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Mapping words to the world: Adults prioritize grammar, but children prioritize descriptions

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Abstract

How do children learn to connect expressions (e.g. “that red apple”) to the real-world objects they refer to? The dominant view in developmental psychology is that children rely on descriptive information (*red*, *apple*). In contrast, linguistic theories of adult language attribute primacy to the grammar: words like *that* or *another* first establish the status of potential referents within the discourse context (old, new) before descriptions can factor in. These theories predict that reference can succeed even when the description does not match the referent. We explore this novel prediction in adults and children. Over three experiments, we found that (i) adults relied on the articles to identify the referent, even when the description did not fit, consistent with *grammar-first* accounts; (ii) consistent with *description-first* accounts, and unlike adults, 3-5yo children prioritized the descriptions provided by the nouns, despite being sensitive to grammatical information. This suggests that children connect expressions to referents differently from adults.

Keywords: reference; identification; sortals; cognitive development

Introduction

How do people connect expressions to the objects they are referring to? Research within developmental psychology tends to assume that descriptions are critical to establishing reference (e.g. Markman, 1992; Waxman & Lidz, 2006; Xu, 2007). Under **description-first (DF)** theories, what allows children to establish the connection between an expression (e.g. “that red apple”) and the relevant physical object (a particular red apple) is the descriptive content provided by the content words, *red* and *apple*. Under this analysis, the child’s main task is to compare the properties provided by language with the ones derived from the physical world. For example, an utterance like, “Look at that red apple,” includes descriptors like *red* and *apple*, while in the physical context there might be an object that has the relevant properties of redness and applehood. On description-first theories, referent identification is the task of matching these linguistic descriptions to object properties. The most important property is taken to be the object kind, typically described using common nouns (Markman, 1992; Xu, 2007).

This view contrasts sharply with **grammar-first (GF)** theories, standard in linguistic semantics, which argue that the connection between what someone says and potential referents in the physical world is not direct, but mediated by an understanding of the discourse context. This involves keeping a list of the objects that are under discussion in a given

context (Karttunen, 1976; Heim, 1982; Kamp, 1981). New elements can be added to this list, or existing ones can be selected, depending on the grammar of an utterance. To see how this works, compare the contexts in which one would use the sentences in (1) and (2), which differ only in whether they contain an indefinite noun phrase (“a red apple”) or a definite noun phrase (“that red apple”).

- (1) A red apple is in my bag.
- (2) That red apple is in my bag.

Intuitively, someone would only use (2) if there was already some discussion of a relevant red apple. In contrast, using (1) would be appropriate to inform the addressee of a new apple, introducing it into the discourse. GF theories explain this difference by assuming that definite and indefinite articles affect the discourse context in different ways. Indefinites create a new entry in the list of things under discussion, while definites point back to an already existing one (Heim, 1982; Kamp, 1981). In these theories, descriptions can only play a role after determining, based on the function words, whether reference is being made to a new or an already-familiar entity.

Both theories might accommodate much of everyday referential communication, but one place where they differ is in how they handle mismatching descriptions. Consider a classic example due to Donnellan (1966). Imagine that you are at a party when you see an interesting-looking person with a martini glass. You might ask the host:

- (3) Who is that man drinking the martini?

This question would be no less sensible, nor would the host be any less able to answer it, if it turned out that the martini glass actually contained water. Indeed, the host would know who you mean even if they were the one who had poured the water, and so *knew* that your description did not apply.

Theories that treat establishing reference as a task of matching descriptions to entities cannot easily accommodate how mismatching descriptions can successfully refer. After all, in (3), there is no man drinking a martini. GF theories fare better: the definite noun phrase (“*that* man”) forces you to find a suitable entity already in the discourse context, so that exact descriptive (in)adequacy matters less.

