exclusive because later in development or processing time, people are able to link files, which enables them to access the coreferential file from the file tracking the object.

Finally, it is worth emphasising that according to the mental files account of co-referential terms, there will only be problems when the terms are used in the same situation or conversation. Children should not otherwise have problems using or learning multiple labels for the same thing.

Bilingualism

A widespread intuition is that children who are bilingual should differ on a range of linguistic and metalinguistic tasks. For example, frequent experience of things being named differently across languages may lead children to not demonstrate a disambiguation effect within a language. This may be because they have not developed it (e.g., Houston-Price, Caloghiris, & Raviglione, 2010) or have abandoned it as a result of linguistic experience (e.g., as they acquire a large number of cross language equivalent words; Byers-Heinlein & Werker, 2013). As another example, children's ability to switch between languages may promote their ability to produce overlapping labels in a single language, as is required in the Alternative Naming task.

Contrary to these intuitions, the strong version of the account advanced here predicts no qualitative difference between monolingual and bilingual development in matters relating to dual naming. The special circumstances of bilingual development may affect the timing of developments. However, the general pattern should be the same: the tracking constraint prevents more than one mental file at a time tracking an object, with consequent effects on naming that persist until children become able to link files. Note, we are not claiming there are no differences between bilinguals and monolinguals, but that any differences will be common to tracking across all relevant tasks. Bilingualism therefore provides an interesting natural test case of the claims advanced here. We begin with alternative naming.

Superficially, switching between labels for an object in different languages resembles switching between coreferential terms in the same language. Monolingual children can switch between terms in the same language from about four years (Doherty & Perner, 1998). Observational studies suggest that to a limited extent children can tailor the languages they speak according to listener from the age of two years (Genesee, Boivin, & Nicoladis, 1996). However, surprisingly little research has investigated when children are aware that they are speaking two languages (Akhtar & Menjivar, 2012). Tare and Gelman (2010) examined this experimentally in 3- to 4-year-olds. Children were asked by a speaker using one language to name a set of six common objects, then by another speaker using children's other language to name the same objects. Children tended to use the same language with each speaker. Their ability, following prompting, to switch to the appropriate language was strongly related to performance on theory of mind tests from Wellman and Liu (2004) scale, r = .60 p < .01. These findings are consistent with the idea that the ability to link files, as reflected in theory of mind performance, relates to the ability to think about co-referential words in two languages.

Regarding alternative naming within a language: Gollek (2013, Experiment 4) found that bilingual children (N = 18) performed similarly on the production version of the Alternative Naming task relative to the False Belief task, and the two were strongly related, $r = 0.72$, $r_p = 0.52$. Karadaki (2019, Experiment 4) replicated this finding with Greek-English bilinguals (N = 45, $r = 0.47$, $r_p = 0.35$). Diaz and Farrar (2018) examined this longitudinally. Their primary aim was to account for the reported bilingual advantage in the false belief task (Goetz, 2003; Kovács, 2009; Nguyen & Astington, 2014). Schroeder (2018) concludes from a meta-analysis that there is a small bilingual advantage, and a medium advantage for studies that adjust for bilingual children's lower proficiency in a single language. Diaz and Farrar (2018) compared performances on false belief tasks, an executive function composite, and a metalinguistic composite which included the judgement version of the alternative naming task (Doherty & Perner, 1998). Bilinguals outperformed monolinguals on all of the metalinguistic tasks, including alternative naming once receptive vocabulary was controlled for. Children were given all tasks twice, one year apart. For bilinguals false belief performance at time 2 was only predicted by metalinguistic awareness at time 1, $r = 0.49$, $p < .05$. Moreover, this relationship was largely driven by the relation between alternative naming and false belief performance, $r = 0.72$, $p < .001$.

The clear relationship between early metalinguistic awareness and later false belief in bilinguals suggests that bilinguals may as a result of their unusual language history have better metalinguistic awareness than monolinguals, and this contributes causally later to their good theory of mind performance. The fact that the effect of early metalinguistic awareness is particularly evident in alternative naming suggests that common factors in alternative naming and theory of mind account for the effect. We suggest that bilingual children's unusual language history promotes their ability to link files, and this ability is naturally evident first in the linguistic domain.

