ACQUIRING WORDS BEYOND THE BASIC LEVEL

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ABSTRACT

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Early word learning is characterized by mapping labels for objects to the so-called "basic" level of description, such as *dog*. This basic-level bias presents a challenge for the eventual acquisition of words that differ in semantic specificity, such as the narrower subordinate-level (e.g., *dalmatian*) and the broader superordinate-level (e.g., *animal*) nouns. Previous literature has typically treated the acquisition of these kinds of nouns as disparate problems. Subordinate nouns are often characterized in terms of the perceptual distinctiveness of their referents and thus their meanings are thought to be acquired via the convergence of physical cues from the world. By contrast, superordinate nouns are thought to be initially difficult due to the unavailability of the corresponding concepts but trivially acquired via induction upon conceptual maturity in later childhood. Of course, such views have not gone unchallenged – a parallel line of work has reported strong contributions from the language input in overcoming the basic-level bias in acquisition, raising questions about the scope of the perceptual and conceptual challenges truly posed by learning words beyond the basic level.

Building on this linguistic perspective, this dissertation develops a pragmatically-motivated framework that unifies the seemingly disparate challenges to the acquisition of subordinate and superordinate nouns. Starting from the premise that hierarchical noun meanings form a *scale* on the basis of their semantic specificity, this position predicts that the acquisition of these words is guided by the accessibility and relevance of specific linguistic-semantic alternatives that pragmatically constrain the generalization of word meanings. A series of studies tests the consequences of this pragmatic position for the acquisition and interpretation of subordinate and superordinate nouns. Beginning with subordinates, Study 1 (Chapter 2) shows that semantic alternatives modulate subordinate-level conjectures in a word learning study with adults. Similarly, Study 2 (Chapter 3) demonstrates that children also generate such contrastive inferences in word learning, and are additionally able to integrate inferences about speaker knowledge. Turning to superordinates, Study 3 (Chapter 4) shows that the distribution of superordinate nouns in the input both reflects, and

is discoverable from, their semantic-pragmatic properties. Lastly, Study 4 (Chapter 5) shows that children are sensitive to the pragmatic conditions that license when superordinate-level meanings are talked about. In conclusion, this dissertation demonstrates that the acquisition and use of words at different levels of specificity is in large part characterized by the task of reasoning about a speaker's intent in their choice of a specific word among relevant alternatives. These findings further our understanding of the pragmatic forces that shape the acquisition of hierarchical noun meanings, and the development of adult-like pragmatic competence that governs the unspoken rules of their usage.

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Chapter 1

Introduction

1.1 The subset problem in acquisition and the basic-level bias

It is well-known that languages encode nominal and other meanings at various levels of semantic specificity, including the so-called basic level (e.g., *dog*), a narrower, subordinate level (e.g., *dalmatian*), and a broader, superordinate level (e.g., *animal*) along a taxonomic hierarchy (Brown, 1976; Rosch et al., 1976; Mervis and Rosch, 1981). Though the precise criteria for drawing these distinctions vary cross-linguistically and even within a language for different meaning kinds (Brown, 1958; Ochs and Schieffelin, 1979), the universal fact that words can have completely nested meanings presents a challenge for young learners from the earliest stages of acquiring their language. This characterizes the so-called subset problem of induction (Quine, 1960): word meaning conjectures which enter into a subset-superset relationship (such as *dog* vs. *dalmatian*) are difficult to disambiguate for the child with limited evidence at their disposal. The difficulty is in part due to the fact that the semantic meanings of these words differ only in specificity (*dalmatian* is more specific than *dog*, which is in turn more specific than *animal*), but there is little observable evidence from the physical world alone for the specificity of meaning that is encoded in a word (Macnamara, 1982; Waxman, 1985; Clark, 1997; Kako, 2005). Before we discuss the problem further, a crucial distinction must be drawn between the subset problem as discussed above and a related but separate problem of referential ambiguity: the challenge of determining the object of reference situated in the physical world, helped by pointing, touching, timing, joint attention, and so on (Aslin and Smith, 1988; Baldwin, 1991, 1993; Tomasello, 1995; Trueswell et al., 2016). What makes the subset problem uniquely challenging in acquisition is that it can persist even under circumstances of referential

clarity – the same object in the world can be called many different names. The primary aim of this dissertation is thus to characterize and understand this particular challenge of determining the *specificity* of meaning encoded in a word (on the separate but related topic of reference resolution, see review in Gleitman and Trueswell, 2020).

In navigating this challenge of semantic specificity, children initially show a bias for mapping novel nouns to the basic-level meaning, as opposed to narrower (subordinate) or broader (superordinate) meanings (Rosch et al., 1976; Mervis and Pani, 1980; Markman, 1984, 1990; among others). Traditionally, the advantage of basic-level categories has been thought to be derived from the convergence of various perceptual mechanisms that give the basic level category a processing boost: members of a basic-level category (e.g., for the dog category, the different dog kinds) tend to have similar overall shapes, share a representative prototype, invite similar kinds of motor actions for a person interacting with them, and so on (see review in Murphy, 2002). On the basis of such criteria, it is also often held that basic level categories are conceptually basic, the earliest kinds to emerge over the course of a child's cognitive development (Mervis and Rosch, 1981; cf. Mandler, 2008). For example, infants as young as three months old can distinguish basic-level categories from pictures of exemplars (e.g., cats as different from birds Quinn et al., 1993; Eimas and Quinn, 1994, Quinn and Eimas, 1996). Whatever its precise nature may be, this basic-level bias is considered to be a distinct and powerful constraint on word meaning conjectures – one among many, such as the whole object bias and the mutual-exclusivity assumption (Markman, 1991) – that facilitates early word learning: nouns at the basic level are acquired first as the prime candidates for "fast mapping" (Carey, 1978) and appear early in production, before subordinate- and superordinate-level distinctions are acquired (e.g., Mervis and Crisafi, 1982; Markman and Hutchinson, 1984; Nelson, 1988). However, the bias also presents a challenge of its own: the tendency to map novel words to basic-level meanings can sometimes be so strong such that it even hinders subordinate-level and superordinate-level categorizations when a referent is labeled, compared to when no labels are presented at all (e.g., Waxman, 1990). Despite these challenges, children must eventually overcome the basic-level bias to acquire words beyond the basic level. What mechanisms facilitate this process of acquisition? And are they different for the acquisition of subordinate and superordinate nouns?

1.2 The challenge of acquiring words beyond the basic level

Studies on the acquisition of object labels for nominal kinds have typically held that subordinate and superordinate nouns are experienced by the child as different kinds of difficulties. Subordinate nouns are thought to be challenging in large part because these narrower object categories are distinguished by the most detailed and fine-grained kinds of features, as opposed to the more salient and primitive features that define the basic-level. Such features are not only difficult to discover under typical circumstances of perceptual observation, but also difficult to maintain and reinforce in memory over the course of word learning. Accordingly, mechanisms for their acquisition in recent years have been dominantly explored within the cross-situational learning paradigm to investigate the kinds of information that accrue over time to help learners narrow-in on the subordinate-level meaning from the "default" basic-level conjecture. These factors include the physical circumstances of a referent's observation (Sloutsky and Fisher, 2004; Sloutsky et al., 2007; Spencer et al., 2011; Jenkins et al., 2015, 2021), and the statistical distribution of label-referent pairings sampled from the world (Tenenbaum, 1999; Xu and Tenenbaum, 2007a,b; Lewis and Frank, 2016, 2018; Emberson et al., 2019). On the other hand, superordinate nouns are thought to be challenging fundamentally due to the abstract nature of their corresponding concepts; since members of a superordinate-level category lack obvious and cohesive perceptual correlates, they are experienced by the child as violations of perceptually-based categories that guide early concept formation and, in turn, word learning (Daehler et al., 1979; Fenson et al., 1988; Landau et al., 1988; Golinkoff et al., 1995). Thus, superordinate nouns are reportedly mastered with the emergence of more complex logical reasoning abilities that emerge in later childhood, involving profound shifts in the child's conceptual organization (Nelson, 1977; Kosslyn, 1978; Barishe and Whitehurst, 1986; Sinclair, 1986) and/or developments in metalinguistic competence that coincide with formal schooling (Denney, 1972; Brown, 1977). Under this view, superordinate nouns are simply not experienced as a mapping problem by the child during the earliest stages of word learning. This is a long-held assumption that persists even in some contemporary word learning models, which assumes the acquisition of subordinate nouns to be trivially solved via induction once the corresponding concepts become

available (Xu and Tenenbaum, 2007b; Liu et al., 2001).

An alternative perspective has emerged as a challenge to these notions, on which the language input plays a significant and necessary role in the acquisition of both subordinate and superordinate nouns (Markman, 1989; Keil, 1989; Waxman, 1990; Waxman and Hatch, 1992; Clark, 1997; Clark and Grossman, 1998; Mandler and McDonough, 2000; Diesendruck, 2005; Wang and Trueswell, 2019, 2022; Choe and Papafragou, 2023, 2025). This linguistic account builds on demonstrations of young children's sensitivity to conventions in linguistic form, such as noun compounds as a syntactic device for marking subordinate categories (e.g., Clark, 1987) and the pattern of using superordinate nouns for plural, but not singular, reference (e.g., Callanan et al., 1994). Such evidence has brought into question the extent to which the acquisition challenge is defined by child-like perceptual processes and conceptual representations. However, as noted above, much contemporary word learning research has largely jettisoned this perspective in favor of bottom-up approaches to concept formation and form-meaning mapping, assuming that such structured linguistic support in the input is sparse and noisy in the actual input to children, and that learners require considerably maturity to leverage these sources of information (Spencer et al., 2011; Huebner and Willits, 2018; Jenkins et al., 2021). Yet, for such primarily perceptual and conceptual explanations for the acquisition of these words, a puzzle remains: even if a child knows an object to be an instance of its narrower subordinate category and its broader superordinate category, the child must also know when those facts rise to the level of being talked about to successfully acquire the words for these categories. In the case of subordinate nouns, when do you talk about an object by its more specific name? In the case of superordinate nouns, when do you talk about the less specific option?

1.3 A pragmatic proposal

This dissertation builds on the above linguistic position, starting with the premise that the distribution of subordinate, basic-level, and superordinate nouns is first and foremost governed by the speaker's *choice* to *name* objects at different levels of specificity. Taking inspiration from prior theorizing of the fundamental link between a speaker's perspective and what is said (Grice, 1975; Macnamara, 1982; Sperber and Wilson, 1986; Clark, 1997; Clark and Grossman, 1998; Diesendruck,

2005; Grigoroglou and Papafragou, 2021) as well as the pervasive challenge of mapping form to meaning that underlie the task of learning words, both easy and hard (Gleitman, 1990; Bloom, 1994; Gillette et al., 1999; Gleitman et al., 2005; Papafragou et al., 2007; Gleitman and Trueswell, 2020), we hypothesize that the frequent function of object labels for naming and identifying referents in the world imbues them with distinctive qualities which both give rise to, and are discoverable from, their linguistic-pragmatic circumstances of use. Specifically, we propose that their distribution is in part governed by their pragmatic informativeness – when the situation presents many choices for labeling a referent, a label for a narrower (i.e., subordinate) category tends to be more informative, and a label for a broader (i.e., superordinate) category tends to be less informative (cf. Cruse, 1977; Levinson, 2000). In contrast, basic-level meanings are by definition preferred across many contexts of use, perhaps because – other things being equal – they are informative enough to satisfy the needs of a *generic addressee* (Brown and Dell, 1987; Lockridge and Brennan, 2002; Luce and Callanan, 2010; Grigoroglou and Papafragou, 2019b,a). From these observations, we propose that the subordinate-basic-superordinate distinction can be understood as forming a scale on the basis of informativeness, which typically aligns with the specificity of semantic meaning (Horn, 1972). Thus, a crucial task for the learner may be to discover the level of informativeness that is intended in a speaker's use of a word, to in turn reason about the level of semantic specificity that is lexically encoded in the word.

In addressing this reframing of the acquisition challenge, I posit a capacity for the young learner to form expectations about informativeness, to identify the level of specificity being talked about within a semantic domain and, more broadly, the relevant question under discussion. This task may be helped by the presence of relevant linguistic-semantic alternatives: these invoke a more restricted alternative set that can indirectly point to otherwise less accessible categories away from the basic level. Though not typically addressed in the context of pragmatic theory, this framing captures both the classic finding that prior mention of the basic-level term anchors and promotes subordinate- and superordinate-level alternatives (Shipley et al., 1983; Callanan, 1985; Gelman et al., 1989; Waxman, 1991; Waxman et al., 1997) and the more recent finding that the presence of semantic alternatives in cross-situational as well as one-shot learning modulates the strength of the basic-level bias (Wang

and Trueswell, 2019, 2022; Choe and Papafragou, 2023). In this dissertation, we synthesize these prior findings in word learning with the long literature on the development of Gricean pragmatic abilities in young children across separate but related phenomena in language development, such as sensitivity to the principle of informativeness (e.g., Papafragou and Musolino, 2003; Katsos and Bishop, 2011; Foppolo et al., 2012; Skordos and Papafragou, 2016) and perspective-taking in referential communication (e.g., Nadig and Sedivy, 2002; Nilsen and Graham, 2009; Kampa and Papafragou, 2020). The primary aim of this dissertation is thus to show the importance of such linguistic-pragmatic considerations for the case of acquiring subordinate and superordinate nouns, and to demonstrate the pervasive and non-trivial mapping challenge involved in the acquisition of hierarchical noun meanings.

The chapters that follow show, in various ways, how the acquisition of words at different levels of specificity is in large part characterized by the task of reasoning about a speaker's intent in their choice of a word among other lexical-semantic alternatives. Each chapter of this dissertation was conceived and written as a stand-alone piece of research; their contents are reproduced as-is in their published and/or journal-formatted form, minimizing alterations in formatting as much as possible. For all pieces of work presented in chapters 2 through 5, I was the first author, and led conceptualization, design, analysis, and writing.

Beginning with subordinate nouns, Chapter 2 (published in the *Journal of Memory and Language*, Choe and Papafragou, 2023) investigates how contrasting alternatives narrow the meaning of a novel label at the subordinate level. For instance, in the sentence "Look, a *wug*!" used to refer to a dalmatian in the presence of a corgi, "wug" is naturally taken to mean *dalmatian*, specifically, and not just *dog*. In a series of word learning experiments with adults, I show that this effect is primarily driven by inferences about speaker intent: learners interpret the referential contrast as a cue to a more specific word meaning, but only if they view it as relevant to the speaker's choice of label. In Chapter 3 I further develop the perspective that discovering subordinate categories for mapping onto language involves social and pragmatic reasoning about a speaker's specific perspective on an object. In a series of word learning experiments with 4-to-5-year-olds, I show that children also incorporate speaker knowledge to reason about the relevant semantic alternatives that constrain

word meaning.

Turning to superordinate nouns, Chapter 4 (published in *Language Acquisition*, Choe and Papafragou, 2025) demonstrates that the distribution of superordinate nouns – both observed (in corpora of child-directed speech) and expected (by adults, when experimentally manipulated) – is strongly associated with specific frames that highlight semantic breadth. These findings motivate the perspective that this peculiar linguistic distribution offers children an initially subtle yet eventually reliable cue for superordinate noun meanings. Lastly, in Chapter 5, I show that children judge superordinate nouns to be infelicitous when used in contexts requiring the speaker to be more specific, such as in ostensive referring to a single familiar object (e.g., "Look, this is an *animal* (when uttered about a dog)"). These data highlight a strong and predictable link between meaning and usage, and challenge prior reports of conceptual failures in children's superordinate noun learning. Combined, these findings across all chapters inform mechanisms of early word learning and offer new insights into how children integrate their linguistic and pragmatic reasoning abilities to discover meaning from language in the social world.

Chapter 2

Acquisition of Subordinate Nouns as Pragmatic Inference

2.1 Introduction

2.1.1 The challenge of acquiring subordinate nouns

Word learning is a challenging task, in part because words do not just map onto objects and events that exist in the world but rather invoke specific meanings that the speaker intends to convey in the moment. A major aspect of word learning involves identifying the level of specificity encoded by word meanings. This is especially relevant for word meanings that enter into a subset-superset relationship, such as *dog* vs. *poodle*: these meanings differ in specificity (*poodle* is more specific than *dog*) but are difficult to disambiguate using evidence from the referential world alone (Quine, 1960). Research suggests that young learners show a bias for mapping novel nouns to the so-called "basic"-level meaning (*dog*), as opposed to the narrower, subordinate-level meaning (*poodle*; Markman, 1984, 1990). The tendency to map novel words to basic-level meanings can be so strong that it even hinders the classification of a subordinate-level category when it is labelled, compared to when no labels are presented at all (Waxman, 1990). Despite these challenges, learners must eventually overcome the strong basic-level bias to acquire labels for subordinate-level categories.

Early work highlighted the role of structured linguistic support that "anchors" the basic-level category as the relevant semantic domain, after which the subordinate-level distinction is explicitly introduced (e.g., "This is a dog. It is a terrier"; Shipley et al., 1983; Blewitt, 1983; Callanan, 1985). Waxman and colleagues (Waxman et al., 1991, 1997) have also shown that this ability for basic-

level categories to serve as an anchor for inferences about novel exemplars has direct implications for the acquisition of subordinate-level categories in experimental settings. In Waxman et al. (1997), preschool-age children were presented with an exemplar from a familiar basic-level category (e.g., a dog) paired with a novel label (e.g., "nooc"), accompanied by a short description. When the exemplar was described with an enduring and generalizable attribute which explicitly contrasted with that of the broader category (e.g., "Noocs help us pull sled, not help us find birds"), children overwhelmingly arrived at a subordinate-level meaning for the novel label. This inference was absent when the attribute was not contrastive or was merely incidental (e.g., "They just took a bubble bath"), suggesting that children can use semantic contrast to generalize to the subordinate-level when they are encouraged to focus on the relevant, defining distinctions.

Other studies have shown that children can integrate such cues with additional evidence from conventions in linguistic form, such that they are even more eager to assign a subordinate-level meaning to compound nouns than simple nouns when presented in the same anchoring context, exploiting the pattern that compound nouns are often used to express subordination (Gelman et al., 1989; Clark, 1992). More generally, the morphological characteristics of basic- and subordinate-level terms reveal how a language encodes contrast between subcategories within a conceptual domain (Cruse, 1986; Lyons, 1977), and this gives rise to crosslinguistic differences in how children produce and understand linguistic cues to subordination. For example, Clark and Berman (1984) and Berman and Clark (1989) find that both English and Hebrew children as young as two years of age understand compound nouns as consisting of a head that selects the (basic level) category and a modifier that encodes a restrictive and contrastive information (cf. "dalmatian-dog" in English). However, Hebrew children produce novel compounds at a later age due to the availability of other linguistic devices to express subordinate-level contrast such as affixation, which is also the preferred form for adult speakers of the language (Berman and Clark, 1989; Clark and Berman, 1987).

Even though carefully designed linguistic support can provide a helpful cue for subordination, others have argued that it is not necessary to rely on such richness of input in child-directed speech as the primary mechanism for the acquisition of subordinate nouns. Instead, it has been proposed that attending to the physical circumstances of a referent's presentation in the perceptual world

(e.g., Spencer et al., 2011; Jenkins et al., 2015, 2021) or to the distribution of label-referent pairings in the input (e.g., Xu and Tenenbaum, 2007a,b; Lewis and Frank, 2016, 2018) is sufficient for the learner to shift away from the basic-level hypothesis for a word's meaning, especially when the evidence accumulates across situations. For example, one class of accounts propose that the acquisition of subordinate nouns can be captured largely via bottom-up perceptual and memory mechanisms, without needing to invoke rational processes Spencer et al., 2011; Jenkins et al., 2015, 2021. Under this view, objects are construed at the basic or subordinate level via the style in which they are presented (i.e., circumstances of observation). For example, if three dalmatians are presented to the learner simultaneously with each labelled "fep," the close proximity of exemplars invites discrimination and enhances memory for fine-grained features that are shared (e.g., black spots); these happen to be the features that define a dalmatian, resulting in a subordinate-level interpretation of "fep" as meaning *dalmatian*. However, if the same three dalmatians are presented sequentially across space and time, the most detailed features decay and learners are only able to maintain a coarse-grained category defined by the more "global" features (e.g., has a tail and four legs); these happen to be the features that define the basic-level category *dog*. In this sense, it is the referential world which presents objects at the subordinate- and basic-level, and the task of the child is to discover the dalmatian-ness and dog-ness of exemplars from the world via a largely bottom-up strategy.

A second class of accounts building on Bayesian models of word learning (e.g., Frank et al., 2009) capitalize on the sheer number of examples for acquiring subordinate-level meanings through a mechanism of rational inference over sampling processes. This is formalized in the so-called *size principle* (Tenenbaum, 1999), which assigns the highest probability to the most restrictive hypothesis that is consistent with the data, which becomes increasingly more likely with more data. For a learner, a bigger category (like the basic-level category *dog*) is more likely to be used for any referential expression *a priori* due to its larger size in the conceptual space, so it is assigned a higher *prior* than a narrower category (like the subordinate-level category *dalmatian*) which is consistent with a smaller subset. But for the same reason, the *likelihood* of repeatedly observing exemplars consistent with a narrower subordinate-level meaning is much greater when assuming

the subordinate-level meaning rather than the basic-level meaning. Thus, when learners encounter multiple exemplars consistent with a subordinate-level meaning, they capitalize on the "suspicious coincidence" of that arrangement to infer that the word most likely means the subordinate-level category as opposed to the basic-level category (Xu and Tenenbaum, 2007b; Lewis and Frank, 2018). In this way, the model formalizes a kind of rational inference over a conceptual space of possible word meanings, given the data.

Despite their differences, both the bottom-up and the suspicious coincidence kinds of accounts treat exemplars with a target (subordinate) label as the fundamental unit of evidence for the learner: what matters for the acquisition of subordinate nouns is the number of such labelled exemplars, their distribution, presentation style and so on. However, this premise has recently been challenged by reports that the basic-level bias can be strongly modulated by the presence of other exemplars in the task. In a series of cross-situational word learning experiments, Wang and Trueswell (2019, 2022) found that adults and three-to-five-year-old children overwhelmingly generalized the meaning of a novel label to the basic-level exemplars (e.g., dogs) even when the label exclusively co-occurred with exemplars consistent with a narrower subordinate-level meaning (e.g., dalmatians). Instead, the crucial determinant for subordinate-level generalizations was the simultaneous learning of a second label when that label was paired with other members from the same basic-level category (e.g., non-dalmatian dogs). Critically, this effect disappeared when the second label was paired with members from a different basic-level category (e.g., birds), suggesting that learners generate task-specific inferences about which category levels are being highlighted in an ostensive labelling event, independently of the information about the distribution of the target label. In other words, there appears to be a strong contribution of other exemplars even in low-context, cross-situational word learning paradigms. Therefore, understanding the acquisition of subordinate nouns requires explanations beyond the number of exemplars, the spatiotemporal dynamics of the learning event, and the like.

2.1.2 The acquisition of subordinate nouns as a pragmatic puzzle

This paper begins with the assumption that learners make pragmatically driven inferences about the hypothesis space over which possible word meanings are proposed and evaluated (for a review of the evidence, see Grigoroglou and Papafragou, 2021). Within this context, we view the acquisition of subordinate nouns as posing a specific kind of pragmatic puzzle. Unlike accounts that frame the acquisition of subordinate-level nouns as a question of how various cues apparent in the physical world interact and converge on a specific concept, we ask under what discourse contexts learners *expect to hear* a label with a narrower meaning. We propose that the crucial task for the learner is to discover the intended level of informativity that is assumed in the labelling event (Grice, 1975; Clark, 2017). Under this framing, the meaningful difference between basic- and subordinate-level categories is not in the inherent size of the area that they carve up in the conceptual space. Rather, the distribution of basic- and subordinate-level labels is primarily governed by speaker intent, which makes it first and foremost a linguistic act.

When the situation presents many choices for labelling a referent, a label for a narrower category (e.g., the subordinate-level category) is typically the more informative one (Murphy and Brownell, 1985; Rosch, 1978). Yet basic-level meanings are by definition preferred across many contexts of use, perhaps because – other things being equal – they are informative enough to satisfy the needs of a generic addressee (Brown and Dell, 1987; Lockridge and Brennan, 2002; Grigoroglou and Papafragou, 2019b,a). For such word meaning conjectures that enter into a subset-superset relationship, a subordinate meaning is only recognizable when the learner needs to consider a more informative (and crucially, *relevant*) level of describing a referent (versus the basic-level alternative). Thus, we predict that the acquisition of subordinate nouns should benefit from contexts that highlight the relevance of being more informative than usual. This is where contrast can help: the choice of a contrastive label can invoke a more restricted alternative set and indirectly point to otherwise less accessible subordinate-level categories and away from more accessible basic-level categories. Even though not typically studied in the context of pragmatic theory, both the classic finding that prior mention of the basic-level term anchors and promotes a subordinate alternative (Gelman et al., 1989; Waxman, 1991; Waxman et al., 1997) and the more recent finding that the

presence of semantic alternatives in cross-situational learning modulates the strength of the basic-level bias (Wang and Trueswell, 2019, 2022) can be understood as addressing this common task of identifying the relevant level of informativeness within a semantic domain with respect to which the utterance is to be interpreted.

The general idea that contrast facilitates conjectures at the subordinate-level is, of course, not new, given the known role of contrast in language acquisition (Markman, 1984, 1990). For example, Clark's (1987, p.2) Principle of Contrast states that "any difference in form in a language marks a difference in meaning," and has been proposed as the driving force allowing learners to discover new mappings between concept and form, for learning word meanings and beyond. The role of alternatives in facilitating inferences that are normally difficult to access has also been extensively explored in the scalar implicature literature. For example, we find a striking parallel to the study of young children's difficulty with generating the pragmatic interpretation of "some" as meaning "some but not all" (Noveck, 2001; Papafragou and Musolino, 2003). This difficulty has sometimes been argued to reflect children's limitations in processing (Guasti et al., 2005; Tieu et al., 2015), similar to how the task of learning subordinate-level categories has been treated by some in the literature on word learning (e.g., Ross and Murphy, 1996; Sloutsky et al., 2007; Sloutsky, 2010). For present purposes, we note that, when the stronger alternative "all" was introduced in a prior context, children were more successful in generating the pragmatic 'not-all' interpretation of "some" – but only when that alternative was relevant for the purpose of the conversation (Barner et al., 2011; Skordos and Papafragou, 2016). Furthermore, children arrived at the 'not-all' interpretation of "some" even when previously exposed to "none" (versus "all"; Skordos and Papafragou, 2016), further suggesting that establishing the relevance of the appropriate scale, not necessarily the accessibility of a particular stronger alternative, is key to computing scalar implicatures. In other words, despite the fact that "none" itself was not intended as an actual alternative of "some" in the scene, it nevertheless constrained children's search for the intended meaning of "some" by making quantification expressions salient alternatives within the discourse context. Relatedly, older children have been shown to even integrate evidence about the epistemic state of a speaker to make such inferences, by reasoning about the informational strength of a statement given a speaker's possibly

limited knowledge state (Papafragou et al., 2018; Kampa and Papafragou, 2020).

In the present study, we explicitly set out to investigate the acquisition of novel subordinate nouns as a pragmatic task. Our goal is to go beyond previous cross-situational word learning research on the acquisition of subordinate nouns, where the role of pragmatic inference was not explored systematically. To do so, we devise new tasks to investigate the role, limits, and potency of semantic contrast in adult learners' basic- vs. subordinate-level generalization of novel words from single learning trials. We posit that a communicative act gives evidence for the meaning of a word, because it affords the learner some insights about the informativity encoded in the word (depending on whether a speaker's intent is to be more specific as reflected in their choice of a subordinate-level noun, as opposed to the basic-level alternative).

In four word learning experiments, we raise and test three interlocking predictions of the above pragmatic position. First, we predict that the presence of a semantic alternative at the subordinate-level should facilitate subordinate-level conjectures for a target label (assuming that the presence of the alternative makes it clear that the more informative, subordinate-level categories are relevant to the task). Accordingly, Experiment 1 asks whether the rate of basic-level generalizations for an ostensive target label (e.g., "mipen" paired with a red apple) decreases if the target is immediately followed by a labelled semantic alternative at the subordinate level (e.g., "kalmick" paired with a green apple). Second, we hypothesize that this effect of contrast should be primarily linguistic, as opposed to merely conceptual (see also Clark, 1987, 1988, 1990). Accordingly, Experiment 2 asks whether the effect of contrast is stronger when the alternative is labelled rather than simply present but unlabelled. Third, we predict that these inferences about contrast and alternative sets need not be limited to the introduction of labelled referents in ostensive contexts; a word meaning conjecture can be revised and updated outside of the "official" point of referent introduction, if the learner discovers the speaker's intent to be more specific in the use of the word. Thus, Experiment 3 explores whether the use of a word beyond ostensive labeling statements can be construed as additional evidence for (the specificity of) its meaning. Lastly, Experiment 4 replicates the semantic contrast effect under input from an unfamiliar language, which more closely mimics the natural circumstances of early word learning. In concluding, we consider alternative interpretations of our findings and

discuss the implications of our data for word learning more broadly.

2.2 Experiment 1

2.2.1 Participants

Fifty-three English-speaking adults participated in Experiment 1. Sample size was informed by prior experiments measuring the basic-level bias using the grid paradigm (around 50 in Spencer et al., 2011; Lewis and Frank, 2016, 2018; Wang and Mintz, 2018; Wang and Trueswell, 2022). Participants were recruited from the undergraduate subject pool at the University of Pennsylvania (n=26) and on Prolific (n=27), a platform for online subject recruitment.[1] The experiment was hosted and conducted online via PCIbex (Zehr and Schwarz, 2018).

2.2.2 Materials and Procedure

To study learners' generalization of word meanings, we adopted the test-grid paradigm (also called the Immediate Generalization Paradigm; Caplan, 2022), a standard experimental design in the literature on the acquisition of subordinate nouns (Xu and Tenenbaum, 2007a,b; Spencer et al., 2011; Jenkins et al., 2015, 2021; Lewis and Frank, 2016, 2018; Wang and Trueswell, 2019, 2022; among others). In this task, learners are given an unambiguous referent-label mapping as an opportunity to learn a target label, after which they are presented with an array of images (presented simultaneously, often in a grid layout) and asked to select all images that match the label. The makeup of the set of images used at test is such that the previously observed referent is simultaneously a member of multiple hierarchical categories (often at the subordinate, basic, and superordinate levels). Thus, the choice of selection at test can reveal which specific meaning the learner generalized the meaning of the novel label to.

In Experiment 1, we used the test-grid paradigm to probe word meaning generalizations from a single exposure to a label. There were ten trials: eight critical trials and two catch trials which tested for attention and color vision deficiency. The eight critical trials involved novel words from

[1] Later comparisons showed that data from the two groups were identical.

eight superordinate-level domains (e.g., fruits, animals, vehicles, etc.), and all words were taught once using a single image of the referent.

Each trial was divided into the *learning phase* and the *testing phase*. Images from eight distinct "semantic domains" (i.e., superordinate-level categories) corresponding to each critical trial were prepared. The domains were balanced in the number of natural (e.g., fruits) and artifact (e.g., cars) kinds. For each domain, a total of fourteen images of single exemplars were created. Twelve of these images (all set against a naturally occurring background) were used in the testing phase: two were from the target subordinate category (e.g., red apples), two from an alternative subordinate category (e.g., green apples), three other members from the same basic category (e.g., other apples), and five members from other basic-level categories within the same semantic domain (e.g., non-apple fruits). The remaining two images – one additional member from each of the two subordinate-level categories – showed the exemplar without a background and were used in the learning phase.

At the beginning of the experiment, a cartoon character, Sally, appeared on the center of the screen and introduced herself as a foreign language speaker. Before proceeding to the trials, Sally told participants that they would be learning words from her native language and that they should pay attention as she would ask questions about these words later. All communication from Sally was delivered in written form, appearing in a speech bubble.

The learning phase began with Sally on the screen by herself for one second, after which objects appeared at Sally's sides one-by-one. When the learning phase introduced two objects, one appeared to the left and then the other appeared to the right of Sally. When the learning phase only introduced one object, it appeared once to the left of Sally. Only one object was visible at any given time and each object stayed on screen for seven seconds while Sally labelled the object.

We manipulated the presence of a semantic alternative in two conditions in a within-participant design. In the *No Contrast* condition, only the target was shown and labelled (Figure 2.1 top panel). In the *Contrast* condition, the target was followed by a semantic alternative at the subordinate-level with a different label (Figure 2.1 top then bottom panel). In effect, participants learned one novel word (the target) in *No Contrast* trials and two novel words (the target and alternative) in *Contrast* trials. After all object(s) had been presented, the learning phase concluded with Sally returning

back to the upright position for one second before the trial moved on to the testing phase.