While the success of reference with mismatching descriptions can be taken as evidence for GF theories in adult lan-

guage, to date there has been no systematic empirical investigation of children. This is in spite of the fact that children seem to possess the cognitive and linguistic prerequisites implicated by both theories. Infants succeed in matching objects to descriptions, a requirement of DF theories, from a remarkably young age (Bergelson & Swingley, 2012; Parise & Csibra, 2012). And as would be required by GF theories, a variety of non-linguistic tasks have shown that toddlers are sensitive to whether their communicative partner introduces a novel object or refers back to a previously mentioned one (Moll, Carpenter, & Tomasello, 2007; Tomasello & Haberl, 2003). Finally, a set of studies have shown that by around 3 years of age children can already produce and comprehend articles with their referential function (Aravind, 2018; Maratsos, 1976; Matthews, Lieven, Theakston, & Tomasello, 2006; Matthews, Lieven, & Tomasello, 2007; Rozendaal & Baker, 2008; Serratrice, 2005).

In this study, we empirically contrast DF and GF theories of referent identification in child development by investigating the main point on which they diverge: whether descriptions must match their intended referents. DF but not GF theories require that descriptors always match (e.g. "an apple" can only refer to an object that is an apple). In contrast, GF but not DF theories would allow for referring to an object with a mismatching description in the relevant grammatical environments (e.g. definite noun phrases).

We designed a novel referent selection paradigm to test these diverging predictions. In our paradigm, an object is first introduced into the discourse and then undergoes a magical transformation that changes its descriptive properties (e.g. from a car to a duck). This setup allows us to systematically ask questions about what utterances children and adults understand as referring to this *transformed object*. Participants heard requests for either a noun matching the object's initial state (car) or final state (duck), using one of three articles: two indefinites (*a*, *another*) and one definite (*that*). This let us ask (i) how both adults and children understand referential utterances that use an out-of-date pre-transformation descriptor and (ii) what the contribution of the articles is to their choice of referent. If participants prioritize grammatical over descriptive information, they should be willing to choose the previously mentioned transformed object (the car→duck object) when asked to pick "that car", even though the noun label no longer applies.

Experiment 1: Adults

Methods

Participants We recruited 50 native English-speaking adults online through Amazon Mechanical Turk (MTurk). They received \$1.20 as remuneration and the experiment took around 10 minutes for them to complete.

Design, Materials and Procedure Participants were first introduced to two on-screen cartoon characters (Tigger and Piglet), who served as the discourse participants throughout the experiment.

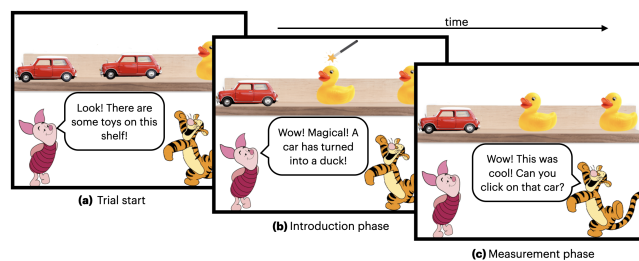


Figure 1: A timeline (left to right) of an example trial in Experiments 1 and 2, in which a car transforms into a duck.

Figure 1 shows an example trial. Each trial consisted of two parts: the introduction phase and the measurement phase. In the introduction phase, three toys appeared and Piglet narrated: "Oh! Look! There are some toys on the shelf". Each toy belonged to one of two different categories (e.g. car, car, duck; on-screen location counterbalanced). Next, one object magically transformed into a different kind of object with accompanying visual and sound effects. The object that transformed was always one of the objects that had two instances at the start (thus a *car, car, duck* display at start could end up being either a *car, duck, duck* display or a *duck, car, duck* display, depending on the counterbalancing). This magical event was narrated by Piglet: "Wow! Magical! An X has turned into a Y", with X labeling the initial object kind (e.g. *car*) and Y labeling the object kind after transformation (e.g. *duck*). This narration verbally highlighted the transformed object and provided an opportunity for the next use of *that* to refer back to it.