Regarding mutual exclusivity research: the handful of studies examining the dual name teaching effect in bilingual children shows little or no effect of bilingualism, either with 2-year-olds (Frank & Poulin-Dubois, 2002), or with preschoolers (Kalashnikova et al., 2015). More studies have examined disambiguation in bilingual children, and have yielded mixed results. Three to 4-year-old bilingual children disambiguate at a similar rate to monolinguals (Davidson, Jergovic, Imami, & Theodos, 1997; Davidson & Tell, 2005; Kalashnikova et al., 2015), although 5-to 6-year-old bilinguals may do so less than monolinguals. Research with bilingual infants is less consistent: they may not disambiguate at all (Houston-Price et al., 2010), or only marginally (Byers-Heinlein & Werker, 2009), or at least as much as monolinguals (Kalashnikova et al., 2018). Lewis et al.'s (2019) meta-analysis found that being monolingual or bilingual did not reliably predict disambiguation. However, the average effect size in bilingual studies was smaller than for monolinguals. It remains possible that there are true differences in disambiguation.

The mental files account attributes any difference in disambiguation between monolingual and bilingual to vocabulary strength. Bilingual children's smaller vocabulary means they are less likely to spontaneously create mental files bearing known labels relative to monolingual children of the same age.

To summarize, bilingual children appear to have similar performance in disambiguation tasks, and perhaps superior alternative naming ability. In support of the current endeavor, however, they show the same pattern of relationships on tasks that require linking of mental files. Diaz and Farrar's study suggests that bilingual experience may have a causal effect on the ability to link files, which may account for bilingual advantages in theory of mind (Schroeder, 2018).

Identity

Our fundamental question, "What does it mean for an entity to have different identities?" was triggered by suggestions in the literature like the one from Markman (1989, p.252, following a suggestion by Flavell, 1988), "children may believe that an object has one and only one identity – that it can only be one kind of thing – and that an object's identity is revealed by object labels". This captures children's problems in the alternative naming game. If they focus on an item as *a rose*, they are unable to conceive of it as *a flower*. However, even 2-year-olds can readily answer questions like "Is this rose a flower?" (Clark & Svaib, 1997). Mental files theory resolves this apparent paradox by distinguishing between nouns used to individuate the object and nouns used not for individuation but for providing information about the object. Individuating information, "This is a rose," versus "This is a flower," creates different files. These correspond to different ways of thinking about the same referent, and therefore different identities. In contrast, "This rose is a flower" leads to a single file in which the object is individuated as a rose, and being-a-flower is predicated of it.

Mental files, therefore, help us specify more precisely when different identities are involved: when we think of an entity in different ways through different files. However, when we think of it with a single file and predicate its membership of a particular class or kind, only one identity is involved. Research shows that children before four years (before passing the false belief task) do indeed have problems with identity—as Markman surmised.

Identity statements

Children, who cannot link coreferential files, as indexed by their false belief task performance, have clear problems establishing identity. For instance, Perner et al. (2011, Study 1) asked children aged 3–5 years old to find out which key in a bowl of keys opened which of three boxes. The first key opened the yellow box, so a yellow marker was stuck on one side and returned to the bowl. A seemingly different key was then chosen, which unbeknown to the child was the same key with only its unmarked side visible. It opened the green box and was marked with a green marker on its unmarked side. Then the experimenter revealed that it already had a yellow marker on the other side. This was reinforced by an identity statement, "Look: The yellow key is the same as the green key." Then with the green side visible children were asked whether it opened the yellow box. Children who failed the false belief task denied this. The correlation was substantial: $r = 0.57$, $r_p = .39$, with age controlled, N = 41.

Mental files theory explains young children's failure by their postulated inability to link co-referential files. The child deploys a file for the first key, with the information that it opens the yellow box. A new file is created for the second key with the information that it opens the green box. Then the identity of the two keys is discovered. Only children who can link the two files can transfer the knowledge from their file for the yellow key, that it opens the yellow box, to their file for the green key. The younger children are unable to link files, therefore deny that the green key opens the yellow box.

Further data involve processing identity statements, e.g., "Mr Mueller is the firefighter," in computer animated stories (Perner et al., 2011; Study 2). A person in civilian clothes was identified as the firefighter. Later a lost bag had to be returned to "Mr Mueller". It was announced that Mr Mueller was the firefighter inside the house. Children saw two men in the house, the firefighter and another man, and had to decide which one was Mr. Mueller. Performance correlated substantially with the false belief task ($r = 0.68$, and $r_p = .50$ with age and verbal IQ controlled, N = 78).[7] The children, who failed both false belief tasks had a strong and significant preference to treat the unlabelled character as Mr Müller over the firefighter, which reflects the workings of the tracking constraint.