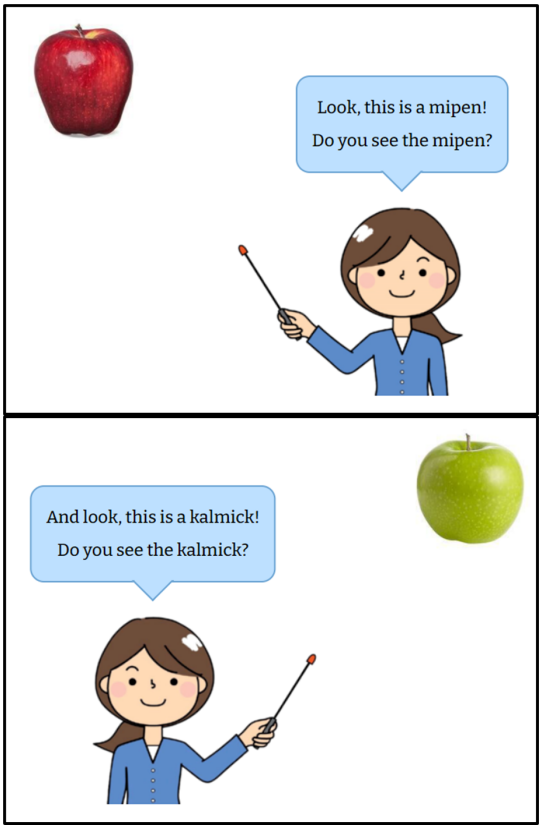

Figure 2.1: Presentation of the target (red apple, "mipen", top panel) and the alternative (green apple, "kalmick", bottom panel) in the learning phase of the *Contrast* condition in Experiment 1. In the *No Contrast* condition, only the target was shown and labelled, as in the top panel.

In the testing phase of each trial, eighteen images were presented in a 3-by-6 grid (Figure 2.2). Each image was placed inside a 150-pixel square cell with 15 pixels of row and column gaps. The grid included two matches to the target subordinate category, two matches to the alternative subordinate category, three other matches to the basic category, three matches to the superordinate category, and eight non-matches (i.e., members of other superordinate categories). The images were laid out in the grid in randomized order between design groups. Figure 2.2 shows an image grid from the test phase for the fruit domain, where participants are asked to find matches to the label paired with a red apple ("mipen") in the learning phase.

Figure 2.2: Images shown in the testing phase for a trial involving the fruit domain. Selections representing the basic-level generalization (all apples) are marked with a blue outer border and selections representing the target subordinate-level generalization (red apples) are marked with an additional inner yellow border.

Sally instructed the participants to select all matches for a novel label introduced in the learning phase. For example, if the target label was "mipen" paired with a red apple in the learning phase, Sally asked participants: "Do you see any other mipens below? Click on all mipens you see!". Participants interacted with the image grid by clicking one image at a time. The testing phase was not timed, and participants could freely select and unselect any images as many times as they wished, as long as at least one image was selected before proceeding. The final set of selections as well as the target and timestamp of individual clicks made in the testing phase were recorded for analysis.

2.2.3 Coding

For each trial-level response, the final set of selections at test was coded into one of three categories: Subordinate, Basic, and Other. A response was coded as Subordinate ("mipen" means red apple) if it reflected a narrow generalization to only the subordinate-level category (e.g., both the red apples and no other images selected). Responses were coded as Basic ("mipen" means apple) if they included both subordinate target exemplars as well as all other members from the basic-level

category (e.g., all apples, including both the red apples and the five other kinds of apples). Consistent with prior work, we applied a strict coding criterion such that partial selections of members from the subordinate- and basic-level categories were excluded from the count for Subordinate and Basic responses.[2] Instead, these were coded as Other, a catchall category consisting of responses where participants selected at least one of the subordinate-level exemplars but otherwise did not exhibit the intent to generalize to a particular noun category (such as selecting all red objects or all apples except the green apple alternative; for details on Other responses for all experiments, see section A.1). The coding scheme also included Superordinate responses (e.g., all fruits), but none were observed in any of our experiments. Lastly, selections which included exemplars from other semantic domains (e.g., a planet) or failed to include any of the target subordinate-level exemplars (e.g., included no red apples) were judged to reflect inattentiveness and were excluded from analysis.

2.2.4 Results

Data from three participants who answered incorrectly on the two catch trials were discarded. Additionally, 12 trial-level responses were excluded because the selections included exemplars from other semantic domains. In total, 388 responses from the remaining 50 participants were entered into the analysis. The distribution of these responses is shown in Figure 2.3.

[2]Throughout our experiments, even if we were to include these more lax coding categories into the analyses, our results would not change.

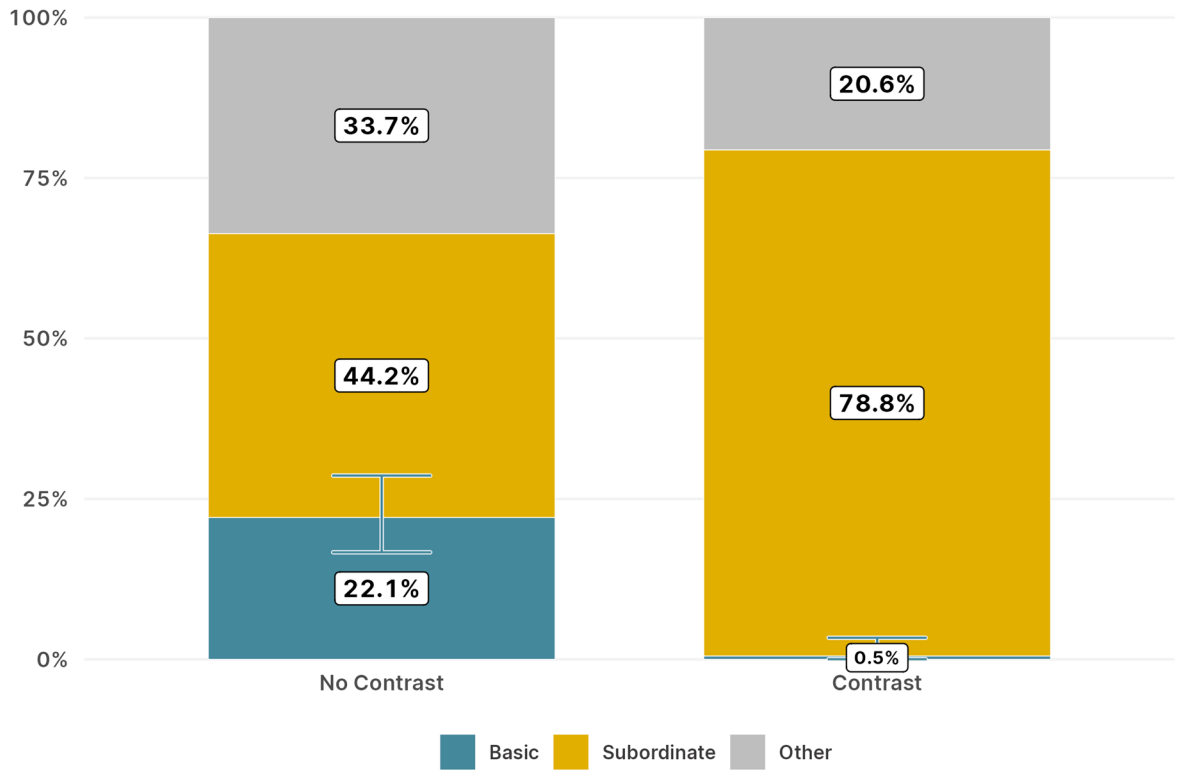

Figure 2.3: Responses at test for Experiment 1.

Following previous experimental work on the acquisition of subordinate nouns (e.g., Lewis and Frank, 2016, 2018; Wang and Trueswell, 2019, 2022), we first conducted an analysis of Basic responses. We fitted a mixed-effects logistic regression model to the rate of Basic responses using the lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages in R (R Core Team, 2021). The model summary is shown in Table 2.1.[3] We found a significant difference in the proportion of Basic responses between the *Contrast* condition and the *No Contrast* condition (β = -2.26, SE = 0.5, p $<$ 0.0001; Table 1), with Basic responses decreasing from 22% to 0.5% when a semantic alternative with a different label was present. A subsequent analysis confirmed that this difference was also reflected in the same model fitted to the proportion of Subordinate responses, where Condition had a similar effect in the opposite direction (β = 0.84, SE = 0.13, p $<$ 0.0001), increasing Subordinate responses from 44% in the *No Contrast* condition to 79% in the *Contrast*

[3]Model formula: Basic ~ Contrast + (1 | Participant) + (1 | Item). Contrast was sum coded with *Contrast* at 1 and *No Contrast* at -1

condition.

Table 2.1: Mixed-effects logistic regression model fitted to Basic responses in Experiment 1

	β (SE)	t	p
(Intercept)	-4.04 (0.8)	5.4	<0.0001
Contrast	-2.26 (0.5)	–4.3	<0.0001

2.2.5 Discussion

We proposed that a crucial task for the acquisition of subordinate nouns is to discover the intended level of informativity or specificity assumed of the labelling event. Consistent with our prediction that a semantic alternative at the subordinate-level makes the less-accessible subordinate-level distinction relevant to the conversation, we find that the presence of the alternative facilitates subordinate-level generalizations, suggesting that learners expected a greater degree of specificity encoded in the target label. In other words, reasoning about the role of the semantic alternative in the choice of the target label makes accessible the vertical contrast between the subordinate- and basic-level meanings for the target label and highlights its relevance in the learning context. Crucially, we achieve this effect from a single encounter with the target noun without explicitly grounding (or "anchoring") the space of possible meanings within the basic-level semantic domain (e.g., Waxman, 1991; Waxman et al., 1997) nor including multiple observations of referent-label pairings for the target label (e.g., Xu and Tenenbaum, 2007a,b; Lewis and Frank, 2016, 2018). This effect cannot be accounted for by either bottom-up or "suspicious coincidence" models of subordinate word learning, since the semantic alternative does not contribute to either the perceptual (e.g., Spencer et al., 2011; Jenkins et al., 2015) or the distributional (e.g., Xu and Tenenbaum, 2007b; Lewis and Frank, 2016) profile of the target label itself.

Additionally, we observed two somewhat unexpected patterns. First, the rate of Basic responses was low, both on the absolute scale and compared to Subordinate responses. Empirically, the magnitude of the basic-level bias has been reported to vary widely, putting 22% on the low end but still comparable to that of other studies.[4] This result might be related to the high threshold for a

[4]For example, Jenkins et al. (2015) reports the magnitude of the Basic-level bias to be 26% in their "single

Basic response in our design: both of the target subordinate-level exemplars (e.g., dalmatians) plus all five other members from the basic-level category (e.g., other dogs) had to be selected for such a response as opposed to two or three basic-level exemplars in prior work (Xu and Tenenbaum, 2007b; Spencer et al., 2011; Lewis and Frank, 2018; Wang and Trueswell, 2022). Second, and relatedly, the rate of Other responses was relatively high, with a distribution that differed substantially between conditions. Of the 67 Other responses in the *No Contrast* condition, two-thirds were incomplete subsets of the Basic response (i.e., a selection of both subordinate targets and some but not all of the five basic-level exemplars), partially explaining the overall low rate of Basic responses.[5] Interestingly, these responses are entirely absent among the 39 Other responses in the *Contrast* condition. Instead, over half of these were the so-called "mutually exclusive" responses (Gelman et al., 1989), which included all basic-level members except the two from the alternative subordinate-level category (e.g., all apples except for the two green apples).[6] We return to these points in later discussion.

2.3 Experiment 2

Experiment 1 offered strong evidence for the role of lexical contrast in promoting subordinate-level conjectures. However, the precise role of contrast is currently open to two interpretations. One possibility is that this effect is limited to (or more strongly connects to) linguistic contrast. This is consistent with our pragmatic account: unlabeled exemplars should not invoke alternative word meanings for the target label, since that they do not constitute evidence for intent underlying

exemplar" trials, which is equivalent to the *No Contrast* condition of Experiment 1. For more comparison, Spencer et al. (2011) reports the magnitude of the bias ranging from 30% to 50% while the estimate from Xu and Tenenbaum (2007b) is higher at 76% in one of the experiments.

[5]Under more liberal schemes which account for partial selections of the basic-level set (e.g., Lewis and Frank, 2016, 2018), the proportion of Basic response in the No Contrast condition increases to approximately 40%, closer to the empirical average for the magnitude of the basic-level bias measured using this paradigm.

[6]While both "incomplete Basic" and "mutually exclusive" responses reflect a failure to generalize to the basic-level category, we make this distinction because the source of the error differs. The "incomplete Basic" responses are likely to be driven by the failure to identify the appropriate basic-level category to generalize to. In the case of "mutually exclusive" responses, however, the basic-level category is correctly identified but participants nevertheless pursue a narrower interpretation which excludes the semantic alternative. Notably, none of the "incomplete Basic" selections in the *No Contrast* condition pattern like the "mutually exclusive" selections in the *Contrast* condition (e.g., no participants selected all apples except for the two green apples after seeing a single red apple labelled in the learning phase).

the specific choice of the target label (cf. also Clark, 1987). A second possibility is that the simple presence of an alternative, subordinate-level referent suffices for making subordinate-level meanings accessible by offering a perceptual contrast that highlights subordinate-level distinctions. This possibility is reminiscent of the position that the arrangement of objects in the world (along with other bottom-up cues) has consequences for the generalization of word meaning (Spencer et al., 2011). Experiment 2 was similar to Experiment 1 but sought to adjudicate between these possibilities by disentangling the effect of labelling from the mere presence of the alternative referent.

2.3.1 Participants

Ninety adults who did not previously participate in Experiment 1 were recruited on Prolific. Sample size was approximately doubled from Experiment 1 to test the statistical significance of the two main effects (but not the interaction effect) in the more complex 2-by-2 design.

2.3.2 Materials and Procedure

Participants were exposed to two conditions in a within-subject design (Figure 2.4). The *Labelled Alternative* condition replicated the Contrast condition of Experiment 1. In the *Unlabelled Alternative* condition, the alternative was present but not labelled: Sally simply drew attention to the object by saying, "(And) look over here! Do you see this?" To guard against possible presentation effects, the order in which the target referent appeared relative to the alternative referent was counterbalanced (*Target First* vs. *Target Second*).

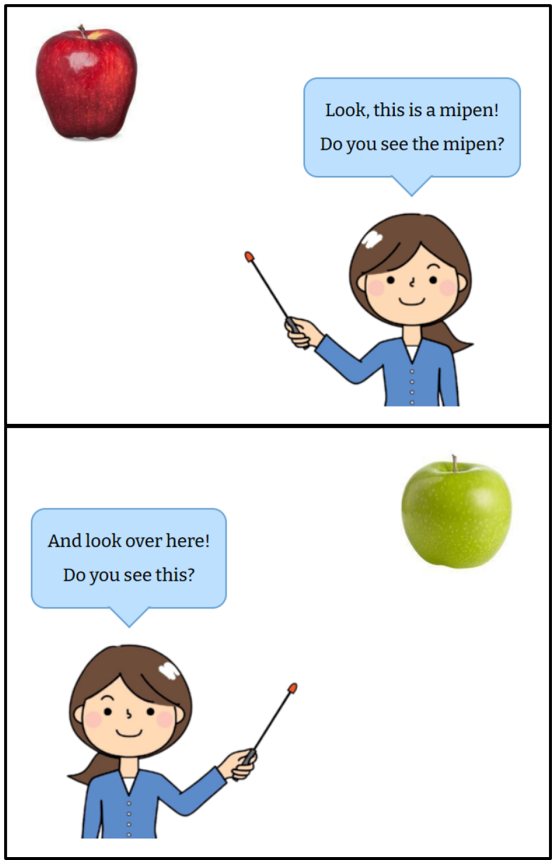

Figure 2.4: Presentation of the target (top panel) and the alternative (bottom panel) in the *Unlabelled Alternative* condition of Experiment 2. The *Labelled Alternative* condition is the same as in Figure 2.1.

2.3.3 Coding

Because participants saw both the target and the alternative in the learning phase for all critical trials, the coding scheme followed that of the *Contrast* condition in Experiment 1.

2.3.4 Results

After applying the same filtering criteria as in Experiment 1, 669 responses from 86 participants entered the analysis. Results are shown in Figure 2.5.

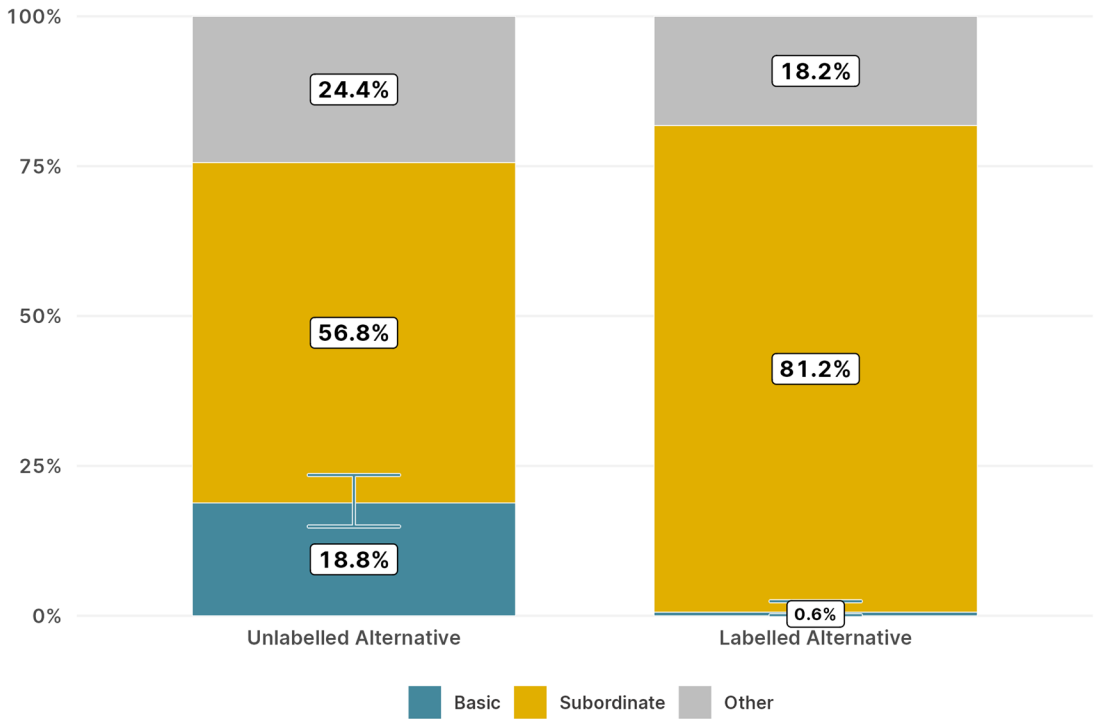

Figure 2.5: Responses at test for Experiment 2.

We fitted a mixed-effects logistic regression model to the rate of Basic responses using the (Bates et al., 2015) and (Kuznetsova et al., 2017) packages in R (R Core Team, 2021). The model summary is shown in Table 2.2.[7]

Table 2.2: Mixed-effects logistic regression model fitted to Basic responses in Experiment 2.

	β (SE)	t	p
(Intercept)	–7.6 (1.7)	–4.5	<0.0001
Label	–2.7 (0.5)	–5.3	<0.0001
Order	2.5 (0.9)	2.9	0.0033

We found a significant main effect of Label ($\beta = -2.7$, SE = 0.5, $p < 0.0001$) such that there was an overall lower rate of Basic responses when the alternative was labelled compared to when it was simply present and unlabelled. There was also a main effect of the Order nuisance variable ($\beta =$

[7]Model formula: Basic ~ Label + Order (1 + Order | Participant) + (1 | Item). Both predictors were sum coded. The interaction effect could not be estimated with the model's logit link function because no Basic response was observed in the condition crossing *Labelled Alternative* and *Target Second* conditions.

2.5, SE = 0.9, p < 0.01), indicating that the basic-level interpretation of the target label was more likely when the target was shown first in the learning phase, before the alternative was introduced. Similar to Experiment 1, we found that this difference in Basic responses between the conditions was straightforwardly reflected in the rate of Subordinate responses, which increased from 57% to 81%. In the same model fitted to Subordinate responses,[8] the effect of Label was again significant (β = 2.3, SE = 0.42, p < 0.0001).[9]

2.3.5 Discussion

Experiment 2 investigated the nature of the semantic contrast effect that constrains the generalization of word meanings. We found that the presence of a linguistically marked alternative at the subordinate-level category was more likely to facilitate subordinate-level generalizations of the target label compared to the presence of a mere conceptual alternative (*Unlabelled Alternative*). This finding is consistent with the proposal that *linguistic* – and not mere conceptual - contrast drives informativity calculations (see also Clark, 1987).

Two additional observations are in order. First, we found an effect of presentation order. This effect is consistent with prevailing hypothesis-testing models of word learning, whereby a learner could initially posit a basic-level interpretation of the target label, which may or may not be revised upon encountering the semantic alternative (Trueswell et al., 2013; Stevens et al., 2017), especially if the labelled target is understood as introducing a basic-level category with respect to which the following (alterative) referent is to be interpreted (Waxman, 1991; Waxman et al., 1997). Second, as in Experiment 1, generalizations to the basic-level category were overall infrequent in Experiment 2, perhaps because of our strict coding criterion for Basic responses. Indeed, just as in Experiment 1, "incomplete Basic" responses in which some but not all basic-level exemplars were selected from the

[8]The model formula is the same as the model for Basic responses, but with the correlation term removed in the subject random effects. The Bonferroni correction for multiple comparisons has been applied to the reported p-value.

[9]Because the semantic alternative was always present across both conditions, we were able to inspect the distribution of "mutually exclusive" responses under different training conditions, as first observed in the Contrast condition of Experiment 1. These responses constituted less than 10% of Other responses in the *Unlabelled Alternative* condition, but over 50% of Other responses in the *Labelled Alternative* condition. While the mechanism driving these "mutually exclusive" responses is unclear, they pattern specifically with the labelling of the semantic alternative, not just its presence, suggesting that these "mutually exclusive" interpretations are specific to the processing of linguistic, as opposed to conceptual, contrast.

grid (now classified under Other) were just as frequent as the more strictly coded Basic responses. We revisit this issue in the next experiment.

2.4 Experiment 3

If, as we have proposed, the acquisition of subordinate nouns crucially involves assuming that the speaker was informative in using a word, then *any* context in which the word is used can also provide important clues to the specificity of meaning it encodes. Beyond the presence of a semantic alternative within the learning phase, as in Experiments 1 and 2, other evidence that highlights the relevance of narrower semantic categories might promote subordinate conjectures. Thus, in Experiment 3 we asked whether the presentation of images and questions *at test* may itself implicitly set up expectations about the specificity of a novel word's meaning.

Within the test-grid paradigm, the idea that expectations about informativity may matter after learners posit their initial hypothesis for word meaning may appear counterintuitive. This is because the paradigm implicitly assumes that testing a word meaning conjecture is benign and insulated from the rest of the exchange. Indeed, the possibility that information beyond the brief moment of exposure to a label has consequences for word learning is unexpected under many accounts of the acquisition of subordinate nouns, as the use of a word in non-labelling contexts is not considered additional evidence for word meaning (Spencer et al., 2011; Lewis and Frank, 2018; among others). However, our account, along with findings from Experiments 1 and 2, challenges the assumption that learning is put on hold when learners are asked a question at test about the meaning of a word. Instead, we assume that effects of contrast on subordinate-level conjectures can appear even at the test phase as the learner considers what the speaker might have in mind within a set of possible meanings.

To probe this idea, we adopted the basic design of Experiment 1 (*Contrast* and *No Contrast* conditions) but made several changes to the test phase. First, we deconstructed the test-grid into a sequence of forced-choice trials (one for each image), so as to get a clearer picture of how learners reason through the choice of generalizing a word's meaning as they navigate the generalization set with each new exemplar. Second, to examine how learners make inferences about contrast

at test to guide expectations about what the speaker might have in mind, we manipulated the order of exemplars in the test sequence. We expected the order to shape the course of word meaning generalization, under the assumption that the basic- and subordinate-level exemplars from the generalization set differ in highlighting the relevance of the less-accessible vertical contrast between basic- and subordinate-level meanings (see also Skordos and Papafragou, 2016 on the role of alternative order in scalar inference). For example, inviting learners to respond to the subordinate-level exemplars first and withholding the basic-level exemplars until later may shift their hypothesis to a narrower category, as the speaker's emphasis on members from the same subordinate-level category is odd assuming a basic-level meaning of the word. On the other hand, inviting learners to consider the inclusion of other exemplars from the basic-level category first may not have such an effect, as the basic-level is the preferred (generic-addressee) level of informativity. Thus, being tested with basic- versus subordinate-level exemplars first may give rise to different inferences about the level of specificity encoded in the word.

2.4.1 Participants

One hundred adults of the same demographic background who did not previously participate in Experiments 1 and 2 were recruited on Prolific. The analysis for Experiment 3 tested the statistical significance of the two main effects in a 2-by-2 design, so the sample size followed that of Experiment 2.

2.4.2 Materials and Procedure

Experiment 3 replicated the within-subject learning conditions of Experiment 1 (*Contrast* and *No Contrast*) but made three changes to the design of the test phase. First, the simultaneous presentation of the grid of images at test was replaced with a sequential presentation of each image. In this new sequential design, participants were instructed to indicate whether each image matched the target label from the learning phase (e.g., "Is this a kapsin?") using keypresses, under a five-second timeout (Figure 2.6).

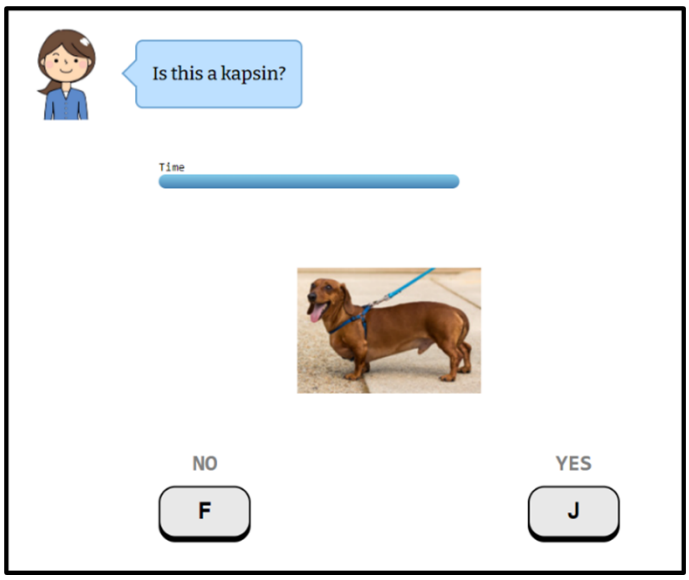

Figure 2.6: Sequential design for Experiment 3 test phase.

Second, we crossed the presence of a semantic alternative (*Contrast* vs. *No Contrast*) in the learning phase with an additional Test Sequence manipulation over the order in which the basic- and subordinate-level exemplars were presented in the test phase. In the *Basic First* condition, learners had to determine whether the label generalized to the three other basic-level exemplars first, before seeing the two matches to the target subordinate-level category. In the *Subordinate First* condition, the blocks of basic- and subordinate-level exemplars were presented in reverse order. The sequence of exemplars presented in the test set for the two conditions are shown in Figure 2.7. Recall that the coding of both Basic and Subordinate responses requires the learners to accept at least the target subordinate-level exemplars at the test phase; we now manipulated the point at which responding to these target trials happens within the testing sequence – before (*Subordinate First*) or after (*Basic First*) being presented with other exemplars from the basic-level category.

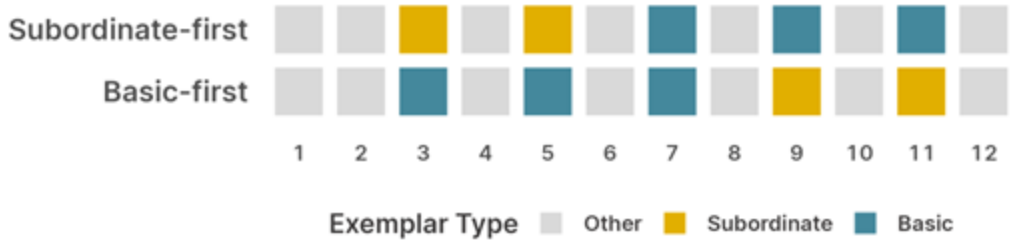

Figure 2.7: Sequential presentation of exemplars at test phase of Experiment 3 (with Test Sequence manipulation).

Lastly, the number of exemplars in the test phase was reduced from 18 to 12 to alleviate the sequential test phase's demands on working memory. This reduced set maintained the relative proportion of exemplar types, including two matches to the target subordinate-level category and three other basic-level matches (in the *Contrast* condition, one of these was a member of the alternative subordinate-level category).

2.4.3 Coding

The same coding scheme was used to categorize responses as in Experiments 1 and 2.

2.4.4 Results

After applying the same filtering criteria from the previous two experiments, 776 responses from 97 participants entered the analysis. The distribution of these responses is shown in Figure 2.8.

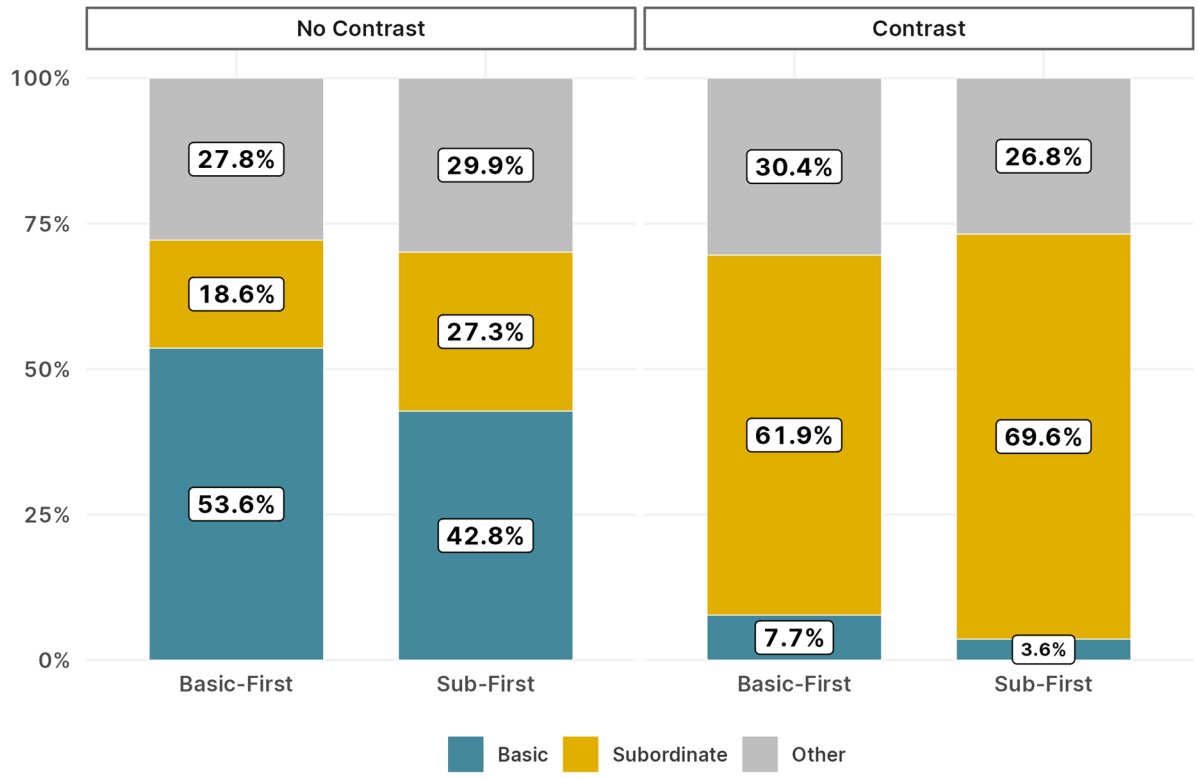

Figure 2.8: Responses at test for Experiment 3.

We fitted a mixed-effects logistic regression model to the rate of Basic responses, with the Contrast (*Contrast* vs. *No Contrast*) and Test Sequence (*Basic First* vs. *Subordinate First*) conditions and their interaction as fixed effects, and random intercepts by subject and item. The model summary is shown in Table 2.3.

Table 2.3: Mixed-effects logistic regression model fitted to Basic responses in Experiment 3.