In the subsequent measurement phase, Tigger made a request: "Wow! That was so cool! Can you click on [a/another/that] [X/Y]?" and participants chose a referent in response by clicking on one of the objects. We manipulated two variables in this request: the article (*a* vs. *another* vs. *that*) and the noun (Initial: the noun corresponding to the initial state, e.g. *car*, vs. Final: the noun corresponding to the transformed state, e.g. *duck*). We chose to include two distinct indefinite articles, as *a* can occasionally (e.g. in environments that trigger free choice or indifference inferences) pick out objects that are already part of the discourse. In contrast, *another* always requires a referent that is new and distinct from a previously introduced object. We opted for demonstrative *that* instead of the definite article *the* because (i) in our setup it was more natural to interpret it as referring back to a previously mentioned object and (ii) looking ahead to the child experiments, prior research suggests that the anaphoric function of *that* is acquired earlier than that of the article *the* (Modyanova & Wexler, 2007; Modyanova, 2009; Wexler, 2011). Throughout, we will refer to the magical object as the "transformed object", to the untransformed object that matches the noun-description in the request as the "noun distractor object", and to the other untransformed object that does not match the noun-description in the request as the "other object".

Taken together, this design resulted in 6 within-subject trial types. Table 1 illustrates the predictions of DF and GF theories on each trial type, with a trial with a car \rightarrow duck transformation as an example and corresponding predictions for reference resolution derived from the two theories.

	Request	Article	Noun	DF	GF
1	A duck	Indefinite	Final	✓	
2	Another duck	Indefinite	Final	✓	
3	That duck	Definite	Final	✓	✓
4	A car	Indefinite	Initial		
5	Another car	Indefinite	Initial		
6	That car	Definite	Initial		✓

Table 1: Trial Types, Experiments 1 and 2. Checkmarks represent conditions where GF and DF theories predict the utterance could refer to the transformed object.

The 6 trial types were grouped into blocks, and each block was presented 4 times to yield 24 total trials. Each trial used distinct pairs of object kinds. The relative position of the three objects, and the position of the transformed objects were counterbalanced between trials, within-participant.

Results and discussion

Our primary question was how the rates of selecting the transformed object vary as a function of article and description. To test this, we built a generalized logistic mixed effects model, predicting the probability of choosing the transformed object from Noun (Initial or Final), Article (*a*, *another*, *that*), and their interaction as fixed effects, with a random intercept of participant. Article was helmert coded, allowing us to compare (i) *that* with the mean of the two indefinite articles and (ii) *a* vs. *another*. Noun was sum coded (a change from our preregistered treatment-coding scheme) in order to report the coefficients of our two contrast-coded effects of Article as main effects across both levels of Noun. Model comparisons revealed that inclusion of Article ($\chi^2(2) = 167.90, p < .001$) and Noun ($\chi^2(1) = 67.37, p < .001$) each significantly improved model fit, while the interaction term did not ($\chi^2(2) = 0.22, p = 0.9$). Reflecting the influence of grammatical information, participants were overall more likely to select the previously mentioned transformed object when the request included *that* ($\beta=1.86, z = 12.37, p < .001$) than the indefinites. We also found that *a* trials elicited greater selection of the transformed object compared to *another* trials ($\beta = -0.65, z = -2.13, p = .003$), consistent with linguistic evidence that *a* can refer back to a previously mentioned object, while *another* requires choosing a different referent. Most importantly, on *that initial noun* trials, participants selected the transformed object on 61.2% of trials, prioritizing the grammatical information over the noun descriptor. For example, upon seeing a car transform into a duck, participants asked for “that car” chose an object that was now a duck more often than a car that had never transformed, but had also not

been mentioned. However, participants were more likely still to select the transformed object when the request involved a noun description that corresponded to its final, transformed state ($\beta = 3.14, z = 6.92, p < .001$), suggesting that they did consider the descriptive information in their choices. See Figure 2.

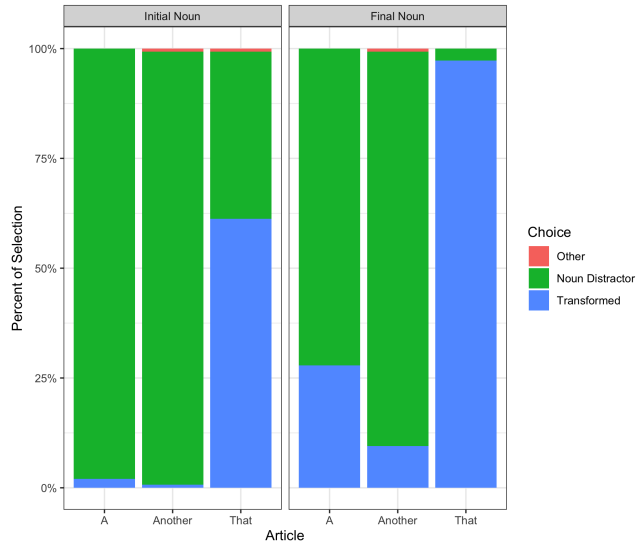


Figure 2: Adults’ choices of transformed object, the noun distractor, and the other object, broken down by the article (*a*, *another*, *that*) and noun (left: Initial; right: Final) in the request in Experiment 1.