The mental files explanation of these findings is straightforward: children deploy a file for the firefighter with which they are able to re-identify that person later. They deploy another file for Mr Mueller with information that he owns the bag but without visual information for recognizing Mr Mueller. The identity information, "Mr Mueller is the firefighter," can only be meaningfully used by children able to link their two files, which according to theory should be the children who pass the false belief test.

Other unpublished studies showed that the younger children have a very basic problem with processing identity statements. They cannot even repeat the identity information just heard. Meitner (2008; N = 59) told children a story in which *the teacher* is still in school. Susie is looking for *her mother* at home. Children are then told that *Susie's mother is the teacher* and asked "Who is Susie's mother?" The younger children could not answer this question. The age trend conformed to typical false belief performance: 30% of young 3-year olds passed, 68% of old 3-year olds, and 90% of young 4-year olds. Nguyen (2011) compared performance on this simple question with false belief performance, and found they correlated $r = 0.35$, $r_p = .25$ with age and language ability controlled, N = 72.

Conclusion

In a nutshell, mental files theory allows us to answer our 4 guiding questions: An object has different **identities** when coreferential files exist for it. Coreferential files also provide different **perspectives** on their referent. With this interpretation a unified notion of perspective can be applied to both alternative labelling and false belief tasks. Providing different perspectives makes it appropriate to **exclude** any file but one from tracking an object at a time, e.g., in a conversation with a specific partner. This constraint is at the heart of conceptual pacts and mutual exclusivity phenomena in children as well as adults. The **developmental** changes we observe around the age of 4 years pertain to children's ability to overcome the confines of mutual exclusivity and pact specificity. This change comes with the ability to link mental files, which makes it possible to access a linked coreferential file from the file currently tracking an object. Linking enables children to master cases of alternative naming: even though they currently think of an entity as a rose they now can also change to thinking of it as a flower, since they can link a coreferential flower file to the rose file. Linking is also required for processing identity statements and for understanding that someone else may have beliefs about an object that differ from one's own beliefs about the very same object. So the onset of linking coreferential files around 4 years explains why all these abilities emerge around the same age and show substantive correlations, as reviewed in this paper.

Here we have restricted consideration to phenomena involving labelling and identity, many of which have not hitherto been recognized as related. We contend that the approach can be readily extended to other kinds of perspectives and abilities emerging around 4 years (Perner & Roessler, 2012). For example, linking of files is as much needed for understanding that others can have different visual perspectives as it is for understanding belief. Looking at the drawing of a turtle on the table, one sees it as standing on its feet, while the onlooker opposite sees it as lying on its back (Masangkay et al., 1974). One needs two coreferential files to register the different views of the onlookers and link them as referring to the same turtle. Similarly for ambiguous figures one needs two coreferential files for registering that the same spatio-temporal entity is a rabbit and then a duck. This understanding also correlates with performance on the false belief task (Doherty & Wimmer, 2005; Wimmer & Doherty, 2011), as does understanding visual perspective (Hamilton et al., 2009).

Explanatory challenges remain. There are also developmentally related labelling tasks that do not involve any perspective

[7] Similar results were found in two unpublished studies: Waidmann (2006), N = 28: $r = 0.70$, $r_p = .29$ with age and verbal IQ controlled; Haring (2013), N = 62, $\Phi = 0.70$, $r_p = .53$ with age controlled.

differences. For instance in the homonyms task (Doherty, 2000; Wimmer & Doherty, 2011; Diaz & Farrar, 2018) children are shown, e.g., an envelope, and asked to point to "a different kind of letter", candidates including another envelope (distractor) and the grapheme A, the target. The ability to do this was substantially associated with false belief performance. However, the task involves labelling different objects, and perspective difficulties only arise with different perspectives on the *same* object. Similar findings show a relation between false belief understanding and awareness of rhyme (Farrar & Ashwell, 2012; Diaz & Farrar, 2018) which again does not appear to involve conflicting perspectives. Both of these metalinguistic phenomena do, however, involve the ability to think separately about a word or sound and the object or situation it represents, which is related to our present concerns. For now, however, we defer detailed consideration to another occasion.

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