	β (SE)	t	p
(Intercept)	–2.2 (0.5)	–4.1	<0.0001
Contrast	–2.1 (0.2)	–10.6	<0.0001
Test Sequence	–0.45 (0.2)	–3.0	0.003
Interaction	–0.12 (0.1)	–0.8	0.44

We found a significant main effect of Contrast ($\beta = -2.1$ SE $= 0.2$, p < 0.0001) replicating the findings from Experiment 1; there was an overall lower rate of Basic responses in the presence of a

labelled semantic alternative. We also found a significant effect of Test Sequence (β = –0.45, SE = 0.2, p = 0.003), such that the rate of Basic responses was lower in the *Subordinate First* condition than in the *Basic First* condition. There interaction term did not reach significance (β = –0.16, SE = 0.1, p = 0.44). The same pattern is reflected in the model fitted to the rate of Subordinate responses, as shown in Table 2.4.

Table 2.4: Mixed-effects logistic regression model fitted to Subordinate responses in Experiment 3.

	β (SE)	t	p
(Intercept)	–0.3 (0.1)	–2.5	0.013
Contrast	1.1 (0.1)	11.5	<0.0001
Test Sequence	0.25 (0.1)	2.8	0.005
Interaction	–0.04 (0.1)	–0.5	0.64

2.4.5 Discussion

The present findings suggest that learners considered information from the test phase as additional evidence for generalizing word meanings beyond ostensive labelling in the learning phase. As predicted by our pragmatic account, when learners were prevented from the opportunity to generalize to the basic-level category immediately after learning the word (by initially only being exposed to exemplars from the subordinate-level category in the *Subordinate First* condition), they were led to believe that the speaker had in mind a narrower, subordinate-level meaning of the target label. In comparison, no such expectation arose in the *Basic First* condition. Together, these data show that the basic-level bias can be fragile and may be abandoned or inhibited under sufficient evidence that the label in fact encodes a different (e.g., narrower) level of specificity than initially thought. By adopting sequential testing, where learners must continually collect evidence and update their inferences about the informativity level encoded in the use of the word, we were able to probe such effects within the structure of the test phase.

The present data are surprising for many subordinate-word learning models, where acting on a hypothesis about a word's meaning is not counted as additional information for that word's meaning. For example, this prediction is explicitly formalized in the notion of strong versus weak sampling in the suspicious coincidence account, which states that a learner acting on their existing

knowledge (e.g., extending a learned label to other, unlabeled exemplars from the same subordinate-level category) does not contribute to the generalization of word meanings because there is no "suspicious coincidence" to be uncovered from that generative process underlying the label-referent pairings (Tenenbaum, 1999; Xu and Tenenbaum, 2007a; Lewis and Frank, 2016). However, on the current pragmatic account, any use of the word can be taken as an indication of what the speaker might have in mind.

Finally, we note that the rate of Basic responses in the No Contrast condition of Experiment 3 (40˜50%) was much higher than those observed in Experiments 1 and 2 (˜20%). This is consistent with the possibility that the suppression of the basic-level bias in those prior experiments was the consequence of the large number of test trials that necessitated a strict coding threshold for consistent Basic responses. Incomplete-Basic responses were still present among Other responses in both the *No Contrast* (mean *Basic First* = 22.30%, mean *Subordinate First* = 25.80% of all responses) and *Contrast* (mean *Basic First* = 11.90%, mean *Subordinate First* = 12.90%) conditions.

2.5 Experiment 4

A remaining question about the present paradigm in both our own work and in previous literature on subordinate nouns is whether the degree to which English is used to teach the novel words plays a role in the generalization of word meanings. In a departure from our earlier experiments and prior work, Experiment 4 made a change to the task to better approximate the natural circumstances of early word learning. Specifically, Experiment 4 replicated Experiment 1 in two versions: an *English* version where the novel words were embedded into English carrier sentences (an exact replication of Experiment 1) and a *Foreign* version, where all input was delivered in an artificial language. Thus Experiment 4 was a 2-by-2 design crossing the presence of a labelled contrast (*Contrast* vs. *No Contrast*) and the type of exposure language (*English* vs. *Foreign*). If the role of contrast truly characterizes mechanisms of subordinate noun acquisition, the results of Experiment 4 should broadly replicate the patterns of our earlier study.

2.5.1 Participants

Participants who did not previously participate in our experiments were recruited from the undergraduate subject pool at the University of Pennsylvania (n=105). The number of participants was roughly balanced between the *English* (n=50) and *Foreign* (n=55) variants of the experiment; each sought to replicate the effect of the Contrast condition in Experiment 1 with similar sample sizes.

2.5.2 Materials and Procedure

All materials and procedure for the *English* version were identical to Experiment 1. In the *Foreign* version, the prior context for the task was communicated in English by a narrator. Participants were introduced to the same cartoon character (now named Sallu) and were told that she was a native speaker of a foreign language called "Uffish" (in actuality, a string of nonce words). As in the *English* condition, participants were told that Sallu would like to play a game to teach them some Uffish words. An exposure session was designed to familiarize participants to Uffish. This session consisted of two trials. In the first trial, Sallu introduced and named her friend Kiel (learning phase), and then asked whether there were any Kiels in an image grid where there were, in fact, two other images of Kiel alongside pictures other faces (testing phase; see Figure 9). Throughout the experiment all communication from Sallu within a trial appeared in two speech bubbles: one was used for labelling ("Lo X! Sook sou X?" meaning 'This is a X. Do you see the X?') and another for asking participants to find matches to the target label ("Lom X? Uske biot mopi X!" meaning 'Do you see the X? Click on all the X!'). These two speech bubbles were the only instances of Uffish within each trial. To help participants interpret the instructions, for the first ('Kiel') exposure trial only, participants were provided with English subtitles generated by a translator device (see Figure 2.9).[10]

[10]The narrator's instructions were: *Sallu would like to play a little game with you and teach you some Uffish words. Sallu says "Hi!"* (speech bubble of a nonce word appears on top of Sallu). *You'll get a translator to help you understand Sallu* (subtitles appear below Sallu), *starting the with names of her friends. Pay attention to the words because you'll be asked questions about them later!*

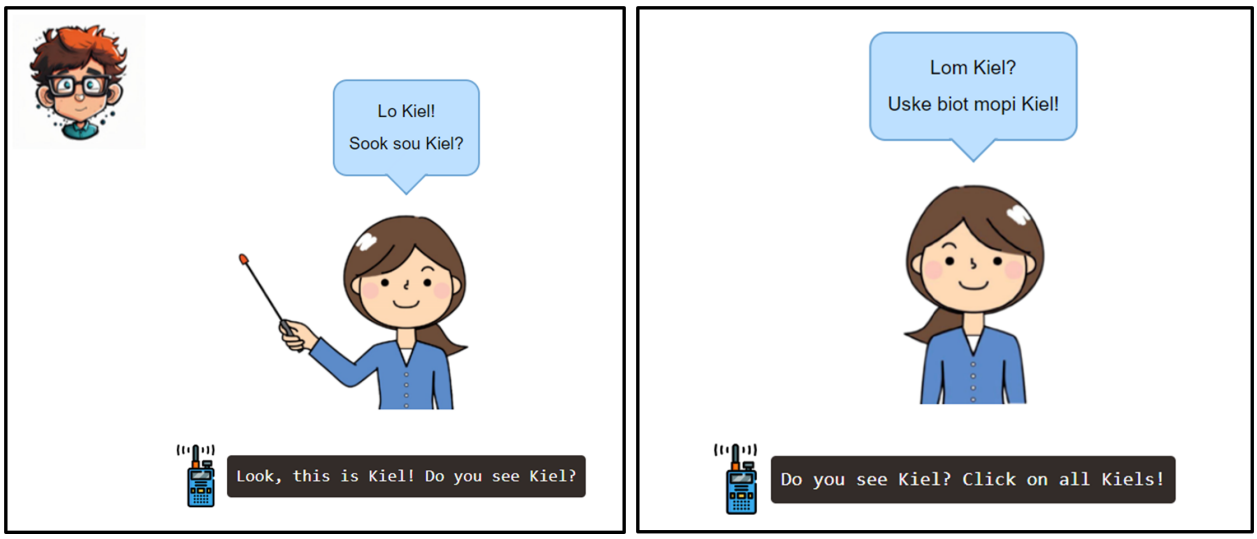

Figure 2.9: Presentation of Sallu's friend Kiel (left) and the instructions to find more of them (right) in the first trial of the exposure session in the *Foreign* condition of Experiment 4. English subtitles generated by a translator device appeared at the bottom of the screen in the first exposure trial and were removed from the second exposure trial onwards.

In the second exposure trial, the narrator took away the translator and told participants that Sallu would now teach them the word for her favorite food.[11] Sallu re-appeared to introduce and label a pizza ("mouli") and asked participants to select more "mouli" from the image grid, where there were five additional pizzas of different kinds alongside other unrelated objects (e.g., beach, ice cream, statue, etc.). There was no number morphology in Uffish, and by virtue of using the exact same carrier phrase for proper names (first trial) and nouns (second trial), participants were led to believe that Uffish lacked definite articles (whereas in the *English* version, labelling was always via definite reference); this design allowed the *Foreign* version to depart more strongly from English. Participants who did not select both Kiel- and all five "mouli"-instances in the exposure phase were removed from analysis. After the exposure session, the narrator told participants that they would continue playing the same game with some more Uffish words, and the same ten trials (8 critical and 2 filler) proceeded in the same manner as in the *English* version, except with speech bubbles in Uffish without the translator and subtitles. The novel nouns used in prior versions of this experiment were

[11]The narrator's instructions were: *Great job! Let's play the game again, now without the translator* (translator icon disappears). *This time, Sallu will teach you the Uffish word for her favorite food!*

therefore now interpreted as part of a foreign language (e.g., "Lo mipen! Sook sou mipen?", i.e., 'This is a mipen. Do you see the mipen?', and "Lom mipen? Uske biot mopi mipen!", i.e., 'Do you see the mipen? Click on all the mipens!').

2.5.3 Coding

The coding scheme followed that of the Experiment 1.

2.5.4 Results

After applying the same filtering criteria as in prior experiments, six participants from the *English* version and four participants from the *Foreign* version were removed. Additionally, 33 trial-level responses were dropped. In total, 711 responses from 93 participants were entered into the analysis. Results are shown in Figure 2.10.

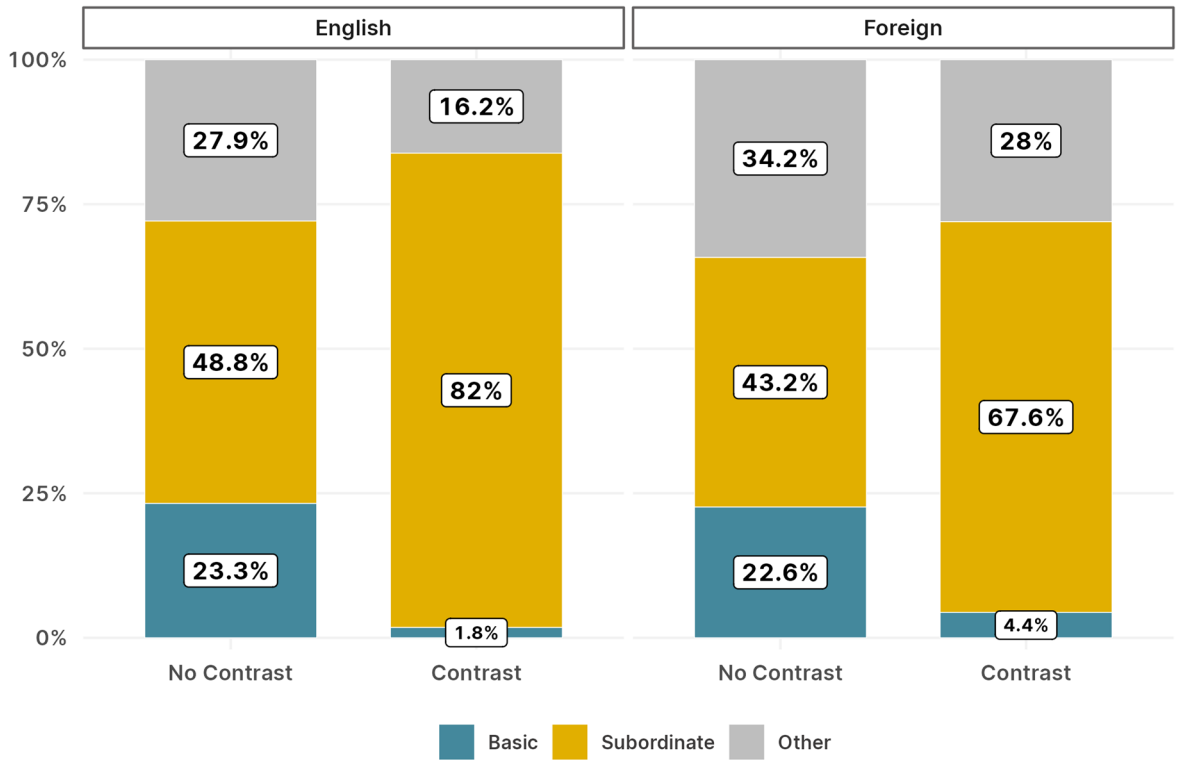

Figure 2.10: Responses at test for Experiment 4.

We fitted a mixed-effects logistic regression model to the rate of Basic responses, with Contrast (*Contrast* vs. *No Contrast*), Version (*English* vs. *Foreign*), and Trial Block (*First half* vs. *Second half*) and all two-way interactions as fixed effects. The model also included random intercepts and slope of Contrast by subject and random intercepts by item.[12] The model summary is shown in Table 2.5. We found a significant main effect of Contrast (β = –3.8 SE = 0.8, p < 0.001), successfully replicating the findings from Experiment 1. No other predictors reached significance.

Table 2.5: Mixed-effects logistic regression model fitted to Basic responses in Experiment 4.

	β (SE)	t	p
(Intercept)	–5.2 (0.9)	–6.0	<0.001
Contrast	–3.8 (0.8)	–4.5	<0.001
Version	–0.2 (0.5)	–0.3	0.736
Trial Block	–0.3 (0.2)	–1.4	0.170
Contrast * Version	-0.2 (0.5)	-0.4	0.673
Version * Trial Block	-0.4 (0.2)	-1.6	0.102
Trial Block * Contrast	-0.1 (0.1)	-0.9	0.369

The same model fitted to the rate of Subordinate responses is shown in Table 2.6. We found a significant main effect of Contrast (β = 0.8, SE = 0.1, p < 0.0001) in the opposite direction, such that there were more Subordinate responses in the *Contrast* condition than in the *No Contrast* condition. We also found a significant main effect of Version (β = 0.4, SE = 0.2, p = 0.035), such that the Foreign condition had an overall lower rate of Subordinate responses than the English condition. No other predictors reached significance.

2.5.5 Discussion

Experiment 4 successfully replicated the effect of semantic contrast on the rate of Basic and Subordinate responses using a different linguistic format with minimal English exposure. Importantly, the design of the *Foreign* version brings the immediate generalization task closer to the natural circumstances of early word learning than iterations of the task in prior studies, where English has traditionally dominated participants' interactions with the interlocutor (whose motivations for in-

[12]Model formula: Basic ~ (Contrast + Version + Order)^2 + (1 + Contrast | Participant) + (1 | Item). All predictors were sum coded with *Contrast* at 1 and *No Contrast* at -1, *English* at 1 and *Foreign* at -1, and *Block1* at -1 and *Block2* at 1.

Table 2.6: Mixed-effects logistic regression model fitted to Subordinate responses in Experiment 4.

	β (SE)	t	p
(Intercept)	0.6 (0.3)	2.0	0.049
Contrast	0.8 (0.1)	7.1	<0.0001
Version	0.4 (0.2)	2.1	0.035
Trial Block	0.1 (0.1)	1.4	0.170
Contrast * Version	0.1 (0.1)	1.4	0.673
Version * Trial Block	-0.04 (0.1)	-0.4	0.102
Trial Block * Contrast	-0.04 (0.1)	-0.4	0.369

troducing novel words in an English frame were often left unclear given the possible English lexical alternatives). These findings thus confirm the generalizability of the semantic contrast effect to unfamiliar language input and its nature as stemming from general principles of communication which includes, but are not limited to, expectations about linguistic form.

As a final note, while the rate of Basic responses was not significantly different between the two language versions, Subordinate responses were more frequent in the *English* version compared to the *Foreign* version, which instead showed more Other responses. In other words, minimizing exposure to English increased the overall difficulty of the (already hard) task of generalizing to the narrower, subordinate-level categories. One possibility is that the use of English makes the familiar subordinate-level semantic categories more accessible for mapping, which is consistent with pragmatic accounts where learners exploit familiar linguistic devices for subordination to infer and encode semantic contrast. However, this finding is unexpected under bottom-up accounts, where the salience of perceptual features determines the ease of mapping words to subordinate-level categories.

2.6 General Discussion

In this study, we proposed that the challenge of acquiring subordinate nouns involves to a large extent a pragmatic puzzle. Assuming that learners make inferences about the interlocutor's intent behind the choice of a word (Grice, 1975), we reasoned that generalizing to the narrower, subordinate-level meaning would greatly benefit from linguistic cues to the specificity of a word in the face of the basic-level bias. Such cues could involve contrast to other lexical alternatives that can

support inferences about the target label. We tested a set of predictions flowing from the hypothesis that the introduction of a semantic alternative at the subordinate level would make subordinate-level conjectures accessible to a learner who would otherwise produce a basic-level generalization for a novel label.

These predictions were confirmed. We found that the presence of a labelled alternative at the subordinate level eliminated the basic-level bias during word learning with adult learners (Experiment 1); furthermore, the mere presence of the alternative referent without a label was less likely to suppress the basic-level bias compared to cases where the alternative was labelled (Experiment 2). Additionally, the role of alternatives in shaping expectations of specificity extended well beyond the moment that a label was ostensibly introduced (Experiment 3). As we had anticipated, these results show that learners choose between subordinate- and basic-level meanings for a label by inferring the level of informativity encoded in the use of the label (and not just from any type of contrast). Lastly, this effect of semantic contrast was not an artifact of task adaptation nor driven by language familiarity; pragmatic inferences about the level of specificity encoded in a word could be calculated even from novel language input (Experiment 4). These results underscore the fact that labels for objects invoke concepts and meanings that the speaker intends to convey, and that this information is often delivered to the listener by highlighting (in verbal and non-verbal ways) how the label contrasts with a specific set of other relevant lexical options that the speaker could have used but did not.

2.6.1 Alternative accounts

The robust finding that the presence of a semantic alternative at the subordinate level facilitates subordinate-level generalizations is unexpected under accounts of subordinate word learning where information outside of labelling and referent introduction is not considered in forming hypotheses about word meaning. This is because the semantic alternative does not contribute to either the perceptual (Spencer et al., 2011; Jenkins et al., 2015, 2021) or the distributional (Xu and Tenenbaum, 2007a,b; Lewis and Frank, 2016, 2018) profile of the target label itself, which has been assumed to be the fundamental unit of evidence for word learning in much prior work. Instead, not only

do the availability and salience of alternatives in the communicative episode guide word meaning generalizations in our data, but we also observe a strong effect of a labelled alternative even after just a single instance of the target label, without needing to expose the learner to multiple exemplars cross-situationally.

Furthermore, the idea that aspects of communication outside of ostensive labelling can affect the interpretation of a word upends the traditional divide between learning and testing, where the latter is not thought to contribute additional evidence for word meaning because it is driven by the learner acting on their own hypothesis (hence the long-standing assumption that the test grid, as popularized by Xu and Tenenbaum, 2007b, simply probes the hypothesized word meaning). In fact, some have explicitly proposed built-in mechanisms that prevent such learning, including the distinction between weak and strong sampling under the suspicious coincidence account which restricts evidence for word meaning to label-referent pairings provided by a knowledgeable speaker (Xu and Tenenbaum, 2007a; Lewis and Frank, 2016). To a degree, this skepticism is warranted, as allowing such a mechanism to take hold may result in a positive feedback loop of confirming hypotheses just via opportunities to act on them. Certainly, this kind of unconstrained learning is undesirable, though there is something to be said about how opportunities to test hypotheses about word meaning can sometimes reveal insights to the word's meaning itself. If learners can integrate information about speaker intent in hypothesizing word meanings, then there may be non-labelling or even non-verbal contexts inviting the learner to respond to or reason about the word that in fact highlight an alternative word meaning that is also consistent with the data (namely, observed exemplars) but was simply more difficult to access at the moment of labelling. We argued that this may be the case for subordinate- vs. basic-level meanings, and indeed, Experiment 3 showed that learners can be led to consider the narrower, subordinate-level meaning when the opportunities for the learner to act on their current conjecture for a word's meaning encourage a narrower interpretation of the word. This model of subordinate-word learning seems reasonable under the assumption that natural circumstances that invite the learner to act on a hypothesized word meaning are often intertwined with some task or goal relevant to a conversation, where the behavior of the interlocutor can also reveal insights into word meaning (Wang and Mintz, 2018).

In sum, information from contrast and alternatives can come from any point in a communicative episode, and the specific question about word meaning that the learner is being encouraged to consider may provide additional evidence to word meaning beyond ostensive labelling. This is a challenge for bottom-up accounts of learning subordinate nouns (e.g., Spencer et al., 2011) as well as associationist word learning models more broadly (e.g., Yu and Smith, 2007; Fazly et al., 2010), but the data may be captured by a class of so-called hypotheses-testing models where learners reason over semantic categories rather than exemplars (Gleitman and Trueswell, 2020) and posit a single conjecture at a time rather than a range of possible meanings (e.g., Medina et al., 2011; Trueswell et al., 2013; Stevens et al., 2017). Other rational models of word learning such as those based in Bayesian inference also share our emphasis on speaker intent (e.g., Frank and Goodman, 2012, 2014) and may thus account for our findings in terms of the likelihood of the data under possible word meanings, although the specific mechanism for the acquisition of subordinate nouns must consider information beyond the sampling statistics of a label as the primary cue to the level of specificity encoded in a word (i.e., beyond the "suspicious" nature of label-referent pairings). Indeed, the suspicious coincidence effect stemming from the observation of multiple positive evidence for the subordinate-level meaning has been argued to be fragile and indirect (Caplan, 2022), which also explains its disappearance under richer contexts providing information about semantic contrast that relieve the learner from reasoning about the specificity of word meaning from such unreliable cues in the referential world (Wang and Trueswell, 2019, 2022).

2.6.2 Pragmatics and the acquisition of subordinate nouns

Inferences about speaker intent are pervasive, and arguably inevitable in word learning, since labels do not simply describe the world (Grigoroglou and Papafragou, 2021). We have argued that this is especially salient for the challenge of acquiring subordinate nouns, where overcoming the basic-level bias requires reasoning about the level of specificity encoded in the word or the level of informativity intended by the speaker in the use of the word. Our work refines the often-cited role of contrast in facilitating word meaning generalizations beyond the basic-level (e.g., Clark, 1987, 1988, 1990; Waxman, 1991; Waxman et al., 1997; Wang and Trueswell, 2019, 2022) by propos-

ing that subordinate-level generalizations are facilitated by not just any contrast to the preferred basic-level meaning. Rather, the successful inference depends on the learner's ability to recognize which particular scale is being highlighted in the task – the lateral contrast between mutually exclusive categories at the same level, or the harder-to-access vertical contrast between basic- and subordinate-level categories.

This perspective is reminiscent of approaches to the development of the pragmatic interpretation of "some" as meaning 'some but not all' from the literature on scalar inference; such pragmatic interpretations in children have been shown to benefit from prior exposure to relevant lexical alternatives such as "all" or even "none" (Skordos and Papafragou, 2016). Likewise, we find that information about semantic contrast and the relevance of specific alternatives, despite not revealing properties about the target label itself, nevertheless constrained the interpretation of the target label to a subordinate-level category. The assumption that children are Gricean has also been extensively explored in other parts of the word learning literature. For instance, children as young as two years old show sensitivity to discourse context and speaker intent in positing hypotheses about word meaning (Diesendruck et al., 2004; Diesendruck and Markson, 2005; Diesendruck, 2005). Our findings affirm the strong contribution of such socio-pragmatic constraints in the case of acquiring subordinate nouns, above and beyond other attested factors such as bottom-up perceptual processes and statistical learning over surface-level properties of label-referent pairings.

In natural input, we expect these inferences built on the contrast between subordinate- and basic-level meanings to be especially crucial for early word learning when the referential world rarely offers direct negative evidence to rule out the basic-level interpretation in favor of a narrower, subordinate-level meaning (see discussion in Jenkins et al., 2015). These sources of information may come from the anchoring of the basic-level category as the relevant semantic domain (Waxman, 1991; Waxman et al., 1997) and the presence of other labelled exemplars in cross situational learning (Wang and Trueswell, 2019, 2022), but may also come from the presence of labelled alternatives at the subordinate-level in single learning trials (Experiments 1 and 2) and even from cues to the relevance of certain alternatives made available outside of ostensive labelling (Experiment 3). Thus, we posit that the unifying principle underlying these various effects of contrast on the acquisition

of subordinate nouns is about guiding learners to discover the relevant set of specific alternatives. Furthermore, although we have primarily focused on cases where the learner is mapping existing concepts to new labels, such as in the task of associating the concept *dog* with the sound "dog" (Gleitman and Trueswell, 2020), this primarily pragmatic learning mechanism could also be useful in explaining how unfamiliar or newly formed concepts are mapped to novel labels (Waxman and Markow, 1995; Lupyan et al., 2007; Lupyan and Thompson-Schill, 2012; LaTourrette and Waxman, 2019; Caplan, 2022). The replication of the semantic contrast effect from even novel language input (Experiment 4) offers a promising lead towards this generalized account of learning specific word meanings via inferences about the relevant alternatives involved in the speaker's choice of label. More broadly, it may be that the conceptual and semantic (i.e., linguistically encoded) categories co-develop as children master the conventions of their native language (Berman and Clark, 1989; Clark, 1992, 2017), which would require learners to also integrate evidence from uses of the word, speaker intent, communicative goals, and the like in forming and updating word meaning conjectures.

2.7 Conclusion

In this study, we proposed that the generalization of word meanings is – among other things – driven by assumptions about the relevant level of specificity intended in the use of the word, and that contrast can offer strong cues for such inferences. In a series of word learning experiments, we showed that semantic alternatives facilitate mappings to subordinate-level meanings, and especially so when the alternative is labelled, suggesting that learners can use linguistically marked contrast to reason about the level of informativity for a word's meaning that is expected from an ostensive labelling event. Furthermore, we showed that learners can integrate evidence from the accessibility of alternatives elsewhere in the communicative episode beyond the moment of labelling to generate such inferences about contrast to constrain word meaning generalizations. This sensitivity to the informativeness of an utterance offers a possible mechanism for the acquisition of subordinate nouns despite the apparent sparsity of evidence for subordinate-level meanings offered by the referential world.

Chapter 3

Children's Subordinate Noun Generalizations: Alternatives and Speaker Knowledge

3.1 Introduction

3.1.1 The challenge of subordinate noun learning

Word learning involves not only the task of mapping labels onto referents in the physical world, but also the task of identifying the intended meaning that a speaker encodes in their choice of a word (Grigoroglou and Papafragou, 2021). This challenge of discovering meaning is pervasive and permeates even the acquisition of concrete nouns for familiar object categories, especially for narrow and specific word meanings such as *dalmatian*, as opposed to *dog* (Quine, 1960; Callanan and Markman, 1982; Clark, 1987; Gelman et al., 1989; Markman, 1989; Waxman, 1990; Clark, 1997; Choe and Papafragou, 2023). In the literature, this distinction is characterized as a difference in specificity between subordinate-level and basic-level categories, respectively. Furthermore, the so-called "basic" categories are generally thought to be privileged in early word learning (e.g., Rosch et al., 1976; Cruse, 1977; Mervis and Crisafi, 1982; Blewitt, 1994; Callanan et al., 1994; Murphy, 2002, 2016). By comparison, subordinate nouns are more difficult to acquire under typical word learning conditions (on the separate but similar problem posed by superordinate nouns such as *animal*, see the review in Choe and Papafragou, 2025).

How then are subordinate meanings acquired? According to an influential proposal, learners extract these narrower categories from the physical world by attending to the perceptual character-

istics of labelling events. Under such mechanistic accounts, subordinate categories primarily emerge from the physical circumstances of observation, influenced by the perceptually salient details of exemplars and the learner's ability to hold onto these perceptual representations in memory, accumulated and refined across labelling events. Whereas objects are typically construed at the basic level by their most salient characteristics (e.g., for a dog, having a snout, a lean body, and four legs), subordinate-level categories are defined by the more fine-grained features that are elusive to the typical circumstances of observation (e.g., for a dalmatian, having short, white fur with black spots). In turn, the availability of these subordinate-level features is heavily influenced by the manner of exemplar presentation, such as whether the learner sees three exemplars of a dalmatian simultaneously, side-by-side, versus seeing the same exemplars sequentially, separated across space and time (Spencer et al., 2011; Jenkins et al., 2015, 2021). Here, the simultaneous presentation is thought to activate subordinate categories due to the immediately available perceptual contrasts between similar exemplars, which improves the discovery and retention of the more specific features that are shared (e.g., Sloutsky and Fisher, 2004; Sloutsky et al., 2007; Samuelson et al., 2009; Spencer et al., 2011). On this view, it is the physical world that offers objects at different levels of categorization by making salient the more specific or global kinds of features; the learner in turn perceives the dalmatian-ness or the dog-ness of the labelled exemplars, and through that process discovers the word's meaning in a largely bottom-up fashion.

On a prominent alternative position, cues to subordinate meanings are primarily found in language. As this literature points out, mapping words to subordinate-level categories is greatly helped by cues to a narrower word meaning; this includes contrastive information that guides children's word meaning conjectures away from the often-preferred basic level. For example, Clark (1987)'s Principle of Contrast states that "any difference in form in a language marks a difference in meaning," and has been proposed as the driving force allowing young learners to quickly discover new mappings between concept and form. In a relevant demonstration, English-speaking children as young as two years old can exploit the morphosyntax of novel noun compounds headed by a basic-level noun to learn that the modifier in the compound encodes a more restrictive, e.g., subordinate-level, category (cf. *dalmatian-dog*; Clark et al., 1985; Gelman et al., 1989). Similarly, three-year-olds

have been shown to leverage specific linguistic devices for expressing subordination that are commonly used for this function by caregivers in child-directed speech: for instance, children rely on "kind of" in English to infer a narrower meaning for a word when it is "anchored" to a known basic-level term (e.g., "This is a dax. It's a kind of a dog"; Markman et al., 1980; Callanan, 1985, 1989; Waxman, 1991). Beyond explicit linguistic devices, subordinate noun learning is additionally helped by the mention of contrastive information about distinct subordinate-level categories with different names, such as the fact that collies help *shepherds* take care of sheep while *settlers* help hunters find birds (Waxman, 1991; Waxman et al., 1997). More recent studies have shown that similar mechanisms are also available for fast-mapping in cross-situational word learning experiments: Wang and Trueswell (2019; cf. 2022) found that three-to-five-year-old children were more likely to generalize the meaning of a novel label at the subordinate level (e.g., taking "dax" to mean *dalmatian* after seeing three dalmatians) if a second novel label was simultaneously paired with other subordinate-level exemplars from the same basic-level category (e.g., three non-dalmatian dogs). In the same study, children generalized the meaning of a novel label at the basic level (e.g., taking "dax" to mean *dog* after seeing three dalmatians) when a second label was instead paired with exemplars from a different basic-level category (e.g., three birds). Finally, learners interpret contrast as a cue to a subordinate meaning for the target label, but this pattern was not observed when the visual alternative was merely present without being labelled. This pattern was replicated even when the input was presented in an artificial language, and these inferences continued to be computed and updated beyond the precise moment of labelling (Choe and Papafragou, 2023).

To summarize, it is widely understood that contrast helps constrain the space of possible word meanings, and that this is especially helpful for the task of discovering subordinate (versus basic-level) noun meanings. A remaining question is how contrast drives the narrowing of a word's meaning. Under mechanistic accounts, what matters are the immediate comparisons available in the referential world. Subordinate meanings arise from circumstances of observation which highlight fine-grained featural distinctions; this procedure is not necessarily mediated by language (or only so to the extent that labels offer cues to attention and encoding; Sloutsky, 2010; but see Wang and Trueswell, 2019; Choe and Papafragou, 2023). Alternatively, assuming that contrast is a linguistic-

communicative phenomenon, it could be implemented via one of two possible mechanisms. On one possibility, contrast works via a surface-level heuristic guided by the availability of alternative form-meaning mappings, whether those are present in the discourse or preexisting in the child's lexicon (e.g., Markman, 1987, 1989; Golinkoff et al., 1992, 1994). Such a lexical heuristic operating at the level of linguistic form may be sufficient to capture the effect of contrast as a cue to subordinate meanings, since much of the relevant prior literature involved children learning exclusively from positive evidence of one-to-one mappings between a label and a referent. On a second possibility, contrast might be understood as revealing a pragmatic choice on the part of the speaker (Clark, 1987, 1990, 2017; Clark and Wong, 2002; Diesendruck, 2005). In that case, learners might not only consider the differences in linguistic forms, but also their interlocutors' mental state in choosing one form over another (Au and Glusman, 1990; Gelman et al., 1989; Diesendruck et al., 2004, 2010). In the next section, we present a pragmatic account of children's subordinate noun learning (including a pragmatic notion of contrast) and test its explanatory potential against alternative possibilities.