Adults’ behavior matched the predictions of GF theories. Their choice of referent incorporated descriptive information, but prioritized grammatical information. Importantly, and compatible only with GF theories, they were willing to entertain reference to an object even when the requested noun did not describe it in its current state, so long as the grammar allowed for it. They tended to choose the object that transformed into a duck when asked for *that car*, but not *a car* or *another car*.

At the same time, they were not at ceiling in choosing the transformed object with an out-of-date description, even when *that* was used. This contrasts with their behavior in the *that final* condition, where they chose the transformed object nearly 100% of the time. This suggests that despite the strong role grammar plays in referent-selection, adults still have a preference for using matching descriptors, i.e. nouns that describe the object in its present state.

Experiment 2: Children

In Experiment 1, we found that grammar influences adults’ referent selection so strongly that it can override descriptive information provided by a kind label. Next, we explore how the influence of grammar on referent identification develops. Experiment 2 adapts the same paradigm for children. One possibility is that children start out prioritizing descriptions

over grammar, as DF theories within developmental psychology have previously assumed. Alternatively, it is possible that, like little adults, children will prioritize grammatical information as soon as they understand the referential functions of words like *that*, *a*, and *another*.

Methods

The experiment was preregistered at OSF (<https://osf.io/znye7>). Methodological and analytical choices were as specified there, unless otherwise noted.

Participants We analyze results from a sample of 32 children (Mean Age = 4.54 years, Range = 3.18 - 5.98 years) recruited from a database of participants at Brown University. An additional 5 children were excluded from the final sample due to inattention (4) and experimenter error (1).

Procedure The task and materials were identical to Experiment 1, except for changes aimed at adapting the task for children. The study was carried out live via Zoom video-conferencing with the experimenter. Rather than clicking on the target images, children pointed to their selections and their caregiver clicked on the corresponding image. To familiarize children with the task, each session began with a set of warm-up trials asking children to point to an object on the screen. We also shortened the task, reducing the number of items per trial type from 4 to 3 (yielding 18 total trials) and introducing a break half-way through.

Results and discussion

The modeling strategy was identical to Experiment 1. Model comparisons revealed significant fixed effects of article ($\chi^2(2) = 11.50, p = .003$) and noun ($\chi^2(1) = 104.81, p < .001$), with a marginal interaction ($\chi^2(2) = 5.09, p = 0.078$). Across all articles, children were more likely to select the transformed object when the noun description matched its final, transformed state ($\beta = 2.74, z = -10.30, p < .001$). In fact, they rarely ever selected the transformed object when the initial noun was used, irrespective of the article (mean 11%). However, children did show some sensitivity to the article. We found a main effect differentiating *that* from both indefinites ($\beta = 0.43, z = -1.93, p = .009$), but not the two indefinites from each other. In exploratory analyses of the simple effects of article at each level of noun, we found that children distinguished *that* from the indefinites only with the final noun ($\beta = 0.9, z = 2.633, p = .008$) and not with the initial ($\beta = 0.08, z = 0.614, p = .539$). See Figure 3. We also explored the effect of children's age in a separate model, but found no significant main effects or interactions involving age.