3.1.2 Subordinate meanings, contrast, and pragmatics

In this study, we pursue the hypothesis that subordinate meanings arise from the expectation that the speaker intends to be informative in their choice of a word, given the availability of relevant alternatives (see Choe and Papafragou, 2023). On this pragmatic account, what constitutes informativeness depends on contextual factors including what information is shared between the speaker and listener, and what alternatives are salient in the discourse context (Grice, 1975; cf. Sperber and Wilson, 1986). For nouns denoting taxonomic categories, the subordinate-basic-superordinate distinction can be understood as forming a scale on the basis of informativeness (Horn, 1972), whereby the subordinate level is typically more informative than the basic level. In turn, the acquisition of subordinate nouns is helped by clear cues to the speaker's intent. This problem of lexical choice from a scale can be understood as audience design, involving the assessment of what level of specificity would be the most conversationally appropriate (Brennan and Clark, 1996); this framing also helps captures one interpretation of the basic-level bias, as the level of specificity that is informative enough to satisfy the needs of a "generic addressee" (Cruse, 1977; Brown and Dell, 1987; Lockridge

and Brennan, 2002; Grigoroglou and Papafragou, 2019a; Degen et al., 2020; Choe and Papafragou, 2023).

On this pragmatic proposal, contrast is helpful for learning subordinate nouns because it allows learners to interpret the speaker's choice of word as an intentional act of narrowly identifying the target among alternatives which differ in a particular dimension. Thus when a speaker provides two distinct labels for a pair of contrasting exemplars at the subordinate level (e.g., "dalmatian" and "corgi"), learners infer that the speaker's intent is more specific in using those words, given the availability of the basic-level lexical alternative ("dog"; Choe and Papafragou, 2023). Classic evidence for this broader perspective includes demonstrations that preschoolers can in fact suspend the mutual exclusivity inference and other lexical heuristics under various conditions, such as when the interlocutor is previously shown to lack knowledge or speak a different language (e.g., Au and Glusman, 1990; Diesendruck et al., 2004, 2010). These findings suggest that hypotheses about word meaning are not only shaped by what children know, but also what they can assume about the speaker's knowledge and perspective. Crucially, on the pragmatic account, contrast need not involve two competing linguistic forms; for example, contrastive inferences may also be facilitated via communicative stimuli beyond words, such as drawings or pictures (Kampa and Papafragou, 2023; Kampa et al., 2024).

Crucially, on a pragmatic account, learners' hypotheses about word meaning are not only shaped by what children themselves know, but also what they can assume about the speaker's knowledge and perspective. This view is informed by demonstrations of effects of their interlocutor's mental state in how informative children are during reference production and comprehension. For example, Nadig and Sedivy (2002) found that 4-to-5-year-olds modulate the specificity of reference by tracking information in the common ground, suppressing their production of modifiers to refer to a target (e.g., referring to a taller cup as "the cup" versus "the tall cup") when the relevant visual alternative (e.g., a shorter cup) was not visible to the interlocutor. Complementing this evidence, Kampa and Papafragou (2020) showed that children can modulate their informativeness judgments depending on the speaker's knowledge state, successfully matching more-informative descriptions (e.g., "I see a box and a spoon") to contexts where the speaker had full visual access to the contents of a box being

described, and less-informative statements (e.g., "I see a spoon") to contexts where the speaker only had a partial knowledge. These findings suggest that children understand pragmatic constraints on informativeness, involving inferences about relevant alternatives and the speaker's perspective.

The pragmatic account makes two predictions about the role of contrast in the acquisition of subordinate meanings. First, it predicts that children should use contrastive information to facilitate subordinate generalizations even when there are no competing lexical forms (but only a single lexical form - e.g., "a wug" - and its negation - "not a wug") within the learning episode. Second, it predicts that children, in generating specific hypotheses for subordinate word meanings, should integrate information about speaker knowledge, such as whether contrastive lexical alternatives for the target referent are also available to the speaker. Together, these two predictions differ from alternative accounts of the role of contrast in subordinate noun learning reviewed earlier. Mechanistic accounts predict that contrast effects emerge primarily from the learner's observation of perceptual contrasts in the world; on these accounts, both labelling contrasts and the speaker's mental access to contrastive alternatives should be irrelevant for learning purposes. Lexical heuristic accounts predict that contrast should exert its effects only when two or more contrasting linguistic forms are explicitly present; these accounts cannot accommodate more flexible implementations of contrast (including cases where one of the contrastive alternatives is fully labelled) and – because they conceive of contrast as a simple heuristic - are silent on the role of the speaker's mental access to contrastive alternatives.

In what follows, we test these predictions of the pragmatic account in two word learning experiments with 4- and 5-year-old children who have been extensively studied in the literature on the acquisition and use of subordinate nouns (e.g., Waxman et al., 1997; Xu and Tenenbaum, 2007a; Jenkins et al., 2015; Emberson et al., 2019; Wang and Trueswell, 2019) and the development of informativeness and perspective-taking (e.g., Nadig and Sedivy, 2002; Barner et al., 2011; Katsos and Bishop, 2011; Skordos and Papafragou, 2016; Papafragou et al., 2017, 2018; Kampa and Papafragou, 2020; Wilson et al., 2022). In Experiment 1, we ask whether children's subordinate-level hypotheses for word meaning are driven by the presence of alternative exemplars that contrast with the target referent at the subordinate level. We predict that children should generalize the meaning

of novel labels to the subordinate level when other subordinate-level exemplars are present (even if only one of these is labelled with a unique label) compared to when only the target referent is present and labelled. In Experiment 2, we ask whether the effect of contrast on subordinate word meanings is modulated by the speaker's knowledge of the potential alternatives to the target. We predict that children should show more subordinate-level generalizations when the speaker has full visual access to the alternatives, compared to when those alternatives are hidden from the speaker's view.

3.2 Experiment 1

In Experiment 1, we tested whether inferences about the specificity of word meaning are driven by the presence of alternatives that contrast along a particular taxonomic dimension. As we have discussed earlier, our hypothesis for the effect of contrast is that it is guided by the expectation that the speaker intends to be more specific than usual in their choice of label. Thus, we predicted that learners would be more likely to generalize novel labels to the subordinate level when other subordinate-level exemplars were present and linguistically negated by the speaker during labeling, compared to when only the target referent was present and labelled.[13] We tested this prediction by presenting learners with a novel label for a target object (e.g., a dalmatian) either in isolation or alongside two other subordinate-level alternatives from the same basic-level category (e.g., other dog breeds).

3.2.1 Participants

Forty English-speaking 4-to-5-year-olds (mean: 5;0, range: 4;0–5;11) were recruited from local daycares in Philadelphia, and forty English-speaking adults were recruited from the undergraduate subject pool at the University of Pennsylvania.

[13] In a prior study, Gelman et al. (1989) taught 3- and 5-year-olds subordinate nouns via negation using a visual alternative (e.g., "This [pointing to one dog] is a dog; it's a dingo. This [pointing to the other dog] is a dog; it's not a dingo"). However, the effect was conflated with anchoring to the basic level. Therefore, it remains open whether linguistic negation can facilitate subordinate meanings on its own.

3.2.2 Procedure

Experiment 1 was administered via the PCIbex platform for web-based experiments (Zehr and Schwarz, 2018). Adult participants were tested virtually and asynchronously; child participants were tested in person by an experimenter who guided their interactions with the experiment on a laptop. In the beginning of the experiment, participants were introduced to a cartoon character named Blue. Children received all instructions from the experimenter; adults read identical instructions in text.

> "We're going to play a game with a friend. Her name is Blue and she speaks a different language. Her language sounds like English but has some words that are different from English. Blue is looking for something from a pile of cards. Once she finds what she's looking for, it's your turn, so pay attention! Are you ready?"

The experiment then proceeded to the word learning task, consisting of eight trials. Each trial involved a learning phase where participants were exposed to a labelling event, and then a testing phase which probed whether participants generalized the meaning of the label at the subordinate or the basic level. In the learning phase, Blue appeared on the screen alongside a row of three cards, all facing down (Figure 3.1). Blue began by stating what she was looking for (e.g., "I'm looking for a gavai!"). Then, she moved next to each card and began flipping them over one-by-one, stopping when the target was revealed.

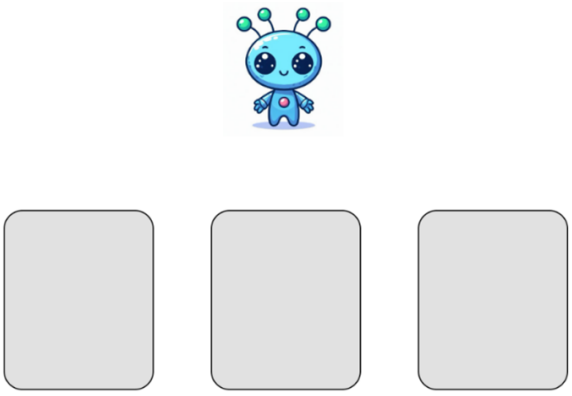

Figure 3.1: Initial display of trials in Experiment 1.

In a between-participants design, we manipulated when the target was found during the card-flipping sequence. In the No Contrast condition, the first card that was revealed happened to be the target card (e.g., a dalmatian; Figure 3.2A). When the target was revealed, it was marked by a red outline and labelled by Blue (e.g., “Look, I found what I was looking for! It’s a gavai!”). Then Blue added, “I don’t see another gavai”, since only one entity (the target) was visible in this condition. Because Blue always stopped flipping cards upon finding the target, this meant that what was on the other two cards remained hidden at the moment of labelling (and would remain unknown to both Blue and the participant for that trial).

In the Contrast condition, Blue discovered the target (the dalmatian) on the third and last card flip (Figure 3.2B). She had previously flipped over the other two cards that depicted two subordinate-level alternatives (a corgi and a terrier), and had made it clear that each was not the target by saying, “This is not a gavai”. Again, when the target was found, it was marked by a red outline and labelled (e.g., “Look, I found what I was looking for! It’s a gavai!”). In this condition, the two non-target cards were already known to both Blue and the participant prior to the labelling of the target, and remained visible on the screen once revealed.

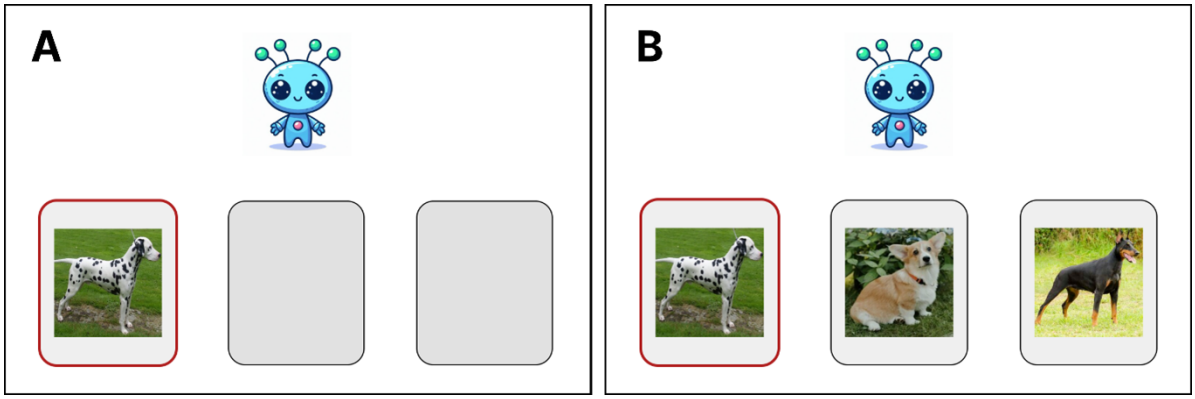

Figure 3.2: Display at the moment of labelling in the 1 No Contrast (A) and Contrast (B) conditions of Experiment 1.

At the end of the learning phase, the experimenter said, "Now it’s your turn to find gavais. Are you ready?" and the trial moved into the test phase after getting confirmation from the participants. Participants’ word meaning generalizations were tested using the immediate generalization

paradigm, in which participants are shown a set of pictures, from which they are instructed to select all instances of the target word. This paradigm has been proven successful in probing the specificity of learners' word meaning hypotheses (Xu and Tenenbaum, 2007b; Spencer et al., 2011; Jenkins et al., 2015; Lewis and Frank, 2018; Emberson et al., 2019; Wang and Trueswell, 2019, 2022; Caplan, 2022; Choe and Papafragou, 2023). There were six items in the generalization set: two subordinate-level matches (e.g., two different dalmatians), two basic-level matches (e.g., two non-dalmatian dogs), and two distractors (e.g., a bird and a dresser). The items in the generalization set were shown one at a time, and for each item participants were asked whether they thought it was an instance of the target label (e.g., "Is this a gavai?"). The fact that participants did not get to see the full set of possible items up front increased the difficulty of the task but was done to minimize potential interference from the test phase in highlighting the relevance of subordinate-level categories (see Choe and Papafragou, 2023).

Blue's dialogue during the learning phase was played from pre-recorded audio from a female native speaker of English. The position of the target card in the row (leftmost or rightmost) was randomized between trials. The eight basic-subordinate category pairs used in critical trials alongside the novel target names were: dog/dalmatian (*gavai*), bus/school bus (*lorpim*), pepper/green pepper (*tuffee*), apple/red apple (*mipen*), dinosaur/T-rex (*tantol*), ball/basketball (*kapsin*), phone/smartphone (*spadil*), and chair/wooden chair (*kalmick*).

Participants' responses were coded using a strict criterion: a response was coded as Subordinate if only the two subordinate-level matches were selected, Basic if both the two basic-level matches were additionally selected, and Other in all other cases (Wang and Trueswell, 2019, 2022; Choe and Papafragou, 2023).[14]

3.2.3 Results

Starting with the data from adults, Figure 3.3 shows the distribution of word meaning generalizations (coded as Subordinate, Basic, and Other) at test. As predicted, adults showed more subordinate-level generalizations of the target label in the Contrast condition (82.9%) compared

[14]Under an alternative coding scheme, incomplete generalizations receive partial scores (Xu and Tenenbaum, 2007b; Lewis and Frank, 2018). Even if we were to assign partial scores, the results would not change.

to in the No Contrast condition (58.8%). To statistically test for this difference, a logistic mixed-effects regression model was fitted to the proportion of Subordinate responses (Table 3.1), using the MixedModels library (Alday and Bates, 2025) in the Julia programming language (Bezanson et al., 2017). The model included a fixed effect of the Contrast manipulation (sum coded with No Contrast = -1 and Contrast = 1) with a maximum random effects structure up to by-participant and by-item random intercepts and slopes with correlations. The model confirmed that Contrast was a significant predictor in the expected direction (β = 2.160, SE = 0.673, p = 0.001), consistent with the hypothesis that the presence of referential alternatives constrained word meaning generalizations at a narrower level.

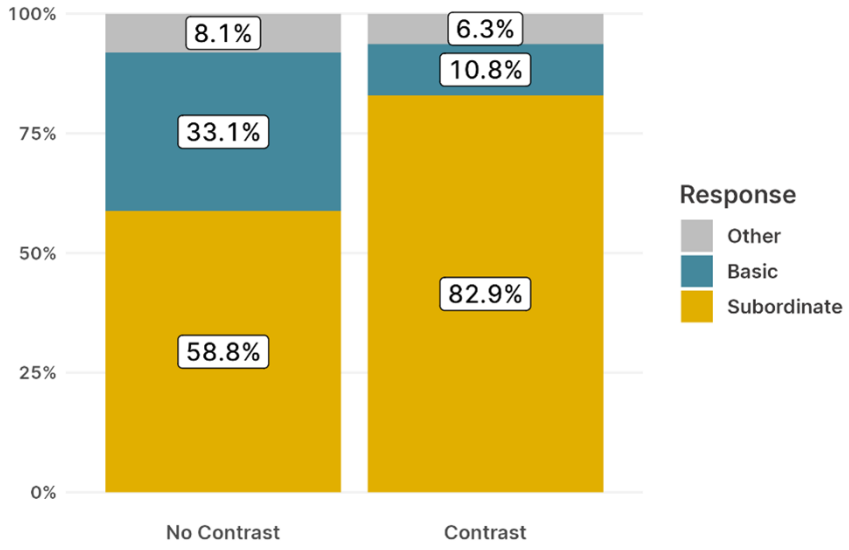

Figure 3.3: Experiment 1: distribution of adults' responses at test.

Table 3.1: Experiment 1: logistic mixed-effects model for Subordinate responses in adults.

	β	SE	t	p
(Intercept)	1.976	0.521	3.792	<0.001
Contrast	2.160	0.673	3.209	0.001

Turning to the data from children, Figure 3.4 shows the distribution of word meaning generalizations at test. Similar to adults, children showed more subordinate-level generalizations of the target

label in the Contrast condition (64.4%) compared to the No Contrast condition (35.8%). A logistic mixed-effects regression model was fitted to the proportion of Subordinate responses (Table 3.2), with identical model specifications except for the addition of a predictor for Age (sum coded with four-year-olds = -1, five-year-olds = 1) and the interaction term. The model confirmed the predicted main effect of Contrast ($\beta = 1.190$, SE = 0.237, $p < 0.001$). Additionally, there was a main effect of Age, such that five-year-olds produced overall more Subordinate responses than four-year-olds ($\beta = 0.880$, SE = 0.257, $p = 0.010$). While not a core prediction from our hypothesis, this finding is consistent with the expectation that older children would be more knowledgeable about category names and concepts; five-year-olds may have been more capable of accessing the subordinate-level categories for the kinds of familiar objects that we used in the experiment. Lastly, the interaction effect was not significant ($\beta = 0.386$, SE = 0.233, $p = 0.097$).

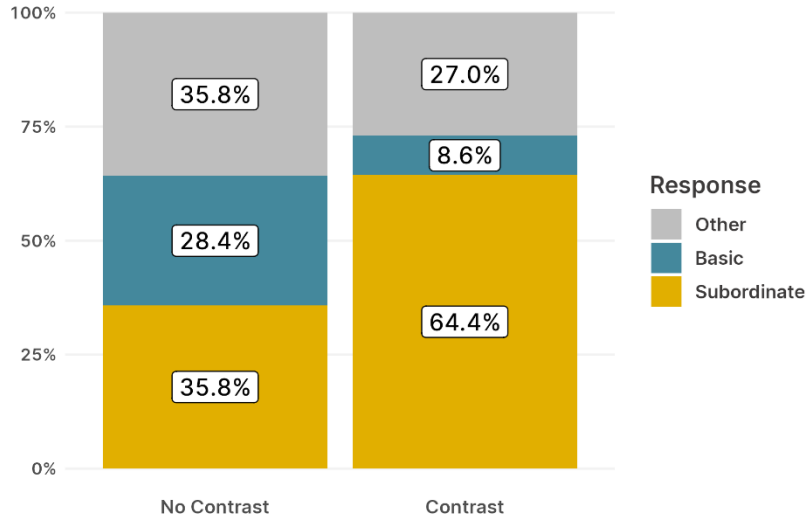

Figure 3.4: Experiment 1: distribution of adults' responses at test.

One striking pattern in the child data is the large proportion of Other responses, totaling approximately a third of all responses. This was not entirely unexpected given the strict coding scheme and the more difficult sequential design of the test phase (Choe and Papafragou, 2023) but merited further analysis. Looking within the Other responses, we distinguished and coded for Incomplete Subordinate and Incomplete Basic responses (e.g., selection of just one of two dalmatians

Table 3.2: Experiment 1: logistic mixed-effects model for Subordinate responses in children.

	β	SE	t	p
(Intercept)	0.112	0.535	0.209	0.835
Contrast	1.190	0.237	5.011	<0.001
Age	0.880	0.343	2.569	0.010
Contrast * Age	0.386	0.233	1.659	0.097

or just three of four dogs, respectively), as well as No-match responses which failed to generalize at all (i.e., no selection of any dalmatians). Additionally, because one of the distractor items in the generalization set was always an instance of the same global kind as the target (e.g., a bird, which is a kind of an animal), we reasoned that Superordinate generalizations were also a valid response for children to make (e.g., selecting all 5 animals, excluding the dresser), though those were not observed in adults. The overall distribution of these granular categories within the Other responses was: Incomplete Basic (47.1%), Incomplete Subordinate (25.5%), No-match (13.7%), and Superordinate (13.7%). Moreover, the shape of this distribution remained largely similar whether splitting by condition or age group. The large proportion of incomplete responses suggests that children may have, in fact, generated the subordinate and basic-level categories as the intended hypotheses for word meaning but simply had difficulty selecting all the necessary items from the generalization set at test. Corroborating this interpretation, a separate post-hoc model fitted to Other responses found only a significant main effect of Age (β = -0.794, SE = 0.287, p = 0.006): there were significantly fewer Other responses in five-year-olds (14.8%) than four-year-olds (39.3%), perhaps due to a greater availability of attentional resources in older children. We revisit the options within the generalization set in Experiment 2.

3.2.4 Discussion

In Experiment 1, we investigated whether children's inferences about word meaning are influenced by the presence of contrasting alternatives at the subordinate level. We found that 4-5-tear-olds, like adults, were significantly more likely to interpret a novel label as referring to a subordinate-level category (e.g., dalmatian) when they observed contrasting alternatives from the same basic-level category (e.g., other dog breeds) compared to cases where no such alternatives were visible.

This effect was robust across age groups, with five-year-olds showing an overall stronger tendency toward subordinate-level generalizations than four-year-olds. Importantly, linguistically negating that these visual alternatives shared a label with the target ("This is not a gavai") helped generate the contrastive inference promoting subordinate-level meanings for the target label *even though the visual alternatives were not themselves given unique labels.*

Our findings complement prior theorizing of contrast as a pragmatic phenomenon, and not a matter of simply attending to differences in visual and lexical form (Clark, 1987, 1990; Diesendruck, 2005; Choe and Papafragou, 2023). These findings are consistent with our hypothesis that inferences about word meaning are guided by pragmatic reasoning about the speaker's intent and the expectation for the speaker to be informative. However, our findings are hard to reconcile with proposals that view contrast only as a simple surface heuristic operating on two co-present competing words with mutually exclusive one-to-one mappings (Markman, 1987, 1989; Golinkoff et al., 1992, 1994). Relatedly, our results cannot be fully explained by perceptual accounts (Spencer et al., 2011; Jenkins et al., 2015, 2021) or other accounts of subordinate noun learning which do consider speaker intent as a filter but nevertheless rely on probabilistic inferences over positive evidence accumulated across multiple labelling events (Xu and Tenenbaum, 2007a; Lewis and Frank, 2016). In our design, participants in both conditions saw identical target exemplars and learned the target label from a single labelling event, with the critical difference being whether the alternative exemplars were also visible. A robust effect of contrast from this design suggests that learners were not simply tracking the perceptual or distributional properties of the target referent and the label, but also taking into account the broader referential context to form expectations about the intent behind the choice of a word (Choe and Papafragou, 2023).

3.3 Experiment 2

Experiment 1 offered strong evidence that contrast via a combination of referential alternatives and linguistic negation serves as a cue to subordinate noun meaning. However, because this information about contrast was always shared by both the learner and the speaker, it was less clear whether (as our pragmatic account predicts) the effect of contrast involved rich pragmatic computations over

the specific speaker's perspective and intent. Experiment 2 presents a stronger test of our pragmatic proposal, by asking whether information about contrast is further sensitive to the speaker's knowledge of the visual alternatives that participate in the contrast. In a slightly modified design, we held the learner's knowledge of the alternatives constant while manipulating the speaker's knowledge of them. If, as we have proposed, the effect of contrast is driven by inferences about what the speaker intends to communicate, then learners should be more likely to generalize novel word meanings at the subordinate level when the alternatives are known to the speaker. In that context, the speaker is expected to be more specific in their label for the target object given the need to contrast it with the alternatives. On the other hand, if the visual contrasts are not available to the speaker, children may be more likely to interpret the speaker's label as encoding the broader basic-level category, since that is informative enough for reference from the perspective of a speaker with partial knowledge.

3.3.1 Participants

Forty English-speaking 4-to-5-year-olds (mean: 5;3, range: 4;0–5;11) were recruited online from across the United States. Their families were given a $10 Amazon claim code for participating. Forty English-speaking adults were also recruited from the undergraduate subject pool at the University of Pennsylvania. They were given course credit for participating.

3.3.2 Procedure

Experiment 2 was administered via the PCIbex platform for web-based experiments. Adult participants were again tested virtually and asynchronously; child participants were tested virtually by an experimenter who guided their interactions with the experimental materials over a zoom call. In the beginning of the experiment, participants were introduced to two characters, a boy named Bob and a girl named Sally, whose voices played from pre-recorded audio. For children, Sally and Bob were introduced by the experimenter who also communicated all subsequent instructions. For adults, instructions were identical but delivered in written form:

> "Let me introduce you to two friends: this is Sally ("Hi I'm Sally!"), and this is her friend Bob ("Hi I'm Bob!"). They speak a language that sounds like English but has some words that are

different from English. Let's go see what they're doing! Are you ready?"

Participants were then shown two short videos designed to familiarize them with the display used in the task. The purpose of the videos was to ensure that participants could establish the link between a speaker's presence in the scene and their visual access to the objects that were also present in the scene. In the first video, Sally stood next to a table with a toy on it, turned to look at the toy, and then turned back to face the camera. The experimenter then asked, "Does Bob know what's on the table?" and recorded children's responses; adults entered their answer into a text box. All adults and all but two children responded with the correct (negative) answer to the question. For the remaining two children, the experimenter reminded them that "Bob doesn't know what's on the table because he is not in the room looking at what's on the table." The second video was identical, but with Bob now present, standing at the opposite side of the table from Sally. Both characters turned to look at the toy on the table, then turned back to face the camera. The experimenter then asked, "How about now – does Bob know what's on the table?" All participants responded with the correct (affirmative) answer to this question.

After participants were familiarized with the characters and the visual scene, they received the following instructions for the main task: "Now we're going to see them play with cards which have pictures on them. And sometimes, Sally will play a trick on Bob. So pay attention to what happens, okay?" As in Experiment 1, each trial involved a learning phase followed by a test phase. The learning phase presented a short scenario played over the course of three frames, with pre-recorded audio dialogue accompanying the frames (Figure 3.5). In the first frame, Sally stood next to three cards which were placed on the table. The images on the cards consisted of three exemplars from the same basic-level category (e.g., dog) that contrasted at the subordinate level (e.g., different dog breeds; a dalmatian, a corgi, and a terrier). One of the three cards served as the target card (e.g., the dalmatian) that would later be labelled by Bob. The position of the target card was randomized between trials (leftmost vs. rightmost). The number of trials and the items used in the learning phase were identical to Experiment 1. During the first frame, participants heard Sally say, "Look, do you see the cards? (Pause.) Oh, I hear someone coming." Speaker Knowledge was then manipulated between participants. In the Contrast Visible condition, Sally said nothing further. In

the Contrast Hidden condition, Sally added, "I'm gonna hide them."

In the second frame, Bob had entered the scene and was looking at what was on the table. In the Contrast Visible condition, Bob saw all three cards and said, "Oh, nice cards!". In the Contrast Hidden condition, Bob saw only the target card (the others had been hidden) and said, "Oh, a nice card!". In the final frame, Bob picked up the target card, showed it to the participants and said, "Look, this is a gavai! Do you see the gavai? Help me find more gavais." To wrap up the learning phase, the experimenter said, "Let's find more gavais."

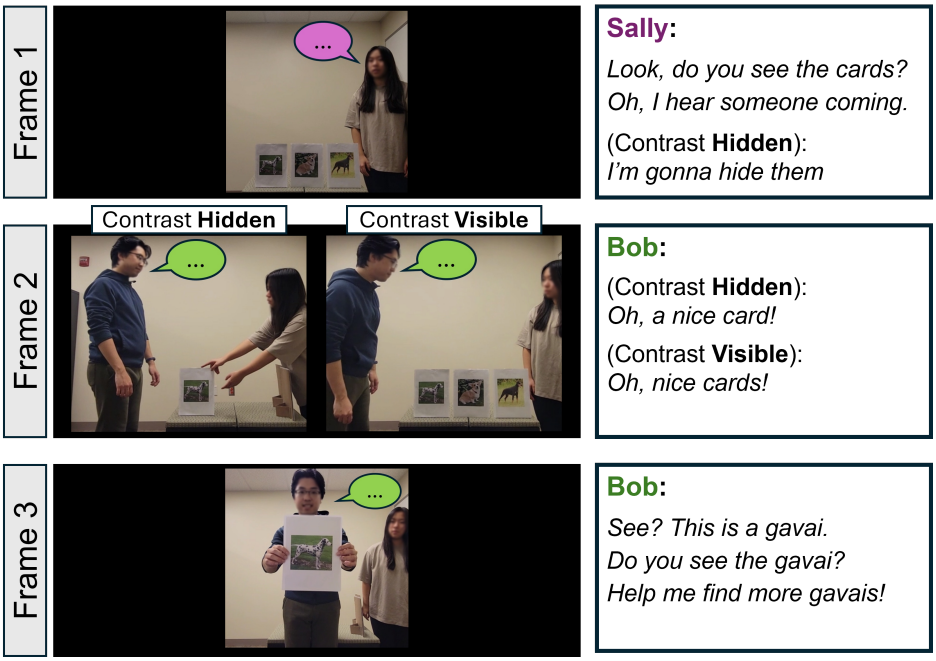

Figure 3.5: A schematic of the learning phase in Experiment 2.

At the test phase, participants were presented with a horizontal array of 6 images. For children, an animated hand moved sequentially over each image, and the experimenter said, "Do you see the moving hand? Tell me when the hand points to a gavai, okay?" The children verbally responded when the hand pointed to an image that they believed was also an instance of the target label. If they selected zero or just one image, the experimenter followed up with "Are there any (more) gavais?" to encourage complete responses (cf. Xu and Tenenbaum, 2007b). Adults freely clicked on their choices within the generalization set without the help of the moving hand.

The 6 items consisted of two subordinate matches (e.g., two different dalmatians), two basic-level matches (two different, non-dalmatian dogs), and two distractors (two different pieces of furniture; Figure 3.6). These items were identical to the generalization set of Experiment 1 except that an earlier distractor from the same superordinate level as the target (e.g., bird) was replaced for simplicity so that both distractors were from a different semantic domain from the target (recall that Experiment 1 did not find a strong tendency for children to generalize at the superordinate level). Unlike Experiment 1, the six items in the generalization set were presented simultaneously to alleviate cognitive load for children. The order of images in the set was randomized between trials. Participants' final choices were recorded and coded as Subordinate, Basic, and Other responses for analysis.

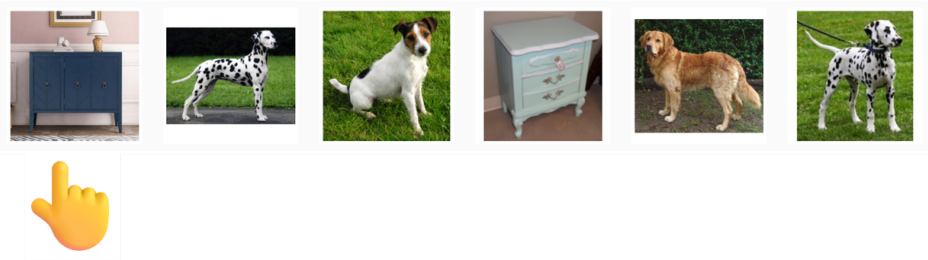

Figure 3.6: Experiment 2: Array of images from the generalization set shown in the test phase. The animated hand was only present for children.

3.3.3 Results

Starting with the data from adults, Figure 3.7 shows the distribution of word meaning generalizations at test across conditions. As expected, adults were more likely to generalize the novel label at the narrower, subordinate-level category when the speaker had access to the subordinate-level alternatives (68.1%; Contrast Visible condition) compared to when the speaker did not (58.1%; Contrast Hidden condition). A logistic mixed-effects regression model was fitted to the rate of Subordinate responses, with Speaker Knowledge as a fixed effect (sum coded: Contrast Hidden = -1, Contrast Visible = 1) and a maximal random effects structure up to by-participant and by-item intercepts and slopes, including correlations (Table 3.3). The model found a significant main effect of Speaker Knowledge in the expected direction ($\beta = 0.966$, SE = 0.343, p = 0.005).

Figure 3.7: Experiment 2: distribution of adults' responses at test.

Table 3.3: Experiment 2: logistic mixed-effects model for Subordinate responses in adults.