Finally, in order to directly compare adults and children in their differentiation of definite versus indefinite articles, we fit two models to the data corresponding to the final and initial noun conditions. When looking only at the final noun, model comparisons revealed a significant effect of article ($\chi^2(2) = 59.23, p < .001$), experiment (children selected the target more often than adults; $\chi^2(1) = 8.2073, p = .004$), and their interaction ($\chi^2(2) = 52.67, p < .001$). The transformed object

was altogether more often selected given the definite prompts compared to the indefinites ($\beta = 3.51, z = 6.68, p < .001$), but this interacted with experiment ($\beta = 2.78, z = 5.38, p < .001$), showing that adults differentiated based on definiteness more than children. In the model looking at the initial noun, we found similar results. Model comparisons revealed significant effects of article ($\chi^2(2) = 30.22, p < .001$) and experiment ($\chi^2(2) = 4.61, p = .03$; in this case children chose the transformed object more frequently than adults), and again, a significant interaction ($\chi^2(2) = 44.71, p < .001$). Across experiments there were more transformed choices in the definite compared to the indefinite frame ($\beta = 3.16, z = 8.71, p < .001$). The interaction between the definite-indefinite contrast and experiment was again significant ($\beta = 2.2, z = 6.22, p < .001$), driven by adults differentiating by the definiteness of the article more than children.

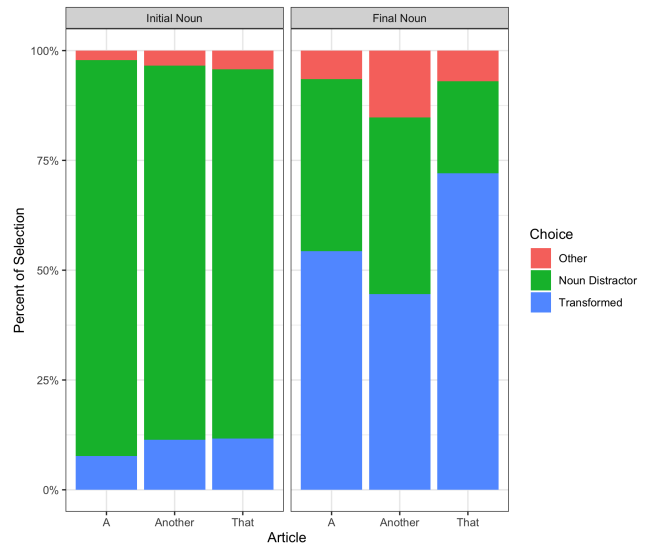


Figure 3: Children's choices of the transformed object, the noun distractor, and the other object by the Article (*a*, *another*, *that*) and Noun (left: Initial; right: Final) in the request in Experiment 2.

Even though we found that children, like adults, were sensitive to both the noun and the article, children's behavior was otherwise quite different. They rarely chose the transformed object given a mismatching description (a kind label that did not match its current state). This suggests that they prioritized descriptive over grammatical information, and thus, that their behavior is better explained by DF than GF theories.

However, two issues limit this interpretation. First, we only have limited evidence that children encoded and understood the grammatical structures in our task. Rather than prioritizing descriptions, it is possible that children did not differentiate definite from indefinite articles reliably enough for them to guide reference identification. Second, there are multiple ways to interpret children's reluctance to select the transformed object in the *that initial noun* condition. It could

be driven by children requiring descriptions to match a referent, as DF theories predict, but it could also be driven by some other constraint on referential communication. A variety of studies (for a review see Doherty & Perner, 2020) have found that young children have trouble with “dual naming”, i.e. applying two distinct noun-descriptors to an object even when they both match, whether they are basic-level and superordinate terms (e.g. *rose/flower*) or two basic-level terms (e.g. *bunny/gardener*). One possibility, consistent with these findings, is that children expect objects to be referred to using only the *single best* description available. For the transformed object in the present experiment, the best (least ambiguous) descriptor would be the noun that describes its final and current state. Experiment 3 tests whether children initially employ a DF approach to reference, or else whether they avoid dual naming in particular but use grammar first when an object does not receive two distinct labels.

Experiment 3

Experiment 3 tested two questions: First, can children distinguish between the referential functions of the articles *that*, *a*, and *another* under more ordinary circumstances, when the description does not mismatch? Second, do children assume that that any matching description can be used in referential acts, or do they have a further constraint against dual naming?