	β	SE	t	p
(Intercept)	1.633	0.662	2.467	0.014
Speaker Knowledge	0.966	0.343	2.817	0.005

Turning to the data from children, Figure 3.8 shows the distribution of word meaning generalizations at test. Like adults, children showed more subordinate-level generalizations of the target label in the Contrast Visible condition (45.0%) compared to in the Contrast Hidden condition (31.9%). A logistic mixed-effects regression model was fitted to the proportion of Subordinate responses (Table 3.4), with identical model specifications except for the addition of a predictor for Age (sum coded with 4-year-olds = -1, 5-year-olds = 1) and the interaction term. The model confirmed the predicted main effect of Speaker Knowledge (β = 0.515, SE = 0.189, p = 0.006). The main effect of Age was not significant (β = 0.189, SE = 0.421, p = 0.654), though the direction of effect was the same as in Experiment 1. The interaction effect was also not significant (β = -0.071, SE = 0.190, p = 0.707). Notice that children made fewer Other responses overall compared to Experiment 1 (i.e., they were more likely to make complete generalizations to the subordinate and basic-level

categories), most likely due to the simplifications to the test phase made in Experiment 2.

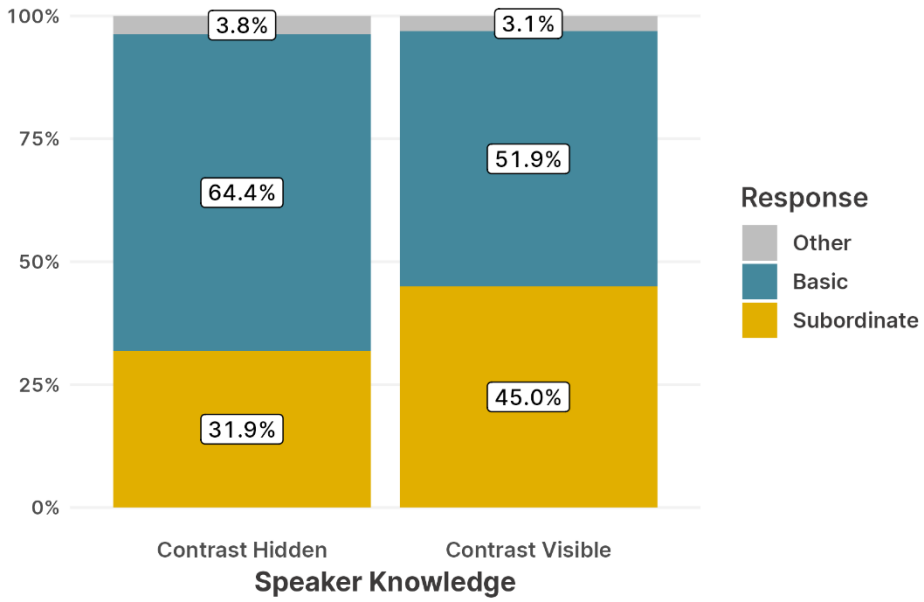

Figure 3.8: Experiment 2: distribution of children's responses at test.

Similar to adults, children showed more subordinate-level generalizations of the target label in the Contrast Visible condition (45.0%) compared to in the Contrast Hidden condition (31.9%). A logistic mixed-effects regression model was fitted to the proportion of Subordinate responses (Table 3.4), with identical model specifications except for the addition of a predictor for Age (sum coded with 4-year-olds = -1, 5-year-olds = 1) and the interaction term. The model again revealed the predicted main effect of Speaker Knowledge, such that Subordinate responses increased in the Contrast Visible condition compared to in the Contrast Hidden condition (β = 0.515, SE = 0.189, p = 0.006). The main effect of Age was not significant (β = 0.189, SE = 0.421, p = 0.654), though the direction of effect was the same as in Experiment 1. The interaction effect was also not significant (β = -0.071, SE = 0.190, p = 0.707).

3.3.4 Discussion

In Experiment 2, we found that both children and adults were more likely to interpret a novel label as referring to a subordinate-level category when the speaker had knowledge about the subordinate-

Table 3.4: Experiment 2: logistic mixed-effects model for Subordinate responses in children.

	β	SE	t	p
(Intercept)	-0.825	0.435	-1.895	0.058
Speaker Knowledge	0.515	0.189	2.727	0.006
Age	0.189	0.421	0.448	0.654
Speaker Knowledge * Age	-0.071	0.190	-0.376	0.707

level alternatives, compared to when those alternatives were unknown to the speaker. Because learners themselves always saw the visual alternatives in both conditions, this effect was tied to what the learner could infer about the speaker's mental state and, more specifically, what the speaker must have meant by their choice of the target label, given the Gricean injunction for the speaker to be informative and relevant. When the speaker had visual access to subordinate-level alternatives, participants inferred that the speaker had to be more informative and thus were more likely to generalize the meaning of the novel label at the subordinate level. However, when the speaker could only see the target object, such a demand on lexical specificity could not be expected of the speaker. As a result, learners were more likely to ignore the visual alternatives that they themselves (unlike the speaker) had seen and generalize the meaning of the novel label at the basic level.

These findings build on the results of Experiment 1 and provide strong evidence that word meaning inferences are guided by reasoning about speaker knowledge and intent, above and beyond information that is privately observed and known by the learner. This sensitivity to the speaker's epistemic state is not predicted by mechanistic accounts which operate on the perceptual details of exemplars, nor by lexical heuristic accounts which operate on competing linguistic forms observed in the input.

Notice that, unlike Experiment 1, Experiment 2 did not exclude basic-level meanings definitively: this is confirmed by the fact that Subordinate responses were lower for both adults and children in the Contrast Visible condition of Experiment 2 (adults: 68.1%, children: 45.9%) than in the Contrast condition of Experiment 1 (adults: 82.9%, children: 64.4%). In Experiment 1, the speaker linguistically negated each alternative (e.g., "This is not a gavai") before revealing and labelling the target. By comparison, Experiment 2 did not use such strong and explicit linguistic cues to signal

that the alternatives were relevant to the target word's meaning, aside from the speaker's choice to pick up and talk about just one of three items on the table in the Contrast Visible condition. The fact that learners still showed sensitivity to speaker knowledge in this condition suggests that subordinate meanings ultimately arise from inferences about a speaker's intent to be specific. Overt forms of contrast offer a strong cue to this inference, but the inference can also emerge from more general reasoning about why a speaker would choose to be specific in their reference given the information that is mutually available in the common ground and relevant in the discourse context.

3.4 General Discussion

3.4.1 Acquiring subordinate nouns

In this study, we proposed that the acquisition of subordinate nouns poses a pragmatic puzzle involving inferences about the speaker's intent. Under broadly Gricean and post-Gricean accounts, listeners engage in a rich computational process that considers the speaker's communicative intentions given their goals and knowledge state (e.g., Horn, 1972; Grice, 1975; Sperber and Wilson, 1986). Applied to the domain of word learning, these approaches predict that learners filter their interpretation of the available evidence for word meaning through the speaker's perspective (see review in Grigoroglou and Papafragou, 2021). We have argued that information from contrast is one such evidence: contrast is a helpful cue to word meaning precisely because it highlights a pragmatic pressure on the speaker, who strives to be informative, to be more specific than usual in their choice of a word. Going beyond prior findings on subordinate noun learning (Clark, 1987, 1990; Waxman, 1991; Waxman et al., 1997; Clark and Grossman, 1998; Wang and Trueswell, 2019, 2022; Choe and Papafragou, 2023), we hypothesized that young children bring these epistemic reasoning abilities into the task of learning subordinate nouns.

We tested and confirmed predictions from this proposal across two experiments. In Experiment 1, both children and adults were more likely to generalize novel labels at the subordinate level when contrastive alternatives from different subordinate-level categories were present and linguistically negated during the learning phase, compared to when only the target referent was visible. This effect

held even though participants in both conditions saw identical target exemplars and learned from a single labeling event, suggesting that learners were able to reason about the speaker's intent by interpreting the linguistically-negated labels as semantic alternatives to the target word's meaning. Complementing this interpretation of the results, in Experiment 2 we found that this contrastive inference was further modulated by the speaker's knowledge state: learners were more likely to generalize novel labels to the subordinate-level meaning when the speaker had visual access to the alternatives, compared to when those were hidden from the speaker's view. Since learners themselves always observed the contrasting alternatives in both conditions, this finding suggests that word meaning inferences were guided by reasoning about what the speaker knew and what level of specificity was appropriate for the speaker to adopt.

Combined, these results provide strong evidence for a pragmatic account of subordinate noun learning and refine prior conceptualizations of contrast in word learning which have often lacked clear consensus. Rather than contrast being a simple surface-level phenomenon involving two competing form-to-meaning mappings or immediate perceptual comparisons, we demonstrate that contrast is fundamentally a cue to speaker intent. As such, contrastive inferences are also available when visual alternatives are linguistically contrasted with implicit competing labels (Experiment 1) and when they are merely present for the speaker to consider (Experiment 2)

3.4.2 Speaker knowledge and pragmatics

Our findings contribute to a well-studied but complex picture regarding young children's emerging perspective-taking abilities. The literature on referential communication has long documented that while children around 5 years of age can successfully integrate information about a speaker's perspective in disambiguating the intended referent, this capacity is fragile and highly sensitive to task demands throughout the preschool years (e.g., Carpenter et al., 2002; Epley et al., 2004; Nilsen and Graham, 2009; Southgate et al., 2010; Houston-Price et al., 2011; Papafragou et al., 2017; Srinivasan et al., 2019; Wilson et al., 2022, with reports that even adults sometimes act egocentrically (e.g., Horton and Gerrig, 2005; Wardlow Lane and Ferreira, 2008). On one interpretation, children's difficulties stem not from an inability to represent others' mental states *per se*, but from the con-

siderable cognitive effort required for tracking and integrating this knowledge while simultaneously managing competing information sources. This is further corroborated by findings that performance correlates strongly with executive function skills, particularly inhibition (e.g., Nilsen and Graham, 2009). Our own experimental design incorporated cues that may have helped children successfully overcome these cognitive factors by establishing a clear visual link to speaker knowledge (via the presence vs. absence of the speaker in the scene) and giving children explicit goals (to help the speaker "find more gavai-s"; cf. Nadig and Sedivy, 2002; Kampa and Papafragou, 2020). Children's success in our study offers independent evidence for children's perspective-taking abilities beyond classic referential paradigms.

Additionally, the present data offer one of the earliest demonstrations of children's success with informativeness computations. Recall that the subordinate vs. basic-level distinction is logically defined in terms of informativeness; in addition, the basic-level typically satisfies the informational needs of a generic addressee, while the subordinate level is more appropriate in contexts where being more informative than usual is called for. On this perspective, taxonomic nouns can be understood as a scalar phenomenon (Choe and Papafragou, 2023), and while taxonomic specificity is unlike classical scales (e.g., quantification) in many ways, we observe similar themes. For example, children's success depends critically on the relevance of the stronger alternatives: just as children compute the pragmatic under-informativeness of *some* more successfully when the relevant alternative *all* or even *none* is made salient in the task (Skordos and Papafragou, 2016), children in our experiments increased subordinate (vs. basic-level) generalizations when the presence of semantic alternatives highlighted a contrast at the subordinate level of categorization. Moreover, the prior finding that children expect informative descriptions from speakers with full knowledge (Kampa and Papafragou, 2020) aligns with our finding that children recognized that knowledgeable speakers must have intended to be more informative in their choice of a (subordinate) word, given the relevant alternatives. These converging sources of evidence point to a more general capacity for sophisticated pragmatic computations in young children, one that integrates considerations of informativeness and relevance with the epistemic state of the interlocutors.

3.4.3 Pragmatics and word learning

Finally, our findings contribute to a rich line of research on the psychological mechanisms that guide early word learning. Classic work in language acquisition has long recognized the fundamental problem of mapping words to their intended meanings (Landau and Gleitman, 1985; Gleitman, 1990; Naigles, 1990; Fisher, 1996; Lidz et al., 2003; Papafragou et al., 2007). This is a seemingly insurmountable challenge when most word learning contexts in natural parent-child interactions are referentially ambiguous (e.g., Gillette et al., 1999; Kako, 2005; Cartmill et al., 2013). Even in the rare cases of referential certainty involving familiar entities, ambiguity in word meaning persists, such as the "subset problem" of identifying the intended level of a taxonomic description (Quine, 1960), as we have discussed at length.

In navigating this challenge, children from the earliest stages of life leverage various filtering mechanisms on the noisy and indeterminate input to identify the rare moments of clarity that hold the richest clues to a word's meaning (see review in Gleitman and Trueswell, 2020). We posit that children's pragmatic reasoning about the speaker's perspective constitutes an important filtering mechanism: by tracking information in the common ground and available to the speaker, children can constrain the space of possible word meanings that could have been intended by the speaker's choice of a specific word. Our findings support the broader perspective that word learning is fundamentally driven by principles of communication (see also Clark and Wong, 2002; Diesendruck et al., 2004; Diesendruck, 2005; Clark, 2017; Grigoroglou and Papafragou, 2021). The domain of hierarchical noun meanings is thus one instance of the pervasive involvement of pragmatic mechanisms in language acquisition, comprehension, and use.

Chapter 4

Distributional Signatures of Superordinate Nouns

4.1 Introduction

4.1.1 Word learning at the basic level and beyond

It is well-known that languages encode nominal and other meanings at various levels of semantic specificity, including the so-called basic level (e.g., *dog* Rosch et al., 1976; Mervis and Rosch, 1981), a narrower, subordinate level (e.g., *dalmatian*), and a broader, superordinate level (e.g., *animal*) along a taxonomic hierarchy. Though the precise criteria for drawing these distinctions vary cross-linguistically (and even within a language, for different meaning kinds), the universal fact that words can have completely nested meanings presents a challenge for young learners from the earliest stages of acquiring their language. This characterizes the so-called subset problem of induction (Quine, 1960): word meaning conjectures which enter into a subset-superset relationship (such as *dog* vs. *animal*) are difficult to disambiguate for children with limited evidence at their disposal. The difficulty is in part due to the fact that the meanings of these words differ only in specificity (*dalmatian* is more specific than *dog*, which is in turn more specific than *animal*), but there is little observable evidence from the physical world alone for the specificity of meaning that is encoded in a word (Kako, 2005).

In navigating this challenge, children initially show a bias for mapping novel nouns to basic-level, as opposed to subordinate- or superordinate-level, meanings (Mervis and Pani, 1980; Markman, 1984, 1990). Traditionally, the advantage of basic-level categories is thought to be derived from the

convergence of various perceptual mechanisms that give the basic level a processing boost: members of a basic-level category (e.g., for dog, different dog kinds) tend to have similar overall shapes, share a representative prototype, invite similar kinds of motor actions for a person interacting with them, and so on (see the review in Murphy, 2002). This basic-level bias has been argued to act as a constraint on word meaning conjectures that facilitates early word learning: nouns at the basic-level are acquired first and appear early in production, before subordinate and superordinate-level nouns (e.g., Mervis and Crisafi, 1982; Markman and Hutchinson, 1984; Nelson, 1988; Golinkoff et al., 1995). However, the bias also presents a challenge of its own, since it eventually needs to be set aside so that learners can acquire words beyond the basic level. In this paper, we focus on the specific issues posed by the acquisition of superordinate nouns, and the ways learners might use patterns in the linguistic input to overcome these issues during word learning (for the separate but related topic of subordinate nouns, see Waxman, 1991; Xu and Tenenbaum, 2007b; Spencer et al., 2011; Jenkins et al., 2015; Wang and Trueswell, 2019; Choe and Papafragou, 2023, among others).

4.1.2 The acquisition of superordinate nouns

As mentioned already, the literature has long observed that young children have difficulty with superordinate-level word meanings. Experimental work has shown that two-year-olds produce superordinate nouns much less often than subordinate nouns (and also much less frequently compared to mothers' production of superordinates during play; e.g., Lucariello and Nelson, 1986). The under-representation of superordinate nouns (versus subordinate and basic-level nouns) in children's production is also apparent in the MCDI data for English, which report an aggregate rate of only around 32% of children producing the superordinate noun *toy* by 18 months of age, despite toy being one of the most frequent words in the input (Fenson et al., 2007; Frank et al., 2016). This number is even lower for *animal* (15% by 18 months, 56% by 24 months), with missing parent-reported entries for other superordinate categories thought to be familiar to children by two-to-three years of age, such as *food*, *clothing*, and *tool* (e.g., Blewitt and Krackow, 1992; Blewitt, 1994; Blewitt et al., 2000).

One explanation for the difficulty of acquiring superordinate nouns is that young children's

representation of superordinate-level categories may be less developed compared to that of adults and thus not fully available for mapping onto language. Relevant evidence comes from non-linguistic classification tasks, where children from a wide age range (two-year-olds up to seven-year-olds) have trouble sorting perceptually dissimilar toys and pictures on the basis of their shared superordinate (but not subordinate or basic-level) membership (Inhelder and Piaget, 1964; Rosch et al., 1976; Mervis and Crisafi, 1982; Fenson et al., 1988), relying instead on more salient perceptual properties such as shape for determining kind inclusion (Imai et al., 1994; Golinkoff et al., 1995). For instance, in Golinkoff et al. (1995), children were first shown a target image (e.g., a banana) and then three additional images for the child to choose from: a superordinate-level match (e.g., a grape), a thematic match (e.g., a monkey), and a perceptual match (e.g., a crescent moon). When asked "Can you find another one?", three-to-four-year-olds made superordinate-level selections less than a quarter of the time, and this performance increased only slightly in seven-year-olds, who made taxonomic selections around half of the time (whereas adults always selected the taxonomic match). On one interpretation of such findings, the relevant standards for categorization are stated in the perceptual representations of young learners (Gentner, 1982; Colunga and Smith, 2005): properties like shape, texture, color, and so on are readily observable and immediately useful for subordinate and basic-level categorization, while entertaining superordinate-level conjectures is simply not the "relevant problem" for the young learner equipped with these perceptual biases (Landau et al., 1988).

On this kind of account, the acquisition of basic-level (and subordinate-level) nouns relies on the ability to hold onto distinctive perceptual representations in memory, accumulated and refined across labelled exemplars (e.g., for 'dog', having a snout, a lean body, and four legs; Samuelson and Smith, 1998; Liu et al., 2001; Colunga and Smith, 2005; Sloutsky et al., 2007; Sloutsky, 2010). In contrast, superordinate-level categories lack obvious perceptual correlates (for example, a dog, a sea cucumber, and a bee have very few perceptible features in common to define their shared membership in the category animal), and thus the acquisition of superordinate nouns is thought to involve a distinct set of learning mechanisms. On this view, superordinate nouns are consequently mastered later with the emergence of more complex logical reasoning abilities after the basic-level (and even subordinate-

level) distinctions are acquired (Mervis and Rosch, 1981; Barishe and Whitehurst, 1986). For example, children are unable to use superordinate nouns to express superordination (e.g., "A dog is an animal that has four legs and ...") until very late in development, when the necessary cognitive changes have taken place (at around the age of 7; Sinclair, 1986). Indeed, it is claimed that children may in fact be shallowly representing superordinates as collections, as opposed to kinds: when prompted to define superordinate nouns, preschool-aged children appear unable to produce verbal definitions for them (e.g., "A vehicle is a thing that ...") and resort instead to simply listing the members (e.g., "A vehicle is a car, a bicycle, ...", Anglin, 1977; Nelson, 1978; Wehren et al., 1981; Watson, 1985). According to such criteria, the relevant domain-general cognitive developments experienced in later childhood precede the acquisition of superordinate nouns in the child's vocabulary. In fact, in some theories of word learning as closely following the trajectory of concept formation (Nelson, 1974), the considerably late acquisition of superordinate nouns is taken to be suggestive of their inherent representational differences; superordinate concepts are distinguished from the subordinate and basic-level kinds because they are formed only through the child's exposure to language (Nelson, 1988). In turn, the acquisition of superordinate nouns is thought to follow a dramatic shift in the child's organization of knowledge in ways that have been characterized as a shift from functional to conceptual (Moran et al., 1964), from syntagmatic to paradigmatic (Nelson, 1977), and so on: this strongly coincides with formal schooling (Brown, 1977) and the development of metalinguistic knowledge experienced in later childhood (see review in Smiley and Brown, 1979). This general view is shared by contemporary theorists of otherwise different persuasions who posit that superordinate concepts may be "less stable" in 3-to-4-year-old children, and that learners must "acquire deeper theoretical knowledge about superordinate categories ... before these categories can become stable hypotheses for generalizing word meanings" (Xu and Tenenbaum, 2007b; cf. Liu et al., 2001).

This empirical and theoretical picture of children' failures in open-ended classification tasks has not remained unchallenged. A powerful challenge comes from a reinterpretation of children' failures in open-ended classification tasks, according to which inferring the intent of the task imposes an additional demand that skews children's performance (Markman and Callanan, 1983). In support of

this argument, Waxman and Gelman (1986) found that 3-to-4-year-olds made more superordinate-level classifications in a variant of the standard sorting task, where children were given clues to the relevance of taxonomic (superordinate kind) relations, as opposed to thematic relations. In that design, children were introduced to two puppets who were "picky" about what they liked. The first puppet who "only likes some things... things called furniture" was used in the familiarization phase to provide both the superordinate label and three instances (line drawings) of the kind (a chair, a dresser, and a stool). The second puppet who "likes a dog, or a duck, or a horse and other things like that" was introduced with those three instances presented and individually named. When the sorting task followed the standard instruction to "put the things that belong together", children failed to generalize to the animal category. However, performance improved when children were encouraged to consider the instances together as forming a set ("Look, those make a good group... How come they make such a good group?") or when the instances were given a shared label ("The puppet wants a *dobutsus*... I don't know what *dobutsus* means, but I know he likes things like a dog, or a duck, or a horse"). In another demonstration, Smiley and Brown (1979) showed that while five-to-six-year-olds do overwhelmingly respond with thematic matches in sorting tasks, it reflects a preference (as opposed to difference in capacity) that is reversible with explicit training, such as having the children model after an experimenter who makes taxonomic matches. Additionally, when the children were asked "last time you said that x (target) and y (thematic match) go together because... But is there any way that x and z (taxonomic match) can go together?", most were able to give adequate justifications for the validity of the alternative, taxonomic relationship (Smiley and Brown, 1979, p. 253).

Complementing the above evidence, research with prelinguistic infants has shown evidence for the early conceptual representation of superordinate-level kinds (e.g., animal vs. vehicle). For example, after hearing an experimenter vocalize "kind-dependent actions" on single exemplars (putting a dog to bed and saying "night, night" or putting a key to a car and saying "vroom, vroom"), 9-month-olds transferred the actions to unseen exemplars on the basis of kind (by putting animals like snake, turtle, fish, bird, and so on to sleep, but not vehicles like chair or truck or airplane; McDonough and Mandler, 1998). This pattern has been replicated for a variety of kinds including

furniture, plants, and utensils (Mandler et al., 1991; Mandler and McDonough, 1998). Similar findings with infants have been reported for other higher-level category contrasts such as animate vs. inanimate (e.g., Keil, 1989), solid vs. non-solid (e.g., Feigenson et al., 2002), and objects that can move on their own versus those that require an external force (e.g., Surian and Caldi, 2010).

Together, these data argue against the conclusion that younger children's superordinate-level concepts are inaccessible and/or immature compared to those of adults (Smiley and Brown, 1979; Benelli, 1988b; Mandler, 1992; Carey, 2009). In fact, on an alternative view, superordinate categories form part of a fundamental conceptual core (Mandler and Bauer, 1988; Mandler, 2008), from which lower-level (i.e., basic and subordinate) categories emerge during development (Waxman and Hall, 1993; Carey, 2009; Clark, 2017). On this view, the tendency to make conceptual groupings at the superordinate level is so strong that infants overgeneralize basic-level properties in inductive reasoning tasks to other instances of the same superordinate class. In one demonstration, even though 14-month-olds could recognize differences between exemplars from different basic-level categories (e.g., a dog vs. a goose), they erroneously generalized both familiar and newly taught actions such as chewing on bones from dogs to geese up until the age of two (presumably because they were both animals; Mandler and McDonough, 1998, 2000). Similarly, one-year-olds have been found to overgeneralize basic-level words such as dog to various other perceptually dissimilar animals such as squirrels, giraffes, and turtles in language production (Rescorla, 1981). To the extent that young children's representation of superordinate-level categories is not deficient or less accessible compared to that of adults, any delays or hiccups in the acquisition of superordinate nouns should thus be attributable to other factors that complicate the process of mapping such meanings onto language (for a similar perspective, see Gleitman, 1990).

Regardless of the debate around the conceptual origin of superordinate-level categories, it is clear that the various processes involved in early word learning do not favor superordinate-level conjectures for word meaning, whatever their nature may be. A separate issue then is how learners map words in their input onto already available superordinate-level meanings. There is general agreement that some linguistic cues facilitate the eventual acquisition of superordinate nouns. For example, labels are thought to steer young children away from context-based thematic relations and

towards kind-based superordinate relations (Waxman and Markow, 1995). Research shows that 2-year-olds reduce reliance on thematic matches in object sorting tasks (e.g., picking a monkey after being shown a banana) when the initial exemplar was presented with a word versus no word ("find another one" versus "find another dax", Markman, 1984; Waxman, 1990), and when the novel word serving as the target of generalization was a count noun versus an adjective (Waxman, 1990; Waxman and Kosowski, 1990). Superordinate-level generalizations in 3-to-5-year-olds are also helped by more sophisticated linguistic cues to kind-inclusion such as kind of and another, as in "This is a wug. A wug is a kind of terval. This is another terval." (Callanan, 1989; Woodward and Markman, 1998). Additionally, the acquisition of superordinate nouns is also generally taken to benefit from the labelling of multiple exemplars (e.g., Xu and Tenenbaum, 2007b; Spencer et al., 2011); this effect coheres with the observation that caregivers tend to use superordinate nouns to name sets of instances of a broader kind (e.g., White, 1982; Shipley et al., 1983; Callanan, 1985; Lucariello and Nelson, 1986).

Indeed, across many observational studies of mother-child interactions, plurality emerges as a common theme on caregiver's use of superordinate nouns in child-directed speech – superordinate nouns are more often used to refer to groups of objects as opposed to individual objects (White, 1982; Shipley et al., 1983; Callanan, 1985; Lucariello and Nelson, 1986). At the same time, superordinate nouns are rarely used for ostensive labelling (i.e., pointing and naming, as in "This is an animal") unlike subordinate and basic-level nouns (Callanan, 1985; Lucariello and Nelson, 1986). Instead, there appears to be a strong tendency to use superordinate nouns to invoke the broader category from a set of instances: even in the presence of only a pair of objects, caregivers use the superordinate label (as opposed to individually naming the objects) and do so as an opportunity to generalize to "other objects with similar functions" (White, 1982). Caregivers do sometimes use superordinate nouns to label a single referent, but only because the basic-level label is unfamiliar or unknown; in such cases, they explicitly signal the convention that the superordinate term itself is insufficient for identification ("I have no idea what this is. Some sort of animal", Shipley et al., 1983). Other times, a superordinate label is used not for identification, but to highlight the inclusion relationship with a known basic-level category ("A koala bear is an animal", Callanan, 1985). These and other evidence

have led Callanan et al. (1994) to propose that the over-representation of basic-level nouns in child-directed speech is perhaps less about the basic-level bias, but instead reflects the perceived need to "provide extra information when [caregivers] introduce [superordinate] labels" due to the belief that "children do not expect superordinate labels" (p. 135). Combined, these patterns suggest that the information encoded in the use of superordinate nouns is in fact very rich, despite the apparent sparsity of superordinate nouns in the child's input.

In sum, there appear to be special considerations for the act of naming objects at the superordinate-level of specificity which imbues it with distinctive qualities; these give rise to, and may be discoverable from, systematic patterns in the language input. In the next section, we expand on this observation to sketch a fuller linguistic-pragmatic profile of superordinate nouns and identify cues in the input that might allow learners to extract their meanings.

4.1.3 Pragmatics, distributional learning, and the discovery of superordinate meanings

Our main proposal in this paper is that there are certain semantic-pragmatic properties of superordinate nouns which lend themselves to specific patterns in their linguistic contexts of use that can in turn offer clues to their meaning. Our perspective is inspired by the treatment of the so-called "hard words" in acquisition, such as verbs of transfer (*give*, *get*, etc.) and mental state (*think*, *believe*, etc.), extensively researched in the literature on distributional learning (see Gleitman et al., 2005 for review). We posit that superordinate-level meanings like animal, fruit, vegetable, and so on are similarly elusive to direct observation. Thus, we hypothesize that the acquisition of superordinate nouns may also benefit from attending to the distributional regularities in their contexts of use, much like how syntactic bootstrapping facilitates the acquisition of referentially non-transparent word meanings (Landau and Gleitman, 1985; Gleitman, 1990; Naigles, 1990; Fisher, 1996; Lidz et al., 2003; Papafragou et al., 2007).

We start from the premise that the distribution of superordinate nouns is in part governed by their pragmatic informativeness, i.e., the circumstances that license the naming of an object (or a set of objects) at the broader category. Under this framing, the distribution of superordinate nouns

reflects the *choice* to *name* the superordinate level; this is governed by the speaker's intent, which makes it first and foremost a linguistic-pragmatic act (cf. also Waxman and Hatch, 1992; Gelman et al., 1989; Diesendruck et al., 2004; Clark, 2017; Choe and Papafragou, 2023). When the situation presents many choices for labelling a referent, a label for a broader category (i.e., the superordinate category) is less informative (Cruse, 1977; Rosch, 1978; Murphy and Brownell, 1985). In contrast, basic-level meanings are by definition preferred across many contexts of use, perhaps because – other things being equal – they are informative enough to satisfy the needs of a generic addressee (Brown and Dell, 1987; Lockridge and Brennan, 2002; Grigoroglou and Papafragou, 2019b,a). From these observations, the subordinate-basic-superordinate distinction can be understood as forming a *scale* on the basis of informativeness (Horn, 1972). This framing captures many of the observations about the special properties of superordinate nouns that give rise to their unique challenges in acquisition, as compared to subordinate and basic-level nouns. For example, the observation that superordinate nouns are often marked as insufficient for identifying a referent (e.g., Shipley et al., 1983) follows from the fact that superordinates are not generally useful for identifying a single referent because that use would be under-informative or otherwise signal lack of knowledge of the more specific, basic-level term (Levinson, 2000). Additionally, the pattern of mentioning the basic-level term when introducing the superordinate term (e.g., Callanan, 1985) and the success of this "anchoring" strategy in word learning experiments (Callanan, 1989; Waxman, 1991; Woodward and Markman, 1998) are reminiscent of children's computation of scalar implicatures that also relies on accessing a stronger alternative (Papafragou and Musolino, 2003; Foppolo et al., 2012; Skordos and Papafragou, 2016).

We make two concrete proposals in the context of this pragmatic account. First, we identify a set of linguistic environments that are likely to host superordinate (as opposed to basic-level) nouns in child directed speech by virtue of highlighting the broader category that an individual (or a set of individuals) belongs to. In this set we include *plurals*, quantifiers (specifically, *some*/*all*), wh-phrases (specifically, *what*/*which*), and the lexical frames *kind*/*type of* and *another*/*other* (also called "anchoring" cues). While they do not directly contribute to the semantic profile of superordinate nouns, we expect these distributional cues to point to superordinate nouns in the input to

a greater extent than they do to basic-level nouns. Specifically, we expect superordinate nouns to surface more often in the plural form than the singular form, above all else, because as mentioned previously, caregivers tend to use superordinate nouns to refer to multiple exemplars of a kind and rarely to refer to individual objects (e.g., White, 1982; Shipley et al., 1983), and children appear to be sensitive to this pattern in their production (e.g., Callanan et al., 1994; Blewitt et al., 2000). The quantifiers *some* and *all* are similarly used frequently to invoke a broader set (as is the case with quantification in general). Additionally, the wh-phrases *what/which* + NP are often used by caregivers to introduce the superordinate-level term in a question meant to elicit the basic-level name for an object (e.g., Nelson et al., 1993; Clark and Wong, 2002). Lastly, the lexical frames *kind/type of* and *another/other* are known to help children generalize novel word meanings to the subordinate-level even after exposure to just one or two exemplars (e.g., Callanan, 1985; Waxman, 1991). To test our hypothesis, in Study 1, we compare the rate of co-occurrence of each of these five linguistic contexts in child-directed speech with frequency-matched pairs of nouns at the superordinate (*animal*, *building*, etc.) and the basic (*cat*, *hospital*, etc.) level. Our account goes beyond prior observations about individual cues that promote children's superordinate conjectures by adding to these observations and integrating them into a pragmatically-inspired distributional account.

Second, we propose that these distributional regularities, as long as the learners attend to them, offer a powerful learning mechanism for the acquisition of superordinate nouns. In Study 2, we seek to offer proof of concept for this possibility by testing whether each of these contexts can promote superordinate (as opposed to basic-level) conjectures in a word learning experiment with adults modeled after the Human Simulation paradigm (Gillette et al., 1999), using utterances sampled from the corpus. In contrast to prior experimental work, we isolate the unique contribution of each context in facilitating superordinate-level conjectures in an impoverished setting that eliminates influences from other words in the sentence, the referential context, and the broader discourse. Together, our findings aim to show that, despite the sparsity of referential evidence for superordinate-level meanings, the acquisition of superordinate nouns is in part a matter of accessing the level of specificity encoded in the word (a process aided by attending to its distributional context of use).

4.2 Study 1: Corpus analysis

4.2.1 Data and analysis

Fifty-one corpora of English child-directed speech were retrieved from CHILDES (MacWhinney, 2000) and filtered to include input to children from the 1-to-5-year-old age range (mean age = 28 months). A total of around 1.3 million utterances across 597 children entered the initial analysis to identify sufficiently frequent superordinate and basic-level nouns occurring in the input. There were approximately 730,000 tokens tagged as nouns, consisting of over 3,000 unique concrete nouns. Of these, we identified seven superordinate noun types about either natural kinds or artefacts that have been attested to be familiar to children in the 2-to-5-year-old range in prior work: animal, fruit, tool, building, vegetable, dessert, and toy (e.g., Rosch, 1978; Blewitt and Krackow, 1992; Blewitt, 1994; Blewitt et al., 2000; Jenkins et al., 2015).[15] For each superordinate noun, we identified a basic-level noun member within the same domain respectively, matched on token frequency in the corpus: *cat*, *strawberry*, *fork*, *hospital*, *pepper*, *waffle*, and *ball*. We chose a constrained set of frequency-matched basic-level items (as opposed to a distribution of all basic-level items) because we found their distribution in the corpus to be heavily skewed, with a few high-frequency items risking an overrepresentation of the minority and the many low-frequency items contributing too sparsely to the linguistic contexts of interest for the model to reliably control for item-level effects. Moreover, a principled identification of all basic-level members under a superordinate category appeared intractable at a large scale (cf. Suffill et al., 2022). In contrast, an analysis of frequency-matched pairs yields a well-controlled context for comparison that offers intuitively interpretable effects; we return to this methodological choice later in the analysis.

Using this combined set of 14 tokens, the set of utterances was further filtered to include only those that contained at least one of these tokens, which resulted in 19,537 utterances. Additionally,

[15] As mentioned already, superordinate nouns are notoriously sparse in the input to children (e.g., Blewitt, 1983; Lucariello and Nelson, 1986). We found this to also be true of our sample. Even superordinate terms that have been frequently used and discussed in prior experimental work with young children were too infrequent in our corpus to enter into our analysis; these included *vehicle* (n=21), *insect* (n=56), *jewelry* (n=21), and *furniture* (n=73). After conducting our main analysis, we nevertheless did consider other superordinate-basic pairs not included in the original set such as *food* (n=3,081)-*cheese* (n=1,909) and *clothes* (n=1,255)-*pants* (n=700) and found consistent patterns as our main set.

only those utterances where the token appeared as the head of the noun phrase were included:[16] this excluded utterances where the token appeared as a modifier, such as "Do you wanna do the *animal* puzzle?" and "Okay, put it back in the *toy* box." The final set of 17,514 utterances entered the co-occurrence analysis. The raw token frequency of the superordinate and basic-level noun pairs used in the analysis is reported in Table 4.1.

Table 4.1: Token frequency of paired superordinate and basic-level nouns in the final corpus (Study 1).

Noun	Level	Token Frequency
toy	Superordinate	3,317
ball	Basic	4,160
animal	Superordinate	2,829
cat	Basic	2,843
tool	Superordinate	427
fork	Basic	419
building	Superordinate	327
hospital	Basic	423
fruit	Superordinate	373
strawberry	Basic	319
vegetable	Superordinate	313
pepper	Basic	274
dessert	Superordinate	237
waffle	Basic	253

Each utterance was tagged for the presence of one or more of the five linguistic contexts of interest: plurals, quantifiers (*some*/*all* + NP), wh-phrases (*what*/*which* + N), and the two anchoring cues (*kind*/*type of* + NP, *another*/*other* + N). The analysis of plurals was conducted by simply tallying up the times when each noun occurred in the plural (e.g., "animals") versus the singular (e.g., "animal") form. The other four linguistic contexts received a more local analysis: these only counted if they appeared as a modifier to the head (superordinate- or basic-level) noun. This criterion excluded utterances such as "Here's *all* different parts of an *animal*" for counting towards quantifiers. In sum, we predict that these target contexts would co-occur more often with superordinate nouns

[16]Extraction and identification of noun phrases was conducted via the SpaCy dependency parser (Honnibal et al., 2020). This was the only step in the text processing pipeline for which we recruited the parser.

than their basic-level counterparts in the input.

In addition to the five target contexts, the analysis also included two comparison contexts: ostensive labelling (e.g., "This is an animal"; *this/that/these/those* + BE + N) and definite articles (e.g., "Look at the cat"; *the* + N). These contexts were chosen because they were not expected to co-occur with superordinate nouns; they thus serve as points of comparison against the target contexts which we predicted to show a strong bias for hosting superordinate (vs. basic-level) nouns in the input. Furthermore, we suspected that superordinate nouns would in fact disprefer the ostensive labelling context, specifically, as the act of identifying and naming an object (for which this linguistic context is often used) places a strong constraint on pragmatic informativeness (Callanan, 1985; Clark and Wong, 2002). Table 4.2 describes the syntactic environment for each cue included in the analysis, along with qualifying examples from the corpus.

Table 4.2: Linguistic contexts and examples from the corpus (Study 1).

context	examples
Plural	"Oh, look at these animals here."
	"Go pick up your toys please."
some/all + NP	"Wanna go in the garden and pick some vegetables?"
	"That's where all the tools go."
what/which + N	"What animals do you want to play with?"
	"Which toy do you like the best?"
type/kind of + NP	"What kind of building is it?"
	"No, I'll get you a different kind of fork."
another/other + N	"Carrots, beets, what other vegetable do you like?"
	"Let Mommy get you another toy."
this/that/these/those +	"Oh, that is a cat."
BE + NP (comparison)	"This is a ball."
the + N (comparison)	"Where are the animals?"
	"Let's pet the cat."

4.2.2 Results

We compared the distribution of the superordinate nouns versus their basic-level counterparts within each context, as shown in Figure 4.1. We found that all target contexts hosted the superordinate nouns more frequently than the basic-level nouns. For example, the lexical frame "type/kind of

X" was nearly five times more likely to host a superordinate noun (e.g., "kind of animal") than its basic-level counterpart (e.g., "kind of cat"), and the size of this effect was similar across all five target contexts analyzed. In contrast, we found no bias for hosting superordinate nouns among the two comparison contexts. Note that since the superordinate and basic-level nouns chosen for the analysis were frequency matched, these distributional patterns are not reducible to simple frequency effects.

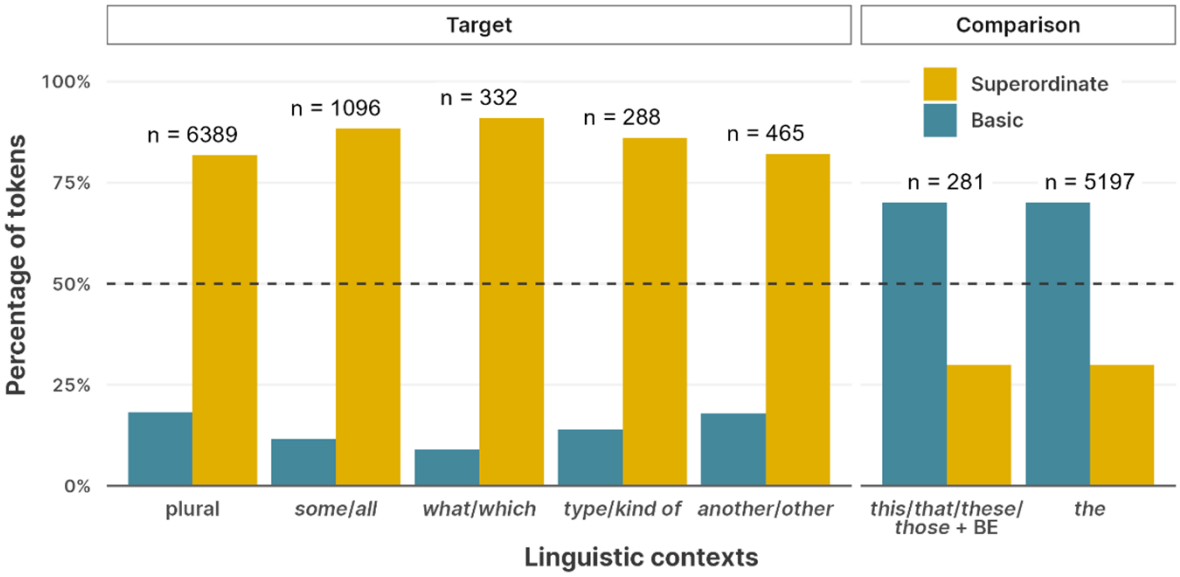

Figure 4.1: The percentage of superordinate vs. basic-level nouns within each linguistic context in Study 1. Within each context, the bars for Basic and Superordinate nouns add up to 100%, with the dotted horizontal line representing equal bias.

A logistic mixed-effects regression model (Bates and Alday, 2024) was fitted to the proportion of superordinate nouns with by-domain and by-child random intercepts and slopes, and full dummy-coding for the contexts; this tested whether the bias for superordinate (vs. basic-level) nouns was significantly different from an equal bias (i.e., log odds of zero). The model (Table 4.3) confirmed the pattern observed in the figure: all five target contexts co-occurred with superordinate nouns significantly more often than they did with the frequency-matched basic-level nouns. In contrast, the two comparison contexts appeared to slightly favor basic-level nouns over superordinate nouns in the aggregate: this opposite direction of effect was significant for ostensive labelling contexts (β

= -1.159, SE = 0.584, p = 0.047) but not for the definite article the (β = -0.163, SE = 0.581, p = 0.779) after controlling for individual variation across children and noun domains. By comparison, the target contexts were more robust to such variation in their tendency to host superordinate nouns.

Table 4.3: Logistic mixed-effects model fitted to the proportion of superordinate nouns (Study 1).

Context	β	SE	t	p
plural	1.765	0.817	2.16	0.031
some/all	2.577	0.634	4.06	<0.001
what/which	2.686	0.610	4.41	<0.001
kind/type of	4.838	1.244	3.89	0.001
another/other	2.445	1.124	2.17	0.030
this/that/these/those + BE (comparison)	-1.159	0.584	-1.98	0.047
the (comparison)	-0.163	0.581	-0.28	0.779

One might wonder whether this finding is representative of the contrast between superordinate and basic-level nouns, as there are many basic-level nouns to a superordinate noun. Therefore, in a supplemental analysis, we repeated the analysis using a different set of basic-level nouns that were the *second-closest* frequency matches to the same set of superordinates: *cat*, *kiwi*, *hammer*, *barn*, *carrot*, *pancake*, and *doll*. Whereas the original set of basic-level nouns showed an average count ratio of 1.05 (i.e., basic-level nouns slightly outnumbering superordinate nouns in the aggregate) to their superordinate matches, the replication set showed a more pronounced ratio of 1.32. Table 4.4 reports the frequency of basic-level nouns in the replication set, as well as the count ratio of each basic-level noun to their corresponding superordinate noun.

A mixed-effects regression model with the same specifications as the original analysis was fitted to the second set of items. For ease of comparison between the results from the original analysis and the replication analysis, Figure 4.2 plots the point estimates and confidence intervals for the effect of each context from the two models side-by-side (the full model output for the replication analysis can be found in Appendix A of Choe and Papafragou, 2025). Broadly, we find a similar pattern of effects for the target contexts: plurals, *some/all*, *what/which*, *kind/type of*, and *another/other* were all significantly biased towards hosting superordinate nouns versus basic-level nouns. As for the two comparison contexts, definite articles (*the*) remained equi-biased (effect size

Table 4.4: Token frequency of basic-level nouns in the replication set and the count ratio to the corresponding superordinate nouns (Study 1).

Superordinate	Basic	Basic-level token frequency (ratio to superordinate)
toy	doll	2,299 (0.69)
animal	bear	3,067 (1.08)
tool	hammer	544 (1.27)
building	barn	534 (1.63)
fruit	kiwi	295 (0.79)
vegetable	carrot	702 (2.24)
dessert	pancake	359 (1.51)

near zero) and thus did not significantly favor either level of word meaning. Ostensive labelling contexts (*this*/*that*/*these*/*those* + BE) replicated the originally estimated size and direction of the effect (favoring basic-level nouns over superordinate nouns) and again emerged as significant; this possibility was not unexpected given our prior discussion (recall that such contexts have traditionally been observed to promote basic-level meanings in caregivers' speech).

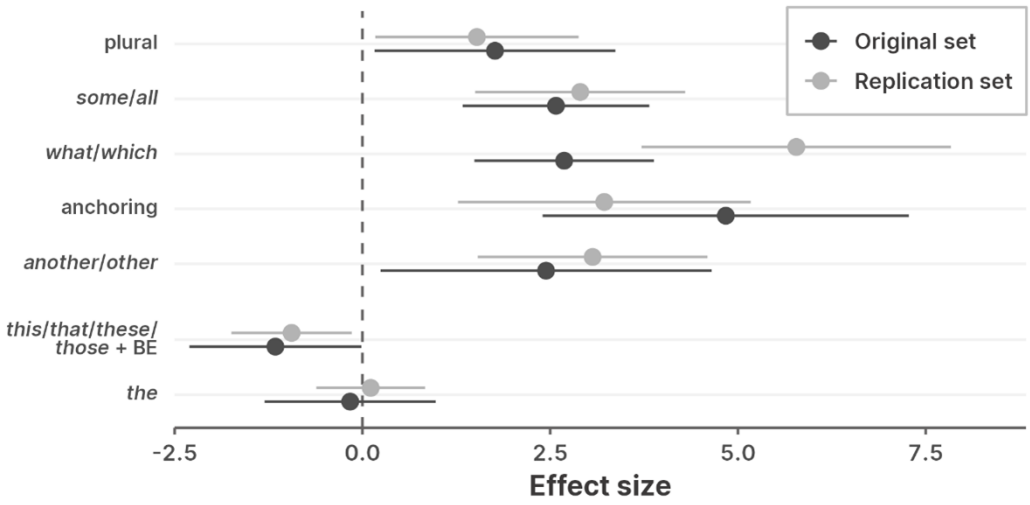

Figure 4.2: Logistic regression model point estimates and confidence intervals for the effect of each linguistic context (Study 1). Results from the original set and replication set are plotted in pairs.

4.2.3 Discussion

We proposed that superordinate nouns show distinct distributional signatures in child-directed speech, preferring to appear in environments that invoke a broader kind vs. its instances. Consistent with our prediction, we found that a certain set of linguistic contexts in the input are more likely to host superordinate nouns than their frequency-matched basic-level counterparts; for example, children are more likely to hear "kind of an animal" or "another animal" than they are to hear "kind of a dog" or "another dog." Of course, this distribution does not arise entirely from the lexical semantics of superordinate and basic-level nouns: one could just as naturally talk about different kinds of dogs as about different kinds of animals. However, superordinate nouns strongly favor these generalization-friendly environments. This finding is in accordance with our pragmatic account and the fact that superordinate nouns are generally underinformative for reference (Cruse, 1977; Levinson, 2000) and inappropriate for naming (Shipley et al., 1983; Callanan, 1985; Nelson et al., 1993). Such a pattern complements the findings from prior experimental work on superordinate-level nouns in children, and can also partly explain the mechanism for their eventual acquisition.

To be sure, the fact that superordinate nouns favor certain contexts of use in child-directed speech does not guarantee that this pattern is discoverable by the learner and leveraged in the process of acquiring superordinate noun meanings. Although some of these linguistic contexts have been studied in prior word learning experiments, they were often accompanied by additional evidence for word meaning in the referential world (i.e., the specific pictures or toys receiving the label) as well as in the broader discourse context (such as the kind of generalizing property that was mentioned or the specific goals of the task). This leaves open the extent to which these linguistic contexts *individually* and *in isolation from other cues* contribute to superordinate-level conjectures. Study 2 was designed to answer this question.

4.3 Study 2: Word learning experiment

To isolate the unique contribution of distributional cues in facilitating superordinate-level conjectures for word meaning, we conducted an experiment akin to the "human simulation paradigm"

of vocabulary learning (HSP; Gillette et al., 1999). In traditional implementations of HSP, adult participants are exposed to a series of visual cues (e.g., vignettes of parent-child interactions) or linguistic cues (e.g., full sentences taken from those interactions) that serve as the learning context for a 'mystery' word. By analyzing participants' success at guessing the word, the task probes the conditions under which the learner can successfully recover different types of word meanings. Here, we adopt an "extreme HSP" version that, in critical trials, only provides learners with one of the linguistic contexts that we have previously found to frequently host superordinate nouns in the input (Study 1) embedded within an otherwise skeletal sentence containing a mystery word ("___ ___ ___ kind of *zoke* ___ ___."). Of interest is whether, as we predict, participants will later choose a superordinate over a basic-level meaning for the mystery word when explicitly given the choice between them.

4.3.1 Participants

A hundred-and-thirty English speaking adults were recruited from the undergraduate subject pool at the University of Pennsylvania. The experiment was hosted and conducted online on the PCIbex platform for web-based experiments (Zehr and Schwarz, 2018).

4.3.2 Materials and procedure

Participants were informed of a game where the players took turns building up a story together by writing down a sentence at a time on a flash card and replacing one word in the sentence with a mystery word. The participants were told that the game had already played out, producing a set of flashcards with a different mystery word in each. Their task was to determine the identity of the mystery word in each card. Critically, all cards had some portions of the sentence blacked out; participants were told that this was done to increase the challenge of the task.

There were six between-subject critical conditions varying in the cue presented to participants on the critical trials: one condition for each of the five target contexts from Study 1 (plurals, *some*/*all*, *what*/*which*, *kind*/*type of* and *another*/*other*), plus one control condition. For each condition, we prepared 7 items (corresponding to the 7 pairs of nouns analyzed in Study 1) as follows. We first

sampled utterances from the corpus that were previously tagged for the presence of each target context in Study 1. For each of the five target contexts, we randomly selected seven sentences, one from each semantic domain analyzed in Study 1 (*toy-ball*, *animal-cat*, *tool-fork*, *building-hospital*, *fruit-strawberry*, *vegetable-pepper*, *desert-waffle*). We placed each sentence on a card and replaced all words with black spaces of appropriate length with the exception of the target word which was replaced by a 'mystery' word. The mystery word appeared in plural form in the plural condition (e.g., *zokes*) and in either the singular or the plural form in the remaining critical conditions depending on the original sentence in the corpus.

Next, participants were given a forced-choice task about the meaning of the mystery word and had to click on either the superordinate or the basic level choice within the noun pairs of Study 1 (e.g., *animal* vs. *cat*, *toy* vs. *ball*). This forced-choice design served to simulate circumstances of ambiguity in the specificity in meaning – this was done to both isolate the problem of lexical choice (as opposed to, e.g., the choice of referent) in the task and also to align the experiment to how the subset problem is typically characterized and studied in the literature (as particularly challenging for acquisition because the problem persists even when the referent has been ascertained; Quine, 1960). With the obvious exception of the plural condition, the choices alternated in appearing in either singular or plural form to match the form of the mystery word. An example trial is shown in Figure 4.3.

Lastly, in the control (Singular) condition, only the mystery word (e.g., *zorg*) was visible, surrounded by blacked-out slots of random number and length, and the choices were presented in singular form (e.g., "animal" vs. "cat"). This served as the baseline (i.e., "no context") condition where participants simply had to guess the identity of the word in the absence of any accompanying cues to its meaning and usage. Thus, we did not have a directional expectation about the preference for basic vs. superordinate meanings for this condition.

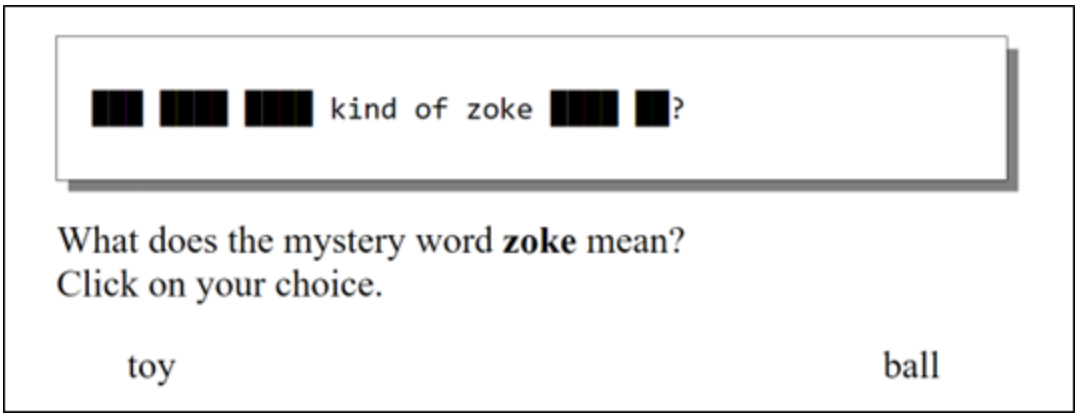

Figure 4.3: An example critical trial in the *kind/type of* condition of Study 2.

In addition, participants saw 40 filler trials (the same set of trials for all conditions) interspersed between the critical trials. Unlike critical trials, these included English phrases with a single 'mystery' word among blacked-out sections; the amount of blacked-out context around the phrase was five words long on average. Mystery words in the filler trials appeared in high-frequency n-grams and idiomatic phrases (e.g., "the eggs *bune* side up", with the choices *sunny* vs. *dirty*), in completely ambiguous contexts (e.g., "a *vate* TV", with the choices *new* vs. *old*), and in contexts where the answer was given by either unambiguous syntactic cues (e.g., "a *wube* mess", with the choices *small* vs. *run*) or semantic plausibility (e.g., "*jarm* the door", with the choices *close* vs. *melt*). Within each condition, the presentation order of all 47 items was randomized across participants. Additionally, the position of the two choices (left or right) for word meaning in the critical trials (basic-level or superordinate) was counterbalanced across items and participants.

4.3.3 Results

Four participants who performed at chance (between 40% and 60% accuracy range) on the unambiguous-syntax filler trials (e.g., "... a wube mess ...", with the mystery word choices of small vs. run) were excluded from the analysis since those trials had a clear correct answer on the basis of syntax (the remaining participants had an average accuracy rate of 98.6% on such unambiguous trials). Six additional participants were dropped in an under-sampling procedure to balance the number of participants in each between-participant condition (n=20) for comparability of effects in the statis-

tical model. Data from the remaining 120 participants entered the analysis. Results are shown in Figure 4.4.

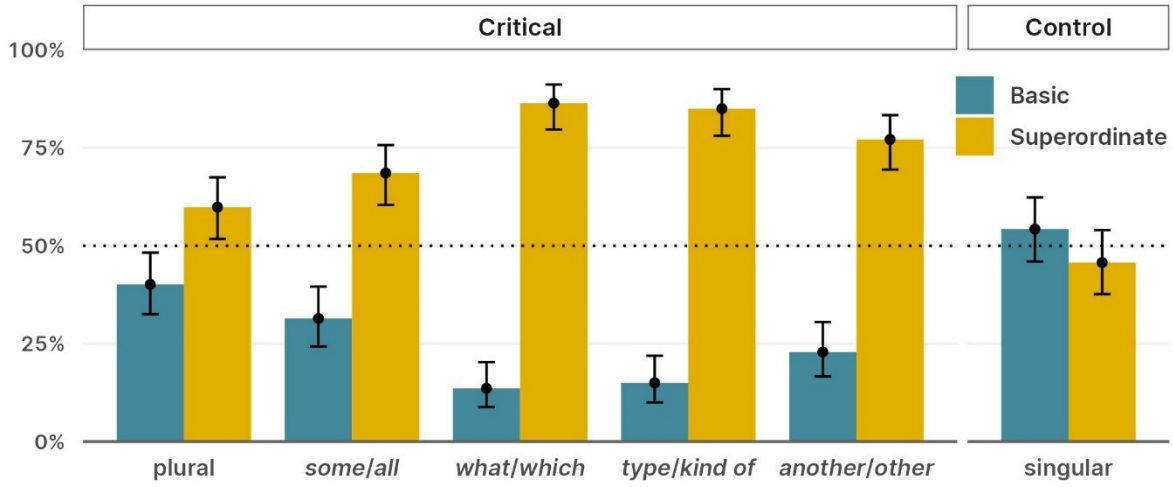

Figure 4.4: The percentage of superordinate vs. basic-level choices in each condition of Study 2.

A logistic mixed-effects regression was fitted to the proportion of superordinate noun choices, with the linguistic context as the predictor and random intercepts and slopes by subjects and items (Table 4.5). As in Study 1, the predictor was again fully dummy-coded; this tested whether the choice of superordinate vs. basic-level meanings for the mystery word was different from chance, within each of the six conditions. Results show that the proportion of superordinate responses in the singular (control) condition was not significantly different from chance (β = -0.149, SE = 0.193, p = 0.441); participants were equally likely to pick the superordinate or the basic-level meaning for the mystery word when it was presented in singular form in isolation. The plural condition revealed a marginally significant effect, showing a numerical trend in the expected direction (β = 0.409, SE = 0.211, p = 0.052). For the remaining four critical conditions (some/all, another/other, what/which, and kind/type of), participants were significantly more likely to choose the superordinate-level versus the basic-level meaning for the mystery word (all p$<$0.001).[17]

[17]For these four critical conditions, the rate of superordinate responses was similar regardless of whether the mystery word (and the choices for its meaning) were presented in singular (79.1%) or plural (78.8%) form.

Table 4.5: Logistic mixed-effects model fitted to the proportion of superordinate responses (Study 2).

Condition	β	SE	t	p
plural	0.409	0.211	1.94	0.052
some/all	0.801	0.243	3.30	<0.001
what/which	2.398	0.446	5.61	<0.001
kind/type of	1.735	0.237	7.33	<0.001
another/other	1.411	0.343	4.11	<0.001
singular (control)	-0.149	0.193	-0.77	0.441

4.3.4 Discussion

We hypothesized that distributional regularities in contexts of use of superordinate nouns in the child's input can act as cues to superordinate-level meanings. In a variant of the human simulation paradigm with adults, this hypothesis was confirmed: the surrounding linguistic environments in the *some/all*, *what/which*, *kind/type of*, and *another/other* (and marginally, the plural) conditions created an expectation for superordinate-level meanings, even in the absence of accompanying discourse and referential information. In contrast, there was neither a superordinate- nor a basic-level bias in the control (singular) condition (i.e., where a single form was presented in the absence of any linguistic cues, including plural marking).[18] These data complement prior experimental evidence for the role of linguistic cues in the acquisition of superordinate nouns and highlight the strength of these cues even in the present severely impoverished context. Combined, our findings lend support to the hypothesis that expectations for both basic- and non-basic-level meanings emerge in part from the role of various linguistic devices in highlighting the semantic breadth of a noun.

[18]Note that the superordinate and basic-level pairs of nouns used in the experiment were matched on token *stem* frequency, i.e., counting both singular and plural form. Given the finding that superordinate nouns infrequently appear in singular form (in Study 1 as well as in prior studies), one might expect a bias for basic-level nouns in the control (singular) condition. However, no such bias for the basic-level (vs. superordinate) meaning was observed when the mystery word was presented in singular form and in isolation.

4.4 General Discussion

4.4.1 Distributional cues in the acquisition of superordinate nouns

Superordinate nouns have long been thought to present a challenge for acquisition, in large part due to the belief that superordinate-level categories are absent or immature within the child's conceptual system, and thus not available for mapping onto language until later childhood (Moran et al., 1964; Sinclair, 1986; Nelson, 1988). Recent word learning models building off of this assumption have treated superordinate nouns as trivial to acquire once those categories become available for mapping; the child only needs to observe evidence against the basic-level (and narrower) hypothesis, for instance, by seeing both a dog and a cat labelled *animal*, to commit to the broader superordinate-level conjecture for the word's meaning (e.g., Xu and Tenenbaum, 2007a; cf. Liu et al., 2001). Under this framing, the problem of mapping superordinate nouns to their corresponding concepts is not experienced in the earliest stages of acquisition because children simply cannot or do not entertain superordinate-level conjectures for word meaning (e.g., Markman, 1987; Landau et al., 1988).

In this study, we focused on an alternative proposal, according to which the acquisition of superordinate nouns in part presents a distinct mapping problem, even under the assumption that the corresponding concepts are available. Drawing on prior accounts of conceptual development in early infancy (e.g., Mandler and Bauer, 1988, Mandler, 2008) and distributional word learning (e.g., Gleitman, 1990; Gleitman et al., 2005) we proposed that superordinate nouns such as *animal*, *fruit*, *toy*, and so on form a class of meanings on the basis of their semantic breadth, and so prefer to emerge in certain contexts of use over others. Consistent with this proposal, our corpus analysis shows that superordinate nouns frequently appear in environments that highlight the broader category from a set of instances; these include plural morphology, quantifiers such as *some/all*, wh-phrases such as *what/which*, and the anchoring cues *kind/type of* and *another/other*. Our analysis affirms and extends similar findings from prior work on caregivers' speech to children during play (e.g., White, 1982; Shipley et al., 1983; Callanan, 1985; Lucariello and Nelson, 1986). Thus, when considering formal aspects of linguistic distribution, a superordinate noun such as *animal* behaves more like another superordinate noun such as *fruit* than a basic-level noun from the same semantic domain

such as *cat*.

We further hypothesized that these language-internal cues that reflect the presence of superordinate-level nouns should in turn offer some clues to their meaning for the learner. In other words, while the sparse and restrictive use of superordinate nouns in the input may at first present a unique challenge for their acquisition compared to subordinate and basic-level nouns, this challenge may be overcome at least in part by attending to the distributional patterns in their contexts of use. In an extremely impoverished variant of the Human Simulation Paradigm, we found that adults took quantifiers such as *some/all*, wh-phrases such as *what/which*, and the anchoring cues *kind/type of* and *another/other* (and, marginally, plurals) as cues to a superordinate-level (versus a basic-level) meaning of the word. Furthermore, these cues exerted their influence independently (of one another) and in isolation (decoupled from other referential or discourse information; cf. Waxman et al., 1997). These findings thus add to prior work on the role of some of these cues for children's superordinate noun learning (e.g., Callanan, 1989; Woodward and Markman, 1998) and offer further evidence for the view that early difficulties for their acquisition are not reducible to immature conceptual representations (e.g., Mandler and McDonough, 2000; Kako, 2005).

4.4.2 Access to distributional cues for learning superordinate nouns

We have presented two complementary findings: (a) the distribution of superordinate nouns is well-characterized by their semantic-pragmatic properties, and (b) the meanings of such nouns are in turn discoverable from attending to their distributional regularities. One remaining question is whether the kinds of linguistic devices we have investigated here are available to young children at all, and (as we predict) are leveraged in the discovery of superordinate-level word meanings. While our present data do not address this question directly, existing evidence supports the conclusion that young learners around two-to-three-years of age can understand the form and function of the linguistic cues we have focused on and could plausibly rely on them to form superordinate-level meaning conjectures.

Beginning with plurals, although children across a wide age range sometimes reject statements involving a superordinate noun in the singular form such as "This is an animal" (while pointing

to a dog) as false, they can be led to accept and even produce a plural statement such as "These are animals" to refer to an assortment of animals (Macnamara, 1982; cf. Waxman and Hatch, 1992). On one interpretation, children recognize the frequent function of superordinate nouns for referring to a set of multiple distinct individuals and thus encode this regularity in usage with the plural morphology (Callanan and Markman, 1982; Blewitt et al., 2000). Similarly, regarding quantifiers, two- and three-year-olds have been shown to perform well in truth-value judgment tasks and *give*-quantifier tasks involving *some* and *all* (e.g., "Give him *some*/*all* of the cookies") (though their pragmatic understanding of *some* remains limited at this age; Hurewitz et al., 2006; Barner et al., 2009). The rates of children's production for *some* and *all* are also closely aligned with the most frequent superordinate nouns such as toy and animal, and presumably outpace less frequent superordinate nouns for which we lack such acquisition trajectory data entirely (Fenson et al., 2007; Frank et al., 2016).