Methods

To investigate these questions, we changed the final request made by Tigger, while keeping all other aspects of the task constant. We leveraged prior findings that, by age 3, children can identify referents given requests for “this one” or “that one” in the absence of informative descriptions, based on pragmatic cues about the communicator’s intent (Matthews et al., 2007). Instead of hearing a noun describing either the initial or final state, children were presented with requests that either (i) had no descriptive content (“one”) or (ii) used a superordinate descriptor (“toy”) that matched both kinds of objects. By removing the descriptive information in the *one* condition, we can probe children’s grammatical performance without interference from any descriptive content, either matching or mismatching. The *toy* condition allows us to test how children treat descriptors that match, but nevertheless fail to meet the “single best descriptor” criteria. If in Experiment 2, children avoided choosing the transformed object in the *that initial* condition because of a failure to understand the grammatical terms, we should continue to see analogous failures here, in both the *one* and *toy* conditions. If children struggled only with dual naming, they should continue to avoid the transformed object when asked for *that toy*, but not when asked for *that one*.

Participants We analyze results from a new sample of 32 children (Mean Age = 4.39 years, Range = 3.07 - 5.98 years) recruited from a database of participants at Brown University. An additional 1 child was recruited but excluded due to inattention.

Materials and Procedure All materials and procedures were identical to Experiment 2, with a crucial difference in the form of the request, which now involved either *that/[null]/another one* or *that/a/another toy* (since “a one” would be ungrammatical, no overt article was used in that condition). To aid interpretation, we change the coding for the distractor objects, calling the distractor that is of the same kind as the transformed object’s initial state the *initial noun distractor*, and the distractor that is of the same kind as the transformed object’s final state the *final noun distractor*.

Results and discussion

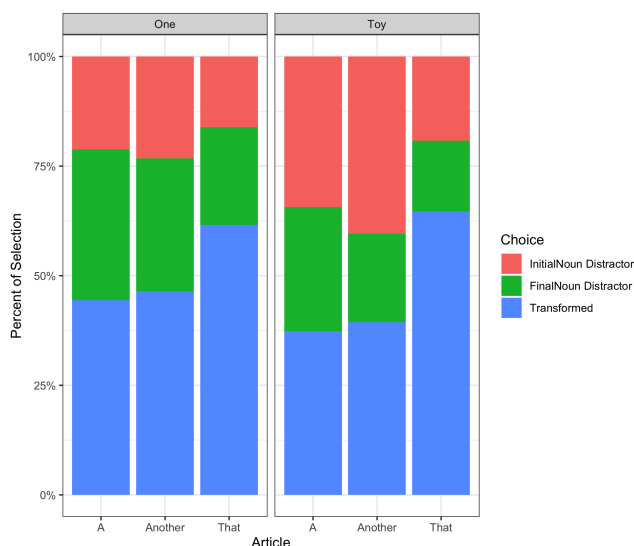


Figure 4: Children’s choices of transformed object, the final noun distractor, and the initial noun distractor by article and noun (left: One, right: Toy) in the request in Experiment 3.

Again, our modeling strategy was identical to Experiment 1, only with *toy* and *one* as the two levels of the Noun variable. Model comparisons indicated a significant effect of Article ($\chi^2(2) = 30.22, p < .001$), but no significant effects of Noun ($\chi^2(2) = 1.15, p = 0.28$) or their interaction ($\chi^2(2) = 1.88, p = 0.39$). Children chose the transformed object significantly more often when the request contained the article *that* relative to the indefinites ($\beta=0.39, z = 5.52, p < .001$), but there was no significant difference between the articles *a* and *another*. As in Experiment 2, exploratory analyses found no significant main effects or interactions with age.

The contrast between the definite article and the two indefinites provides evidence that children encode the crucial grammatical distinctions. Together with the effect of Article from Experiment 2, we can conclude that children understand and use the grammatical elements, but only as long as the descriptions match the referent. In other words, their behavior in Experiment 2 indicates that they prioritize descriptive over grammatical information, even as Experiment 3 confirms they do not disregard or misunderstand the latter.

Importantly, children also chose the transformed object at comparable rates when asked for both nouns, *toy* and *one*. This shows that children have no problem referring to the transformed object using descriptions that diverge from the final noun (calling a duck *that toy*), so long as the descriptive content currently applies to the entity. This argues against interpreting the results of Experiment 2 as the product of children's inability to accept multiple labels for a single object (Perner & Leahy, 2016; Doherty & Perner, 2020).