With regard to wh-questions, children show an understanding of the form and function of questions from a very young age (Ervin-Tripp, 1970; Tyack and Ingram, 1977); relevant to the present account is the further observations that two-year-olds recognize the information seeking nature of wh-questions, the way such questions mark new and old information in the discourse, and the consequences for a speaker's lexical choice. For example, children themselves often respond at the basic or lower level of specificity when asked "What is this (called)?" and this behavior has been argued to reflect the input pattern of caretakers often mentioning the superordinate level only to mark it as insufficient for naming (e.g., "Gee, I don't know what this is. Some kind of mammal?"; Shipley et al., 1983; Clark and Wong, 2002; Luce and Callanan, 2010).

Turning to anchoring cues, three-year-olds have been shown to understand the function of the term *kind* and phrases like "kind of" for signaling subcategorization, especially when these frames were accompanied by further facts about the subclasses (Markman et al., 1980; Waxman, 1991; Waxman et al., 1997). Similarly, the use of "(an)other" accompanying a noun as in "find another *dax*" has been extensively documented in word learning studies with children as young as two years of age (e.g., Markman, 1984; Waxman, 1990). Additionally, as mentioned earlier, the use of frames such as "This is a wug. A wug is a kind of terval. This is another terval." has been found to

facilitate superordinate-level generalizations of novel word meanings in children as young as three years of age (Callanan, 1989). Combined, these demonstrations of children's understanding of the form and function of specific linguistic frames lend feasibility to our proposal: the mapping problem of superordinate nouns can be overcome by attending to the kinds of discourses that these nouns frequently appear in.

4.4.3 Probabilistic distributional cues and semantic generalizations

It must be noted that the contributions of distributional linguistic cues to superordinate meaning differ from traditional cases of syntactic bootstrapping, where the syntax often dictates a word's meaning in a deterministic manner. For example, verbs of transfer, owing to their semantics, cross-linguistically take three arguments: the English verb *give*, for instance, selects a giver, a givee, and an entity being given (e.g., "John gave a book to Mary"). This aspect of their meaning is in turn discoverable from, for example, "counting the nouns" in the argument structure (Fisher et al., 1991; Lederer et al., 1995; cf. Perkins et al., 2024). In contrast, the kinds of linguistic co-occurrences we have presented here are not determined by the semantics of superordinate nouns; for example, nothing about the fact of something being an animal makes a statement like "this is an animal" ungrammatical or false in reference to someone's dog. Nevertheless, there are clearly strong selectional pressures on when and how speakers talk about the superordinate level, which – we have argued – necessarily involves considerations of pragmatic informativeness. Moreover, to achieve adult-like competence, children must eventually come to understand why the superordinate level is more appropriate to name in some contexts than in others; thus, the convergence of various linguistic cues, in conjunction with information from the perceptual and social world, must help to reveal important aspects of superordinate-level word meanings that are also relevant in usage (Benelli, 1988a; Callanan et al., 2014; Clark, 2017).

More generally, our study highlights a predictable (though not deterministic) relationship between a word's meaning and its distribution, such that words will tend to find themselves in certain discourses that promote the expression of their core meaning. This perspective is shared with recent accounts for the distribution and acquisition of modals such as *can* and *must* (Hacquard,

2022), universal quantifiers such as *each* and *every* (Knowlton et al., 2023) and subjective adjectives (Gotowski and Syrett, 2024). Specifically, our account of the distribution and acquisition of superordinate nouns is reminiscent of how the literature has treated the mapping problem raised by the abstract and unobservable class of the so-called "hard words" in acquisition (Gleitman et al., 2005). For example, there are clear parallels between superordinate nouns as we have discussed them and the mental state verb *think*: thinking as an action and event is pervasive, but *think* is only used in situations where talking about thinking is pragmatically called for (e.g., contexts where an agent's belief is inferable and relevant; "He *thinks* that the cookies are all gone," (Papafragou et al., 2007)). In a similar manner, the superordinate-level category is always conceptually "present" in a referent by entailment, but the superordinate level is only *named* under contexts where that broader category (versus the specific individual) is relevant (for a similar perspective on other noun categories, see Kako, 2005). We have argued that this in turn points to a uniquely linguistic-pragmatic (as opposed to merely conceptual) source of early difficulty in the acquisition of superordinate nouns.

4.5 Conclusion

In two studies, we investigated the distributional signatures of superordinate nouns as a way of addressing the challenge to acquisition posed by the various levels of semantic specificity in the domain of nominals. We find that overcoming the basic-level bias to learn nouns for broader categories such as animal or toy can benefit from attending to the language-internal cues to their meanings. The peculiar yet informative distribution of superordinate nouns should play a part in the story of how children discover superordinate-level meanings as candidates for mapping onto linguistic forms.

Chapter 5

Children's Sensitivity to Informativeness: Basic-level vs. Superordinate Nouns

5.1 Introduction

Languages encode nominal and other meanings at various levels of semantic specificity, including the so-called basic level (e.g., dog), a narrower, subordinate level (e.g., dalmatian), and a broader, superordinate level (e.g., animal) along a taxonomic hierarchy (Rosch et al., 1976). The organization of hierarchical word meanings has been extensively studied in the literature on language acquisition and conceptual development (Quine, 1960). For example, it is well known that basic-level categories are privileged in both children's and adults' production and comprehension (Carey, 1978; Mervis and Rosch, 1981; Mervis and Crisafi, 1982; Markman, 1984, 1990; Cruse, 1977; Golinkoff et al., 1995; Clark, 1997; Blewitt et al., 2000; Xu and Tenenbaum, 2007b; Spencer et al., 2011). This so-called "basic-level bias" is thought to act as a heuristic that facilitates early word learning, but in turn presents a challenge for the eventual acquisition of words beyond the basic level. In this paper, we investigate the role of pragmatics in children's interpretation of superordinate nouns.

5.1.1 The challenge of learning superordinate nouns

Superordinate-level categories are traditionally thought to pose a challenge for word learning due to their conceptual abstractness. Thus, children's difficulties with superordinate nouns have often been taken to reflect conceptual limitations in early childhood. On this view, superordinates are at

first experienced by children as violations of perceptually-based categories that guide early learning (Daehler et al., 1979; Fenson et al., 1988; Landau et al., 1988; Murphy, 2002) and are mastered with the emergence of more complex logical reasoning abilities in later childhood, with the advent of formal schooling (Inhelder and Piaget, 1964; Moran et al., 1964; Brown, 1977; Nelson, 1977, 1988). In support of this view, various studies have demonstrated children's failures in both linguistic and non-linguistic reasoning at the superordinate level of categorization. One line of evidence comes from free classification tasks Inhelder and Piaget, 1964. In one such task (Golinkoff et al., 1995), two- to seven-year-old children were first shown a target picture (e.g., a banana) and were asked to "find another one" within a set of three pictures: a superordinate-level taxonomic match (e.g., a grape), a thematic match (e.g., a monkey), and a perceptual match (e.g., a crescent moon). Even seven-year-olds failed to choose a match on the basis of taxonomic kind around half of the time; adults always selected the taxonomic match. On one interpretation of such findings, children do not appreciate superordinate-level groupings, preferring instead to sort and match objects on the basis of thematic congruence or perceptual similarity.

Another line of evidence comes from observations of so-called "collection errors," in which children erroneously comprehend and use superordinate nouns to shallowly refer to a collection of many objects, as opposed to linking them to a taxonomic kind. For example, children's earliest interactions with superordinate nouns are often marked by the refusal of statements such as "This is an animal" (while pointing to a dog); no such refusals emerge when children are offered labels at the subordinate or basic-level of specificity (e.g., Anglin, 1977; Markman, 1989; Clark, 1997; Blewitt et al., 2000). Similarly, two-to-three-year-olds have been observed to pick up multiple toys when directed to "pick up a toy" (Callanan and Markman, 1982). Such difficulties in comprehension and production have also been reported in even older children. For example, unlike other word meanings (Brown, 1958), superordinate nouns resist verbal definitions: when prompted to define a superordinate noun, preschool children simply list the individual members instead (e.g., "a vehicle is a car, a bicycle, ..."; Nelson, 1978; Wehren et al., 1981; Watson, 1985). According to such perspectives, children only become able to reason about and articulate the logical properties of the superordinate level of categorization much later in childhood, and it is only at this point that children become

capable of acquiring superordinate nouns (see also Xu and Tenenbaum, 2007b).

On an alternative perspective, children's failures at the superordinate level of abstraction do not necessarily reflect conceptual limitations. For one, at least some superordinate concepts seem to be available in infancy (see review in Croteau et al., 2024). For example, Mandler and McDonough (1996) found that 14-month-olds who were shown a dog drinking water from a cup construed that event as an animal drinking water, such that they later imitated the action using other animals of disparate perceptual characteristics (e.g., aardvark, shark, etc.) but not members of non-animal categories. In another demonstration using a preferential looking paradigm, Behl-Chadha (1996) habituated 3-to-4-month-olds to a series of mammal photos, after which a pair of novel exemplars that contrasted at that category level was presented (e.g., a giraffe and a bird). Infants showed a preference for the novel non-mammal picture in those pairs, but no preference was found in a different condition where the novel mammal was paired with a previously seen mammal. Similar abilities to reason at the superordinate level in inductive generalization tasks have been reported in infants for a variety of superordinate kinds including furniture, plants, and utensils (McDonough and Mandler, 1998; Bonatti et al., 2002; Mandler, 2008; Carey, 2009; Spelke, 2022), though the scope of these abilities remains debated (Xu and Tenenbaum, 2007b; Murphy, 2016).

In the context of children's categorization, it has been argued that certain elements of the free classification paradigm skew children's performance (see review in Honke and Kurtz, 2019). For example, Markman et al. (1981) found that three-to-four-year-olds performed better at superordinate-level categorization when sorting objects and putting them away into bags, as opposed to rearranging objects on a flat surface (as had been traditionally done). Thus highlighting spatial arrangement as the goal of the task may inadvertently encourage thematic grouping in children on the basis of how objects commonly appear together in physical scenes: for example, people and chairs do not form a taxonomic category, but nevertheless "go together" in a classroom or a theatre. In another demonstration, Smiley and Brown (1979) showed that children's tendency to respond with thematic matches in sorting tasks is malleable and can be modified with explicit training in taxonomic matching (cf. Waxman and Namy, 1997).

Turning to children's labeling abilities, later research has revealed that children show a sophis-

ticated understanding of superordinate nouns in communication. For example, Waxman and Hatch (1992) found that, even though three-to-four-year-olds may respond "No" to the question "Is this an animal?" while pointing to a dog, they themselves can be led to produce the statement "This is an animal" for the same referent (e.g., when they are asked, "Is this a plant?"). Similarly, even though children sometimes refuse superordinate-level labels for single referents, two-to-three-year-olds are more likely to accept plural statements such as "These are animals" where the superordinate noun refers to an assortment (Macnamara, 1982; Callanan et al., 1994; Callanan and Markman, 1982; Blewitt et al., 2000). In sum, children's sensitivity to the various constraints on the use of superordinate nouns in language may independently contribute to the kinds of behaviors that have been classically attributed to children's conceptual limitations.

5.1.2 The pragmatics of superordinate nouns

In this study, building on the perspective outlined towards the end of the previous section, we propose that children's performance with the superordinate level of abstraction reveals their understanding of the rich pragmatic properties of superordinate nouns. In other words, rather than reflecting conceptual limitations, children's initial difficulties with superordinate nouns, as well as the later resolution of these difficulties, may be at least in part indicative of children's maturing competence in pragmatics – namely, the ability to identify the correct taxonomic level for a linguistic description to refer or predicate appropriately in context.

This reframing of the learnability challenge for superordinates represents a specific instantiation of the mapping problem (Gleitman, 1990; Kako, 2005; Choe and Papafragou, 2025): even if a child already possesses the requisite superordinate concepts (e.g., ANIMAL, FRUIT, TOY as denoting a taxonomic kind), the child must still determine which linguistic forms encode superordinate meanings. Thus, conceptual issues aside, a question remains: when does the child expect the superordinate level to be talked about? While various sources of information in the input can constrain possible word meanings, we propose that the case of superordinate nouns presents a unique communicative puzzle: listeners must recognize the conditions under which a speaker's mention of a higher taxonomic category is relevant and informative (Grice, 1975), given the availability of other

lexical alternatives.

A key assumption within this proposal is that linguistic levels of taxonomic specificity can be understood as forming a scale on the basis of informativeness Horn (1972): *dalmatian* logically entails *dog* and *dog* in turn logically entails *animal*, such that the superordinate-basic-subordinate distinction corresponds to increasing levels of informativeness. As a result of their semantic breadth, superordinate nouns are frequently, though not inevitably, under-informative (Grice, 1975), and their use gives rise to the inference that the speaker is either ignorant or unwilling to offer more specific information (e.g., Cruse, 1977; Levinson, 2000). For example, a statement such as "I saw an animal" can give rise to the inference that the speaker either does not know the name of the specific animal (an "ignorance implicature"; Sauerland, 2004) or does not want to reveal its precise identity (assuming that it is relevant to the conversation). We posit that these salient pragmatic properties must factor into the story of children's acquisition and use of superordinate nouns.

According to this rationale, the choice to name the superordinate level is governed by the speaker's intent, which makes it first and foremost a linguistic-pragmatic act (cf. also Gelman et al., 1989; Waxman and Hatch, 1992; Diesendruck et al., 2004; Clark, 2017; Degen et al., 2020; Choe and Papafragou, 2023). When the situation presents many choices for labelling a single, familiar referent, a label for a broader category (i.e., the superordinate category) is less informative Cruse, 1977; Rosch, 1978; Murphy and Brownell, 1985; Levinson, 2000; Frisson and Murphy, 2020. In contrast, basic-level meanings are preferred across many contexts of use, perhaps because – other things being equal – they are informative enough to satisfy the needs of a generic addressee (Brown and Dell, 1987; Lockridge and Brennan, 2002; Grigoroglou and Papafragou, 2019b,a).

This pragmatic account can explain many of the unique developmental patterns characterizing superordinates. Consider children's collection errors – including their rejection of statements such as "This is an animal" when referring to a single dog; Anglin, 1977), and their selection of multiple toys when asked to "pick up a toy" (Callanan and Markman, 1982). While these behaviors are not adult-like, they strongly align with the distributional patterns of superordinate nouns in the language input to children, where superordinate nouns are frequently used to refer to groups of objects as opposed to individual entities (e.g., Shipley et al., 1983; Callanan, 1985; Lucariello and Nelson, 1986;

Choe and Papafragou, 2025). This fact is entirely consistent with the idea that, for both children and adults, naming a single individual entity at the superordinate level is informationally deficient when the basic-level label is familiar and assumed to be shared with the interlocutor. Similarly, the sparsity of superordinate nouns in children's spontaneous production (e.g., Shipley et al., 1983; Lucariello and Nelson, 1986) and the general difficulty of eliciting superordinate nouns from children even in experimental settings (e.g., Macnamara, 1982) may be due to the understanding that the use of a superordinate noun can signal lack of knowledge (see also Waxman and Hatch, 1992; Callanan et al., 2014). Indeed, a metalinguistic survey with seven-to-eight-year-olds found that children believed superordinate nouns to be an unconventional and socially inappropriate way of naming things, especially when talking to adults who were deemed to be authoritative sources of knowledge (Benelli, 1988a; see also Koenig and Jaswal, 2011).

Furthermore, and most importantly for present purposes, consider the finding that children successfully produce superordinate nouns ("This is an animal") when answering questions involving other, incorrect superordinates (e.g., "Is this a plant?", uttered while pointing to a dog; Waxman and Hatch, 1992). This suggests that children are not oblivious to the semantic and pragmatic properties of superordinates, especially when those are highlighted through linguistic devices such as lexical contrast (e.g., Clark, 1987, 1994; Waxman and Hatch, 1992; Wang and Trueswell, 2019, 2022; Choe and Papafragou, 2023). This perspective aligns with similar demonstrations in other domains of pragmatic development. For example, even though earlier studies claimed that children were unable to detect the infelicity of under-informative statements (e.g., "Some giraffes have long necks" when all giraffes have long necks; Noveck, 2001), later studies have reported some degree of success (e.g., Katsos and Bishop, 2011; Tieu et al., 2015; Papafragou and Musolino, 2003; Pouscoulous et al., 2007), especially in contexts that highlight the relevance of the stronger alternative (e.g., Skordos and Papafragou, 2016; Grigoroglou and Papafragou, 2017).

Currently, this pragmatic account has not been tested directly – hence it remains to be seen whether children are sensitive to the pragmatic constraints governing the use of superordinates: Do children judge utterances with superordinate nouns as pragmatically under-informative when appropriate? And are they able to further adjust such judgments depending on the contextual

relevance of alternatives? In the present study, we explore these questions. We focus on 4-5-year-old children who have been extensively studied in the literature on the acquisition and use of superordinate nouns (e.g., Smiley and Brown, 1979; Markman, 1984; Waxman and Gelman, 1986; Gelman and O'Reilly, 1988; Xu and Tenenbaum, 2007b) and the development of pragmatic informativeness (e.g., Nadig and Sedivy, 2002; Katsos and Bishop, 2011; Skordos and Papafragou, 2016; Kampa and Papafragou, 2020).

5.1.3 The present study

In this study, we ask whether children can detect the under-informativeness of superordinate nouns, and whether this sensitivity to informativeness can be further mediated by local considerations of relevance. We raise and test two interlocking predictions of our pragmatic account. In Experiment 1, we test whether children understand that superordinate nouns can be pragmatically under-informative for naming, compared to basic-level nouns. We predict that children should be able to detect the pragmatic infelicity of using superordinate nouns to refer to single, familiar referents, as has been reported for adults. In Experiment 2, we test whether children's judgments can be modulated by differing demands on the relevance of a speaker's choice of label. We predict that the penalty for superordinate labels can be ameliorated when these labels are sufficiently informative for identifying the target referent among other visual alternatives.

5.2 Experiment 1

In Experiment 1, we probed children's (and adults') pragmatic sensitivity to informativeness by manipulating labelling at the superordinate level ("This is an animal") versus the basic level ("This is a dog") for the same, familiar item in the absence of other contextual cues. The ostensive labelling frame ("This is a ___") has been assumed to be a neutral frame for probing word meaning conjectures, including at the superordinate level (e.g., Xu and Tenenbaum, 2007b; Spencer et al., 2011; Lewis and Frank, 2018). However we hypothesize that this linguistic frame selects for a particular level of informativeness. As we have discussed earlier, our hypothesis is that, when identifying a referent for a generic addressee, speakers are expected to provide sufficiently

informative description given the common ground, which is typically at the basic-level for familiar entities (Callanan et al., 2014; Degen et al., 2020; Choe and Papafragou, 2025). Thus, we predicted that a statement with a superordinate label using this frame should be judged as under-informative, though not false, when identifying single referents, for which the basic-level label is known. We tested this prediction by adapting a paradigm that has been successfully used in the investigation of other pragmatic informativeness phenomena with children of this age (Katsos and Bishop, 2011).

5.2.1 Participants

Twenty English-speaking four-to-five-year-olds (mean: 4;9, range: 4;1-5;5) were recruited from and tested at local daycares in Philadelphia, and twenty English-speaking adults were recruited from the undergraduate subject pool at the University of Pennsylvania.

5.2.2 Procedure

The experiment was administered via the PCIbex platform for web-based experiments Zehr and Schwarz (2018). Adult participants were tested virtually; child participants were tested in person, accompanied by an experimenter who guided their interactions with the experiment on a laptop screen. In the beginning of the experiment, participants were told that they would be playing a game of "I-Spy" with a cartoon character, Mr. Lion, who appeared on the screen. For children, Mr. Lion was introduced by the experimenter who also communicated all subsequent instructions; adults received identical instructions delivered in written form.

> "This is my friend, Mr. Lion. Today Mr. Lion wants to play a game of I-Spy with us! When Mr. Lion spies something, he is going to tell us the word for it! But Mr. Lion is still learning his words, so we are going to help him."

Following the introduction of Mr. Lion, participants were shown a rating scale consisting of three strawberries (introduced as Mr. Lion's favorite snack). The strawberries were of varying sizes: small, medium, and large (see Katsos and Bishop, 2011). Participants were provided with instructions on how to use the scale to give feedback on what Mr. Lion said:

> "If Mr. Lion uses a wrong word, give him the small strawberry, so that he can do better next

time. If Mr. Lion uses the best word, give him the large strawberry. If Mr. Lion uses a word that isn't wrong, but it isn't the best word and you can think of a better one, then give him the medium strawberry."

After participants confirmed their understanding of the instructions, the trials began. All trials followed the same sequence of events: first, an image appeared next to Mr. Lion, then, a pre-recorded audio was played in which Mr. Lion described the object in the image, and finally, the strawberry scale appeared at the bottom of the screen for the participants to make their judgment (Figure 5.1). Children told the experimenter which strawberry they wanted to give to Mr. Lion; adults taking the experiment online simply clicked on the strawberry of their choice. Two practice trials with familiar objects unrelated to the goals of the experiment, involving proper names, were used to familiarize participants with the task design. In these trials, and for child participants only, the experimenter followed up on the children's choice of reward with the question, "Why do you want to give Mr. Lion that strawberry?" and recorded whether the child could produce a justification consistent with the instructions that they received for the rating scale (all children understood the function of the strawberries as a rating device).

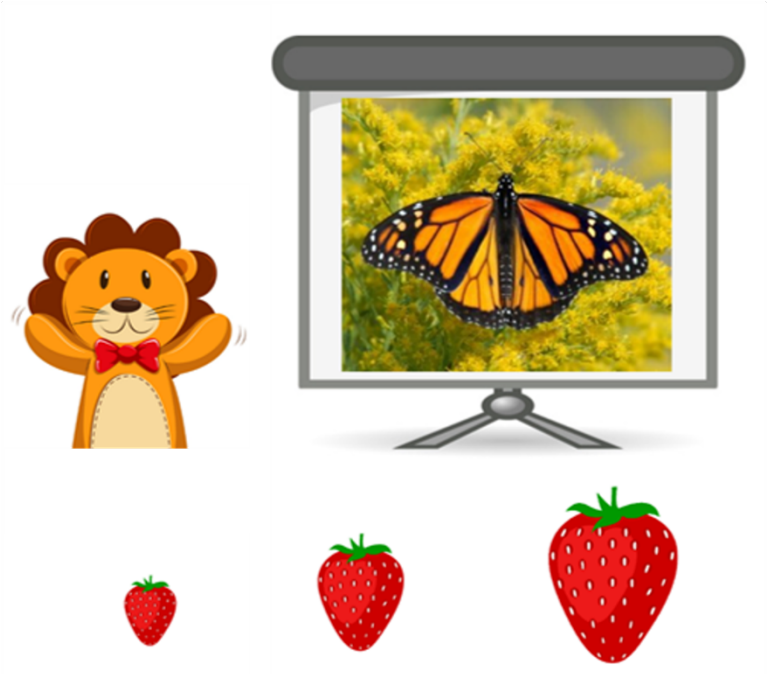

Figure 5.1: The display in a critical trial of Experiment 1. The strawberries appeared after Mr. Lion had labelled the entity.

Turning to the critical trials, Figure 5.2 shows the distribution of rewards in the adult data. We see that basic-level labels received mostly large-size rewards (85%), while superordinate labels elicited a split between large-size (45%) and medium-size (55%) rewards. (Small-size rewards were vanishingly rare throughout critical trials for adults.) To test the difference in the distribution of mid-size and large-size strawberry responses between the Label conditions, two logistic mixed-effects regression models were fitted to each reward size (Table 5.1, Table 5.2), using the MixedModels library Alday and Bates (2025) in the Julia programming language Bezanson et al. (2017).[19] The models included a fixed effect of the Label condition (sum coded with Basic-level Label = -0.5 and Superordinate Label = 0.5) with a maximum random effects structure up to by-participant and by-item random intercepts and slopes without correlations. Results showed that Label was a significant predictor in both cases: mid-size responses increased while large-size responses decreased in the Superordinate compared to the Basic-level Label condition, consistent with the view that adults judged Mr. Lion's use of superordinate nouns to be under-informative in the task.

[19] A Bonferroni correction for multiple comparisons has been applied to the p-values reported in all tables.

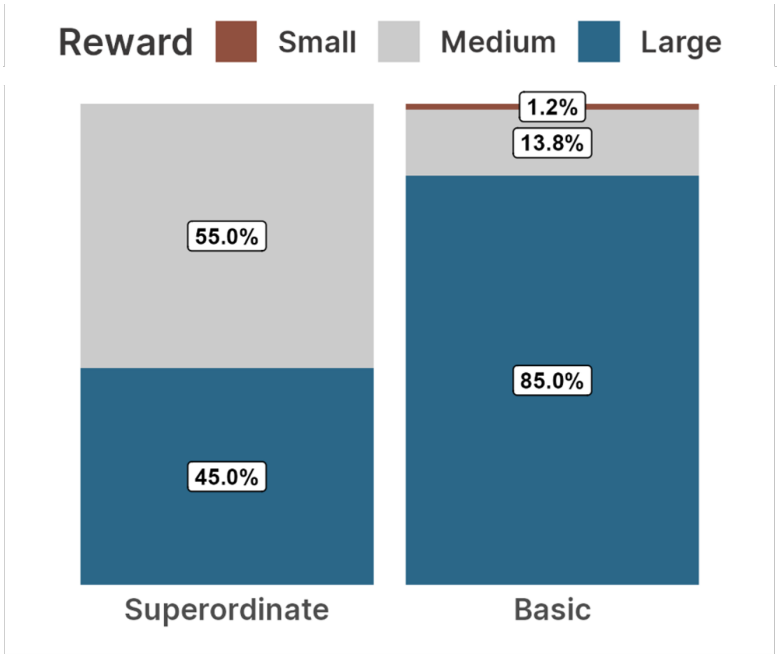

Figure 5.2: Experiment 1: distribution of rewards (critical trials) in adults.

Table 5.1: Experiment 1: logistic mixed-effects model for mid-size rewards (critical trials) in adults.

	β	SE	t	p
(Intercept)	-1.27	0.462	-2.747	0.012
Label	2.96	0.600	4.933	<0.001

Table 5.2: Experiment 1: logistic mixed-effects model for large-size rewards (critical trials) in adults.

	β	SE	t	p
(Intercept)	1.241	0.491	2.527	0.024
Label	-2.904	0.616	-4.712	<0.001

Turning to the critical trial data from children (Figure 5.3), a similar pattern was found: basic-level labels elicited mostly large-size rewards (78.8%), while the distribution of rewards was more varied for superordinate labels. Using the same model specifications (Table 5.3, Table 5.4), we found the predicted effect of Label: compared to basic-level labels, superordinate labels received more mid-size rewards and fewer large-size rewards. Additionally, we found that superordinate-labels also received more small-size rewards than basic-level labels (27.5% vs. 7.5%); this difference was found

to be significant in a separate analysis of small-size rewards with the same model specifications (β = 1.89, SE = 0.76, p $<$ 0.05). While not a core prediction of our hypothesis, we consider two possible explanations for this pattern of small-size rewards. One possibility is that this reflects children's underlying categorization abilities at the superordinate level of abstraction, i.e., their failure to identify these entities as an instance of a superordinate kind. A second possibility is that the small-size rewards are children's way of expressing a particularly strong dissatisfaction with Mr. Lion's use of superordinate nouns to identify familiar entities, i.e., a reaction akin to the "refusals" observed in prior studies (e.g., Waxman and Hatch, 1992). We return to these possibilities in Experiment 2.

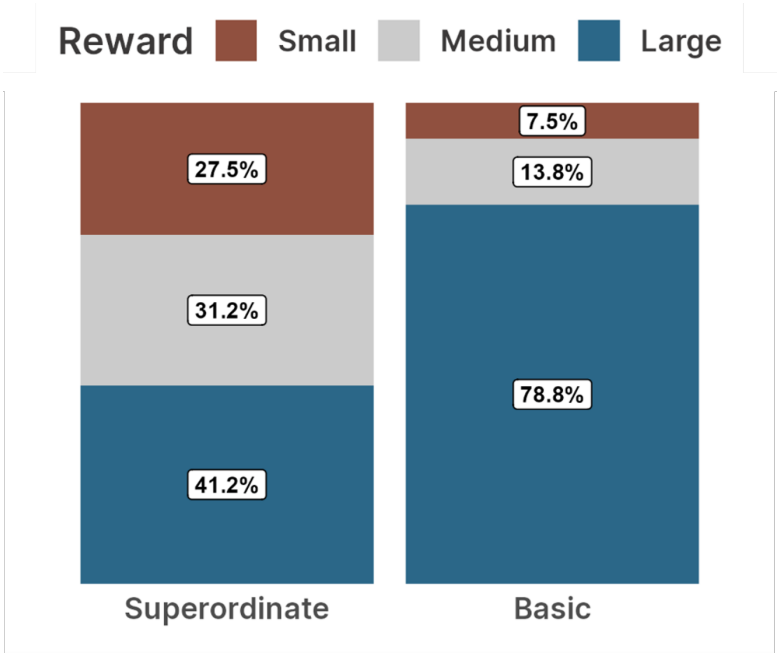

Figure 5.3: Experiment 1: distribution of rewards (critical trials) in children.

Table 5.3: Experiment 1: logistic mixed-effects model for mid-size responses (critical trials) in children.

	β	SE	t	p
(Intercept)	-1.983	0.499	-3.976	$<$0.001
Label	1.370	0.483	2.840	0.010

As mentioned earlier, children received a brief, post-experiment task where they provided their own labels for the images from the critical trials. Children's labels were coded at the superordinate

Table 5.4: Experiment 1: logistic mixed-effects model for large-size responses (critical trials) in children.

	β	SE	t	p
(Intercept)	0.906	0.610	1.485	0.274
Label	-2.902	0.763	-3.802	$<$0.001

(e.g., "insect"), basic (e.g., "butterfly"), or subordinate (e.g., "monarch butterfly") levels of specificity (no child incorrectly identified the object). We note two patterns. First, children showed a strong overall preference for labelling objects at the basic-level (71%), suggesting that the critical items were indeed familiar objects for which the basic-level label was known and preferred. Second, in those cases where Mr. Lion had previously used a superordinate label, children still produced mostly basic-level labels (64%), as opposed to repeating the superordinate label that they had heard (18%). This tendency to overwhelmingly produce basic-level labels was similar to cases where Mr. Lion had previously produced a basic-level description (87% of responses involved these basic-level terms, and no superordinates). These data confirm a general basic-level preference and show that children's choice of label was not simply dictated by what they had previously heard.

5.2.3 Discussion

In Experiment 1, we hypothesized that children could recognize that labelling objects at the superordinate level is typically pragmatically under-informative when used to name single, familiar referents. As predicted, children, like adults, gave out more mid-size rewards and fewer large-size rewards for the use of superordinate labels compared to basic-level labels, reflecting under-informativeness judgments. Furthermore, the analysis of children's production data from a subsequent task lends support to our hypothesis that this effect is driven by a contrast to the familiar basic-level lexical alternative, which children prefer when offering labels themselves. In sum, we find that children – as well as adults – judge statements such as "This is an insect" as an acceptable but not optimal way of talking about a butterfly, presumably because of their grasp of the informativeness properties of superordinate nouns.

This result is significant in part because, as noted earlier, the use of an ostensive labelling frame

to identify single referents (e.g., "Look, this is a fep!") is ubiquitous in prior research on children's categorization and word learning at the superordinate level (e.g., Xu and Tenenbaum, 2007b; Spencer et al., 2011; Lewis and Frank, 2018). Yet, our findings suggest that such syntactic frames are far from neutral – and are in fact biased against even known superordinate nouns in ways that children are sensitive to; just like adults, children recognize the pragmatic infelicity of choosing to name a referent at the superordinate level in the absence of a reason to do so. Thus, prior reports of children's poor performance in categorization and word learning tasks involving superordinate nouns may be partly explained by children's expectation that naming the superordinate level is under-informative or otherwise infelicitous in those contexts. This reasoning would in turn cause children to be reluctant to posit superordinate-level conjectures for word meaning on such a pragmatic basis.

Two additional observations are in order. First, the Superordinate Label condition (e.g., "This is an insect!") was not uniformly judged to be under-informative: even for adults, 55% of responses were mid-size rewards, but the remaining 45% were large-size rewards, reflecting an evaluation of the literal, true semantic meaning of the statement. This split is a classic signature of adults' under-informativeness judgments that has also been observed for statements such as "Some dogs are mammals" Fairchild and Papafragou (2018, 2021). The second observation is that children also gave small-size rewards in the Superordinate Label condition around a quarter of the time (but never did so in the Basic-level Label condition). While not a core prediction from our hypothesis, this pattern is not unexpected given prior reports that children show an especially strong reaction against uses of superordinate nouns and might reject even familiar superordinate nouns when used by an interlocutor to label single referents (e.g., Anglin, 1977; Macnamara, 1982). Nevertheless, this pattern, together with elevated use of basic-level nouns in children's own production, might lead one to wonder whether these responses necessarily reflect semantic/conceptual difficulties (as opposed to pragmatic sensitivity). We revisit this pattern in Experiment 2.