General Discussion

In three studies, we compared the role of descriptive and grammatical information—nouns and articles—in referential disambiguation by adults and children. Experiment 1 revealed that adults prioritize grammatical information. When the request involved the article *that*, which picks out a referent that was already established in the discourse, adults chose the transformed object – the object that was made salient immediately prior to the request. More strikingly, as long as *that* was used, they chose the transformed object when given an out-of-date descriptor – asked for “that car“, they picked the object that used to be a car, but had transformed into a duck – a result that is compatible only with *grammar-first (GF)* theories. Adults also distinguished between *a* and *another*, perhaps because they sometimes interpreted *a* as indicating indifference on the speaker's part (i.e. give me anything such that it matches the description), rather than introducing a new object. On the other hand, they almost never chose the transformed object when asked for *another*, confirming that this article always required that the referent contrast with one that has been previously established.

In contrast, children behaved very differently from adults. In Experiment 2, we found that they almost never picked the transformed object when the noun did not describe that object's final state. Experiment 3 further tested and confirmed that children at these ages do have the requisite grammatical understanding of how the definite and indefinite articles in our paradigm could be used to refer.

Additionally, Experiment 3 helped to tease apart two different kinds of expectations children could have about how descriptions refer. It contrasted two types of noun phrases: *one*, which provides no descriptive information and thus gives a clearer test of sensitivity to grammar, and *toy*, which describes all the objects on the screen truthfully – but not in the best way – to assess whether children cannot entertain dual-naming. We found that children showed a statistically robust sensitivity to the grammatical contrast given both nouns, and that they had no trouble resolving reference to the transformed object with a less-than-ideal, but still matching, descriptor (i.e. *toy*). Together, these results make it unlikely that the results from Experiment 2 were due either to a lack of grammatical understanding or confusion about dual-naming.

Is it possible to explain children's non-adultlike behavior as stemming from a non-adultlike understanding of the task, rather than a non-adultlike understanding of how language

is used to refer? For instance, could children have understood our task to be a game of *matching descriptions*, leading them to only entertain descriptive information? This seems unlikely, given that children were sensitive to grammatical information and only disregarded it when the noun did not match the referent that grammar would otherwise point to.

Another possibility is that children understand the task, but misconstrue the communicative context. If, for instance, children considered all three target objects as equally discourse-familiar, irrespective of the fact that the transformed object was verbally highlighted, the articles would not differentiate between referents. The simplest form of this explanation is ruled out by children distinguishing between requests involving definite and indefinite articles. But it is not impossible that children made that distinction in a non-adultlike manner. They might assume that definite noun phrases should refer to objects that are salient from their own first-person perspective rather than in the shared discourse. Notably, this explanation would require two stipulations: a non-adultlike construal of the context and a non-adultlike semantics for *that*. A significant body of work argues against the latter possibility (Aravind, 2018; Maratsos, 1976; Matthews et al., 2006, 2007; Rozendaal & Baker, 2008; Serratrice, 2005).

Finally, could adults and children differ in their understanding of the critical magical transformation? For instance, children could believe that the magical transformation actually involves switching one object for another rather than transforming a single object – this would make referring back to that object using the initial noun impossible. This, however, seems unlikely given prior studies that have found that 3- and 4-year-old children interpret not only causally plausible (Gelman, Bullock, & Meck, 1980), but also impossible magical transformations (Goddu, Lombrozo, & Gopnik, 2020) as acting on a single object.

More likely, these findings imply that there is more to attaining an adult understanding of referring expressions than having basic command of the relevant articles. Children must further figure out how descriptions and grammatical information interact. This raises several options for what exactly the difference between adults and children is, suggesting new directions for investigations of the relationship between descriptions and grammar in both populations. One possibility is that grammatical information and descriptive information are separate, simultaneous cues to establishing reference. If so, children would simply need to learn that grammatical information has higher priority than descriptive information, at least in contexts like ours. Alternatively, grammatical information could be qualitatively different from descriptions. According to some linguistic theories, the grammar is responsible for establishing reference by indicating entities' relationship to the discourse (new or familiar) while descriptions only have a function to restrict from the set of familiar ones (Heim, 1982; Kamp, 1981). In this case, children's non-adultlike behavior might suggest a more substantive difference between how children and adults connect words to the world.

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