5.3 Experiment 2

In Experiment 1, both children and adults judged the use of superordinate nouns as less appropriate than that of basic-level nouns for identifying single, familiar referents. We hypothesized that this

effect was driven by a contrast to the basic-level lexical alternative: even though a statement such as "This is an insect" was literally true when uttered for a butterfly, it fell short of the informational needs that a regular ("generic") addressee would be reasonably expected to have. This account expects the penalty on superordinate labels to be lower in a minimally different context where superordinates would be informative enough given the goals of the conversation. In Experiment 2, we tested this prediction.

5.3.1 Participants

Forty four-to-five-year-olds (mean: 4;9, range: 4;0-5;4) and forty adults from the same demographic groups as in Experiment 1 were recruited for Experiment 2. None had participated in the earlier experiment.

5.3.2 Procedure

The procedure and materials were similar to those of Experiment 1 except for the changes noted below. Participants played a game of "Find the different one" with both Mr. Lion and the experimenter (for adults, a second cartoon character) who now took an active part in the task. At the beginning of each trial, four images in a 2-by-2 grid appeared on the screen next to Mr. Lion. One of the four images was always taken from the critical trials of Experiment 1 and was the target (e.g., the butterfly in Figure 4; the position of the target in the grid was randomized between trials). The experimenter then said, "Hey Mr. Lion, this one is different! [At that point, a red frame appeared around the target object.] What is it?" Mr. Lion responded by producing a label for the target object via the same pre-recorded audio used in Experiment 1.

Experiment 2 used a two-by-two design. First, as in Experiment 1, the Label that Mr. Lion used was manipulated within-participants: Mr. Lion either provided a Superordinate Label (e.g., "This is an insect!") or a Basic-level Label (e.g., "This is a butterfly!") for the target object (see Figure 5.4; these materials were taken from Experiment 1). Additionally, the identity of the three non-target Alternatives in the display (i.e., the "same ones") was manipulated between-participants: these visual alternatives either formed a different basic-level category within the same superordinate

domain as the target (Same-Superordinate condition; e.g., "ladybug" in Figure 4A), or a different superordinate-level category compared to the target (Different-Superordinate condition; e.g., "body part" in Figure 4B). The pairs of superordinate categories between the target and visual alternatives were: *animal–vehicle*, *building–electronics*, *dessert–plant*, *fruit–furniture*, *insect–body parts*, *tool–clothes*, *toy–meal*, and *vegetable–occupations*.

Figure 5.4: Same-Superordinate (A) and Different-Superordinate (B) conditions in Experiment 2. The butterfly was the target in this trial across both conditions. The target was described as either "This is a butterfly!" (Basic-level Label) or "This is an insect!" (Superordinate Label).

Since the experimenter identified the target as "different", participants had to rate Mr. Lion's response on the basis of how appropriate it was as a unique description for that object compared to all others in the display. We predicted that there would be an interaction between Label and Alternatives: participants would judge superordinate labels less favorably in the Same-Superordinate compared to the Different-Superordinate condition, but no such difference would emerge for basic-level labels which are always informative enough for the target. The reasoning was that superordinate labels in the Same-Superordinate condition, while contributing to logically true statements, were pragmatically infelicitous because they did not single out the target object as different from the rest (e.g., in Figure 5.4A, the utterance "This is an insect" was used to refer to the butterfly in

the presence of three ladybugs, also insects). This infelicity should be reflected in fewer large-size rewards and more mid-size rewards compared to when the basic-level label was used (e.g., "This is a butterfly") since the basic-level always uniquely identifies the target, by design. However, this penalty should be reduced in the Different-Superordinate condition, where a visual contrast at the superordinate level of categorization makes the superordinate label sufficiently informative for distinguishing the target among the alternatives (e.g., "This is an insect!" to label the target butterfly among three body parts, in Figure 5.4B).

There were 8 critical trials in total, as well as 16 fillers, consisting of 8 clearly true and 8 clearly false statements. The fillers were also adapted to use the 2-by-2 grid display. For example, in a filler involving a true statement, participants would hear Mr. Lion say "This is Elmo" after an image of Elmo had been identified as different alongside three images of another character (e.g., Cookie Monster). All participants saw the identical set of filler trials. For the critical trials, the Label and Alternative manipulations were counterbalanced across four item lists. The presentation order of all filler and critical trials was randomized for each participant.

5.3.3 Results

Accuracy on filler trials was again high in both adults (83.1%) and children (84.6%), suggesting that the instructions for the scale remained appropriate given the changes to the paradigm in Experiment 2. The distribution of different-size rewards in the critical trials was again analyzed by fitting logistic mixed-effects regression models within each age group. All models included fixed effects of Label and Alternatives, as well as their interaction. The models also included a maximum random effects structure up to by-participant and by-item random intercepts and slopes for both conditions, without correlations. The analysis used sum coding for Label (Basic-level Label = -0.5, Superordinate Label = 0.5) and Alternatives (Same-Superordinate = -0.5, Different-Superordinate = 0.5).

Starting with adults, Figure 5.5 shows the distribution of rewards, first split by the Alternatives manipulation and then by the Label manipulation. Our predictions were not borne out: the visual alternatives did not modulate adults' judgment of superordinate labels for either mid-size (50%

vs. 47.8% for Same-Superordinate vs. Different-Superordinate, respectively) or large-size rewards (38.6% vs. 47.8% for the same comparison). Statistical analysis confirmed that the interaction between Alternatives and Label was not a significant predictor for either mid-size or large-size rewards; only the main effect of Label emerged as statistically significant, reflecting the global pattern in the data where superordinate labels are penalized more heavily than basic-level labels (i.e. they elicited overall more mid-size rewards and fewer large-size rewards than their basic-level counterparts; Table 5.5, Table 5.6). We return to this pattern later in this section. For completeness, we add that small-size responses appeared to a limited degree in the adult data of Experiment 2 and only for superordinate labels (see Figure 5.5).

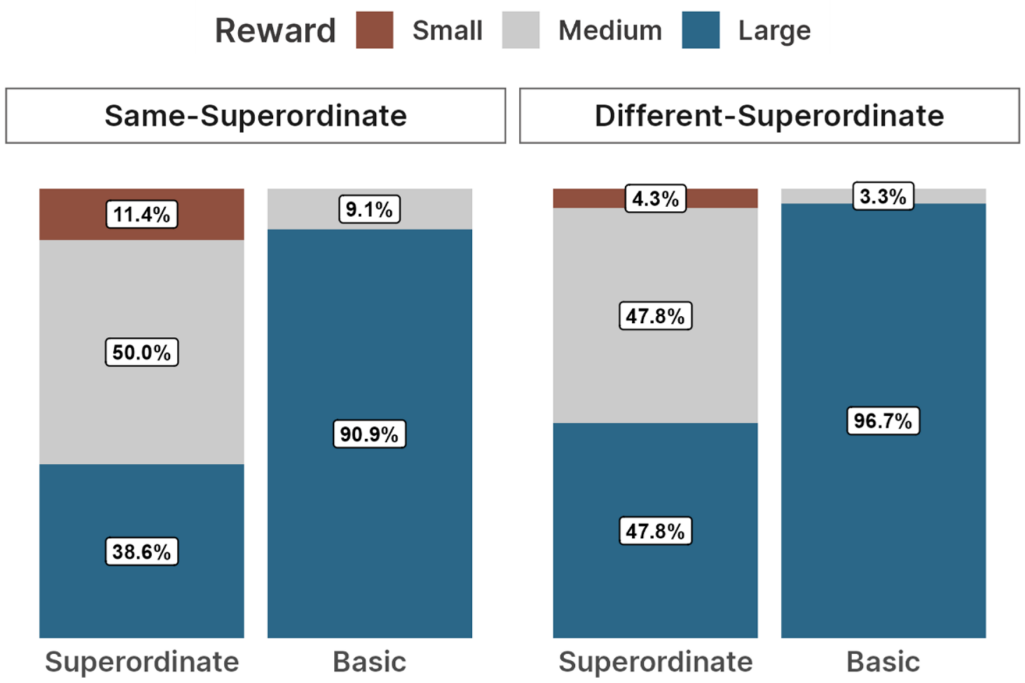

Figure 5.5: Experiment 2: distribution of rewards (critical trials) in adults.

Turning to the data from children (Figure 5.6), the distribution of strawberry responses produced the expected pattern: even though superordinate labels overall were penalized through more mid-size and fewer large-size rewards compared to basic-level labels, this penalty was reduced when the superordinate label uniquely identified the target among the visual alternatives (Different-Superordinate

Table 5.5: Experiment 2: logistic mixed-effects model for mid-size rewards (critical trials) in adults.

	β	SE	t	p
(Intercept)	-3.378	0.761	-4.440	<0.001
Alternatives	-1.060	1.435	-0.739	0.878
Label	6.573	1.418	4.636	<0.001
Alternatives * Label	1.891	2.433	0.777	0.874

Table 5.6: Experiment 2: logistic mixed-effects model for large-size rewards (critical trials) in adults.

	β	SE	t	p
(Intercept)	3.155	0.995	3.172	0.003
Alternatives	2.028	2.044	0.992	0.642
Label	-9.030	1.935	-4.666	<0.001
Alternatives * Label	0.497	3.545	0.140	1.000

condition) compared to when it did not (Same-Superordinate condition). The models confirmed that the Label by Alternative interaction effect was a significant predictor for both mid-size and large-size responses (Table 5.7, Table 5.8); post-hoc models further showed that, when splitting the data by Label, the effect of Alternatives was driven by differences within the Superordinate Label cell (mid-size reward p = 0.026, large-size reward: p = 0.034) but not within the Basic-level Label cell (mid-size reward p = 0.114, large-size reward p = 0.055), reflecting the fact that adults consistently evaluated basic-level labels at ceiling. Combined, the data suggest that the presence of visual alternatives from a different superordinate category reduced the penalty on the use of a superordinate label to identify the target, as predicted. For large-size responses only, we also found a significant main effect of Label, confirming the underlying, baseline preference for basic-level labels as previously discussed (Table 5.8). Finally, similar to Experiment 1, we continued to find small-size rewards for superordinate labels at consistent rates across both experimental conditions (25% and 22.3%); a separate analysis of small-size rewards with the same model specifications confirmed that small-size rewards were driven solely by a significant main effect of Label (β = 3.02, SE = 1.13, p < 0.01).

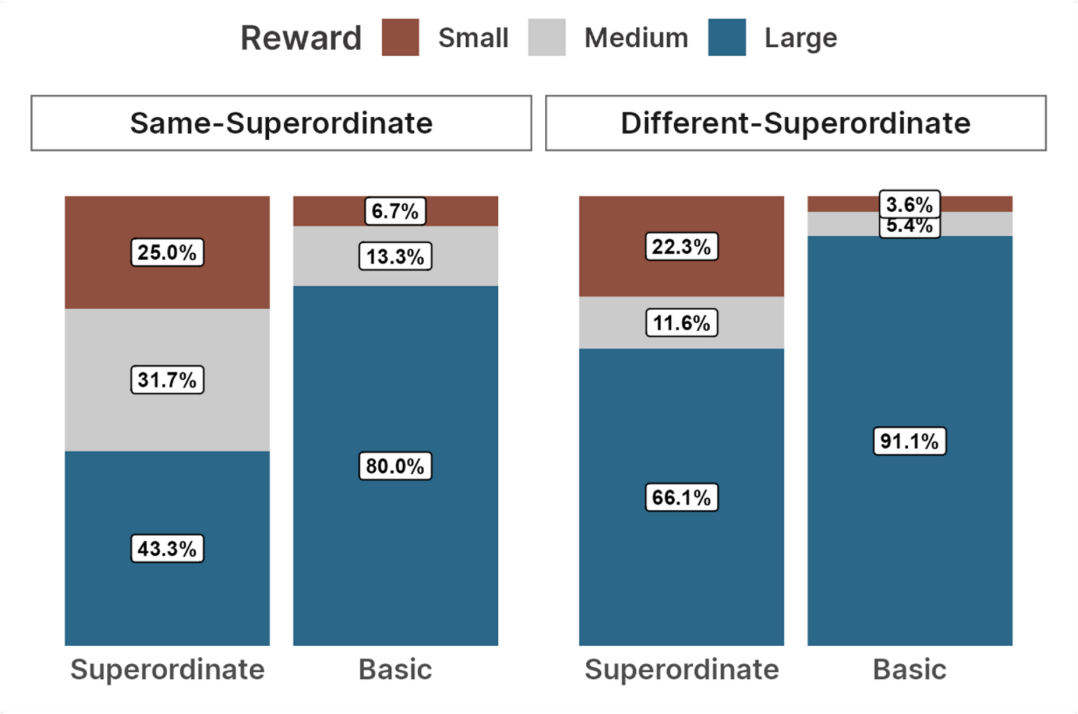

Figure 5.6: Experiment 2: distribution of rewards (critical trials) in children.

Table 5.7: Experiment 2: logistic mixed-effects model for mid-size rewards (critical trials) in children.

	β	SE	t	p
(Intercept)	-2.500	0.322	-7.774	<0.001
Alternatives	-0.303	0.471	-0.645	1.000
Label	1.140	0.471	2.423	0.308
Alternatives * Label	-3.350	1.286	-2.606	0.018

Table 5.8: Experiment 2: logistic mixed-effects model for large-size rewards (critical trials) in children.

	β	SE	t	p
(Intercept)	1.163	0.270	4.311	<0.001
Alternatives	0.082	0.336	0.244	1.000
Label	-2.054	0.431	-4.762	<0.001
Alternatives * Label	2.394	0.869	2.754	0.012

One puzzle from the adult data remains: why do adults appear pragmatically insensitive to

different Alternatives, especially given children's success? In a subsequent replication experiment, we sought to answer this question. The replication (N = 40 adults) was identical to Experiment 2 except that it also asked participants to type in a justification for their choice of reward in all critical trials. We were particularly interested in whether justifications for mid-size rewards in the Superordinate Label condition (e.g., "This is an insect"; Figure 5.4) would reveal underlying differences if split by Alternative. The main results from the replication were identical to Experiment 2, with only the main effect of Label being significant for mid- and large-size rewards (see section A.2: Figure A.5, Table A.1, and Table A.2). The justifications for mid-size rewards (a sizable portion of the data, see Figure A1) were coded into three categories depending on whether they mentioned (a) the other visual alternatives in the scene (e.g., "The rest are insects too"), (b) the stronger lexical alternative for the target (e.g., "This is specifically a butterfly"), or (c) other reasons (Table 5.9).

Justification...	Same superordinate	Different superordinate
mentions the other visual alternatives	**63%**	10%
mentions the stronger lexical alternative	33%	**80%**
mentions other reasons	4%	10%

Table 5.9: Experiment 2 replication (adults): Justifications for mid-size rewards in the Superordinate Label condition, split by the Alternatives manipulation (Same- vs. Diferent-Superordinate).

We find that, in the Different-Superordinate condition where a superordinate label was sufficient to uniquely identify the target, the majority of responses (80%) justified the mid-size reward by mentioning that the more specific label must have been available to the speaker (e.g., "This is indeed an insect, but he could be more specific and say it's a butterfly."). In other words, participants recognized that while the speaker had given an adequate response, they could have also chosen an even more felicitous (and known) word. By contrast, in the Same-Superordinate condition, the majority of justifications for the mid-size reward (63%) mentioned the other visual alternatives, recognizing that this response was not specific enough for the informational demands of the task. In sum, adults' judgments of superordinate labels were primarily driven by consideration of the speaker's lexical alternatives in general (i.e., other words that Mr. Lion could have said but did not) beyond a simple consideration of the set of lexical options that could satisfy the immediate goals of the task.

5.3.4 Discussion

In Experiment 2, we asked whether children's judgments of superordinate nouns could be modulated by the relevance of a label at the superordinate level. Specifically, we hypothesized that the under-informativeness penalty for superordinate labels would be ameliorated when those were sufficiently informative for distinguishing the target image from visual alternatives. More concretely, we predicted that superordinate labels would be judged more favorably in the Different-Superordinate condition, where they uniquely identified the target (e.g., "This is an animal!" when the others were non-animals), compared to the Same-Superordinate condition, where superordinate labels did not distinguish the target from the visual alternatives (e.g., "This is an animal!" when the others were also animals).

Results show that children attend to such local considerations by evaluating the relevant dimension of contrast between the target and the visual alternatives. The distribution of rewards for superordinate labels was modulated by the Alternatives manipulation: children provided more large-size rewards (66.1% vs. 43.3%) and fewer mid-size rewards (11.6% vs. 31.7%) for superordinates in the Different-Superordinate condition compared to the Same-Superordinate condition. This suggests that children were able to consider the visual alternatives to be relevant for the speaker's choice of word. In doing so, children ameliorated the penalty on superordinate labels in the Different-Superordinate condition compared to the Same-Superordinate condition.

Adults, however, departed from this pattern; they maintained a consistent distribution of mid-size and large-size rewards regardless of the makeup of the visual alternatives. Data from a replication experiment prompting adults to provide explicit justifications revealed that, in addition to considering the visual alternatives, adults also consulted the lexical alternatives that must have been available to the speaker. On that basis, a knowledgeable speaker's choice of a superordinate noun generates the more specific basic-level lexical alternative. Accordingly, we find that adults overwhelmingly justified their mid-size rewards by casting Mr. Lion as knowledgeable but unwilling to produce the basic-level label. In sum, adults appear to more readily engage in the richer computational process that takes into account the speaker's communicative intentions given their goals and knowledge state (see, e.g., Horn, 1972; Sperber and Wilson, 1986; Carston, 1998; Sauerland, 2004,

2012; Geurts, 2010); this is reminiscent of a parallel finding from production, where adults prefer to produce over-informative descriptions at the basic-level even when a superordinate label would suffice (Degen et al., 2020). By contrast, children may have only considered the locally available alternatives specific to the goals of the task. This reveals a potentially important developmental difference: while children seemingly attend more to the local demands on informativeness brought on by changes to the task (of labelling what the "different one" is), adults additionally evaluate the total lexical alternatives that must have been available (or unavailable) to the speaker.

Finally, as in Experiment 1, children continued to give small-size rewards to superordinate labels. We previously raised two possible explanations for this pattern: a semantic/conceptual difficulty associated with the superordinate level of abstraction, or a "refusal" against the use of a superordinate noun, given the strong linguistic-pragmatic constraints that license its use (e.g., the fact that such nouns typically make for under-informative singular referents for familiar objects; Shipley et al., 1983; Callanan, 1989; Blewitt et al., 2000; Choe and Papafragou, 2025). The finding that adults also sometimes gave small-size rewards to superordinate labels in Experiment 2 offers evidence against the conclusion that these patterns must reflect deficiencies in children's underlying categorization abilities. Instead, this finding lends support to the alternative possibility that a strong dis-preference for the use of a superordinate label can be expressed through the small-size reward. In other words, for both children and adults, a superordinate label could be judged as "wrong" in senses other than strictly logical (recall that the instruction for the small strawberry was "If Mr. Lion uses a wrong word . . . "). Thus, for the present data, we take small-size rewards to reflect the strongest penalty for the use of a superordinate noun.

5.4 General Discussion

In this study, we investigated children's sensitivity to the pragmatics of superordinate nouns. Across two experiments, we found that 4-to-5-year-old children penalize the use of superordinate nouns when they are pragmatically under-informative. In Experiment 1, children (and adults) rated superordinate labels (e.g., "This is an insect") using more mid-size and small-size rewards and fewer large-size rewards compared to basic-level labels (e.g., "This is a butterfly"), demonstrating an under-

standing that superordinate nouns are infelicitous for naming single, familiar objects. Furthermore, in Experiment 2, children's penalty for a superordinate label was significantly reduced when the superordinate label uniquely identified the target among visual alternatives of a different superordinate category compared to when the visual alternatives were from the same superordinate category as the target. In Experiment 2, however, adults were "overly pragmatic" compared to children: they consistently preferred the basic-level lexical alternative regardless of whether the superordinate label was sufficient for the task. Below we discuss implications of these results for theories of how superordinate meanings develop and, more broadly, how pragmatic principles shape children's use and comprehension of taxonomic labels.

5.4.1 Superordinate and basic-level meanings in acquisition

Our findings provide important insights into the long-standing debate about children's acquisition of superordinate vs. basic-level nouns. As discussed in the Introduction, traditional accounts have attributed children's difficulties with superordinate nouns to immature conceptual representations, suggesting that children lack the ability to reason about class inclusion relationships at the highest levels of taxonomic categorization until later childhood (e.g., Inhelder and Piaget, 1964; Rosch et al., 1976; Murphy, 2002). This view holds that superordinate concepts emerge relatively late in development, after children have mastered the basic-level categories and developed more sophisticated and abstract logical reasoning abilities (e.g., Rosch et al., 1976; Murphy, 2002).

The results from our experiments support an alternative interpretation: children's challenges with superordinate nouns may at least in part reflect their developing pragmatic competence. For one, the finding from Experiment 1 that children can treat superordinate labels as under-informative (versus wholly incorrect) is difficult to capture if children cannot represent the entailment relationship between superordinate and basic-level meanings. If the concepts were degraded, we might have expected a strong dislike for superordinate labels that would persist globally across tasks. Additionally, children's sensitivity to local contextual factors in Experiment 2 reveals an understanding of the pragmatic interplay between informativeness and relevance constraints that govern the usage of superordinate nouns: children recognized that labelling at the superordinate level can become more

appropriate when it serves the purpose of uniquely identifying the target among visual alternatives (the Different-Superordinate condition) compared to when it does not (the Same-Superordinate condition). This suggests a sophisticated understanding of both the semantic properties of superordinate nouns and the pragmatic principles that affect their use. Thus, our findings align with prior demonstrations of children's improved ability to respond at the superordinate level upon a more careful control of task demands (e.g., Smiley and Brown, 1979; Markman et al., 1981; Waxman and Hatch, 1992).

These findings also cohere with available evidence pointing at the early availability of superordinate concepts in infancy (Croteau et al., 2024) and address an apparent developmental paradox Murphy (2002): how could a concept be present early in thought and yet emerge late in language? Our study sought to address this puzzle from the angle of pragmatics: conceptual issues aside, there is a separate and nontrivial problem of knowing when superordinate level meanings rise to the level of being talked about in language. We posited that, if children's knowledge of the pragmatic properties of superordinate nouns is still maturing, then that may explain some of the challenges that have been documented in prior studies. Consider the finding that children, unlike adults, perform poorly in prior word learning studies involving superordinate noun meanings introduced via simple, ostensive labeling ("This is a *wug*"; Xu and Tenenbaum, 2007b; Spencer et al., 2011; Lewis and Frank, 2018). Far from being simple, however, these frames do not naturally host superordinate nouns (e.g., Cruse, 1977; Shipley et al., 1983; Callanan, 1989; Choe and Papafragou, 2025) for reasons that, we propose, are pragmatic in nature. Thus, our study highlights a previously overlooked explanation for children's comparatively poor performance in superordinate noun learning tasks: children do not expect superordinate nouns to appear in such linguistic contexts on the basis of their pragmatic properties, and (unlike adults, who can presumably overcome the pragmatic infelicity of the ostensive frame) do not entertain superordinate meanings as a hypothesis for the novel word's meaning. Our study also suggests that attending to the pragmatic constraints that license the use of superordinate nouns in language may facilitate the mapping of superordinate meanings onto novel linguistic forms.

5.4.2 Superordinate vs. basic-level nouns as a scalar phenomenon

On the present account, the basic-level bias in both children and adults is – at least partly – driven by pragmatic considerations: specifically, the fact that the "basic" level of specificity typically satisfies the informational needs of a generic addressee. A key part of this account is the assumption that superordinate and basic-level meanings form a scale of semantic specificity in a similar manner to the universal quantifiers *some* and *all* that are standardly taken to form a scale (Horn, 1972). Thus, computing the under-informativeness of statements such as "This is an animal" (while pointing to a dog) and "Some dogs are mammals" should draw on a shared set of pragmatic competencies.

The present data offer one of the earliest demonstrations of children's success with informativeness computations (cf. also Stiller et al., 2015; Kampa et al., 2024). Recall that this area has attracted a lot of experimental attention and is typically thought to pose challenges to five-year-olds and sometimes even older learners (Noveck, 2001; Barner et al., 2011; Papafragou and Musolino, 2003). At the same time, there have also been reports of young children's success (e.g., Papafragou and Musolino, 2003; Pouscoulous et al., 2007; Katsos and Bishop, 2011; Tieu et al., 2015; Kampa and Papafragou, 2020). Despite their differences, these accounts converge on the idea that, to evaluate informativeness, the listener needs to access and reason about a stronger, more informative alternative that the speaker could have uttered, but did not. Our data strongly support this idea and further show that children's – and adults' – pragmatic reasoning takes into account not simply the informativeness but also the relevance of scalar alternatives as well (see Skordos and Papafragou, 2016).

Our data raise several further questions about the place of taxonomic nouns along scalar phenomena. Compared to classical scales (e.g., quantificational scales involving some and all), names for entities can contrast along many different dimensions, not just specificity: a dog is also an animal, but it can also be called a pet, a friend, Lucy, and so on, with each lexical alternative potentially invoking a different dimension of comparison (Macnamara, 1982; Shipley and Kuhn, 1983; Clark, 1997). We leave a fuller exploration of these properties of taxonomic scales to future research.

The present scalar-pragmatic account to taxonomic nouns can be extended in a number of straightforward ways. First, pragmatic considerations should generalize beyond the basic and su-

perordinate to the subordinate level as well (see Choe and Papafragou, 2023 for a related proposal). Second, children's assessment of taxonomic alternatives should be constrained by the speaker's mental state, as predicted by a fully pragmatic rich-computation model (Grice, 1975; Sperber and Wilson, 1986; Carston, 1995). Lastly, given the ubiquity of taxonomic hierarchies in natural language meanings, the present findings from English-speaking children and adults are expected to generalize cross-linguistically. We are pursuing these directions in ongoing work.

5.5 Conclusion

In this study, we investigated children's knowledge of the pragmatic properties of superordinate nouns. Our findings demonstrate that children, like adults, recognize that the use of superordinates can violate expectations of informativeness, but can also modulate this judgment when contextual factors make the superordinate level relevant and sufficiently informative. The present data and theorizing allow us to synthesize prior, sometimes conflicting results about children's use and comprehension of superordinates into a coherent picture.

Taken at their broadest, the present data bear on the long-standing idea that the emergence and use of vocabulary in young children offer a straightforward piece of evidence for the timetable of conceptual change (for classic statements of this idea, see Inhelder and Piaget, 1964; Brown, 1977; Johnston and Slobin, 1979; Huttenlocher et al., 1983; Bowerman, 1996). Our findings suggest an alternative, perhaps complementary, perspective: children's lexical use and comprehension do not necessarily reflect incorrect semantic meanings or immature concepts, but rather pragmatic pressures that are also active in adult communicators. As the present data suggest, in navigating these pressures, children display previously overlooked signatures of pragmatic competence, thereby confirming the pervasive role of pragmatics in early communication.

Chapter 6

Conclusions

The goal of this dissertation was to investigate a puzzle in word learning: while children are quick to acquire basic-level nouns like "dog" – owing to various constraints, biases and heuristics – they must eventually also acquire words that operate at different levels of semantic specificity; these include the narrower subordinate nouns such as "dalmatian" and the broader superordinate nouns such as "animal." How is this achieved and what are the challenges involved? In a series of experimental and corpus studies with both adults and children, this dissertation developed a unified pragmatic framework that demonstrates how the acquisition of hierarchical word meanings is shaped by fundamental principles of human communication, involving the consideration of informativeness and relevance, their contextually-relevant semantic alternatives, and the epistemic state of interlocutors. Throughout these studies, I have argued that the acquisition, comprehension, and use of hierarchical nouns involve a distinct and non-trivial challenge of recognizing the pragmatic pressures that govern *when* and *why* speakers choose to talk about a particular level of taxonomic description over another. In this final chapter I synthesize the main findings from each study and discuss their broader theoretical implications.

6.1 Summary of findings

The dissertation began by addressing te puzzle of subordinate nouns. In Chapter 2, I examined whether learners are sensitive to semantic alternatives when generalizing novel word meanings to the narrow subordinate level (e.g., *dalmatian*) versus the typically preferred basic-level (e.g., *dog*). Recall that much of prior research on subordinate noun learning has treated label-referent pairings

as the fundamental unit of evidence for the learner: what matters for the discovery of subordinate categories is the number of labeled exemplars as well as their statistical distribution, perceptual characteristics, circumstances of observation, and so on. Instead, I posited that word learning must also involve higher-level inferences that help constrain the space of possible hypotheses for word meaning, with the strength of these inferences modulated by the accessibility of the relevant semantic alternatives to the target word's meaning. I presented a series of word learning experiments with adults, manipulating the presence and salience of semantic alternatives (e.g., other labeled exemplars) during word learning. The experiments show that learners generalized novel word meanings at the narrower subordinate level when presented with labeled alternatives that contrasted at the subordinate level (Experiment 1), with this effect being specific to labeled rather than unlabeled alternatives (Experiment 2) and persisting even under artificial language input (Experiment 4). Moreover, I found that inferences about the relevant alternatives to word meaning continued to be computed well after the moment of labeling (Experiment 3), suggesting that indirect cues to speaker intent are also available to learners in forming word meaning generalizations.

In Chapter 3, I further investigated the nature and role of these contrastive inferences in subordinate noun learning, focusing on four-to-five-year-old children. I proposed that contrast is a helpful cue to subordinate meanings because it highlights a pragmatic pressure on the speaker – who strives to be sufficiently informative – to be more specific than usual in their choice of a word. Under the assumption that children in this age range can compute such rich pragmatic inferences which also consider the speaker's mental state, I hypothesized that children should modulate their word meaning generalizations based on whether the speaker has access to the relevant alternatives that participate in the contrast. I first demonstrated children's ability to generate contrastive inferences for subordinate (vs. basic-level) noun learning beyond a simple avoidance of lexical overlap (Experiment 1). Then, I tested their ability to additionally integrate the speaker's perspective by manipulating the speaker's visual access to the subordinate-level alternatives prior to the labeling of the target (Experiment 2). Not only were children more likely to generalize novel labels to subordinate-level categories when contrastive alternatives were present during labeling, this effect was further modulated by speaker knowledge: children showed stronger subordinate-level

generalizations when the speaker could see the contrasting alternatives (versus when when those alternatives were hidden from the speaker's view). These findings provide one of the earliest pieces of evidence for children's ability to integrate considerations of informativeness and relevance with common ground, for the acquisition of taonomic meanings.

In Chapter 4, I shifted the focus to superordinate nouns, investigating the challenges to word learning posed by these broader word meanings (*animal*, *toy*, *fruit*, etc.). While the previous two chapters addressed how learners discover more specific meanings than the basic level, superordinate nouns present the opposite challenge. Traditional developmental evidence suggests that these broader, more abstract categories are unavailable or deficient until late childhood, when children undergo radical shifts in conceptual organization (e.g., Inhelder and Piaget, 1964). However, I proposed an alternative perspective: superordinate nouns may be late in acquisition in part due to language-internal reasons, above and beyond conceptual and perceptual reasons. Specifically, I hypothesized that superordinate nouns have distinct distributional signatures in the input that reflect their pragmatic informativeness properties; these peculiar patterns may at first present a challenge but later emerge as helpful cues to their meanings. Through a corpus analysis of child-directed speech, I found that superordinate nouns systematically co-occurr more with certain linguistic contexts that highlight semantic breadth: plurals, quantifiers (*some*/*all*), wh-phrases (*what*/*which*), and anchoring cues (*kind of*/*type of*, *another*/*other*). Critically, these contexts reflect the pragmatic conditions that license the use of superordinate nouns, such as the fact that superordinates are useful for referring to a group of many distinct individuals (versus referring to single entities). In a complementary word learning experiment using the patterns gathered from the corpus analysis, I demonstrated that each of these distributional contexts independently biased adult learners toward superordinate (versus basic-level) meanings for novel words; in other words, they pulled their own weight. Combined, these findings suggest that superordinate nouns, owing to their semantic breadth, favor specific linguistic environments in natural language that can facilitate their eventual acquisition through distributional learning mechanisms.

In Chapter 5, I asked whether four-to-five-year-old children show an understanding of the pragmatic properties of superordinate nouns that the previous chapter found to be reflected in, and

discoverable from, the language input. Specifically, I asked whether children recognize the informativeness constraints that license the use of superordinate nouns in communication. In Experiment 1, I found that children, like adults, judged superordinate labels (e.g., "This is an insect") as less appropriate than basic-level labels (e.g., "This is a butterfly") when the labels were used to identify single, familiar objects in an ostensive naming context. Children demonstrated this sensitivity by giving fewer "large" rewards and more "medium" rewards to superordinate labels, reflecting an understanding that while statements with such labels are not wholly false, they are nevertheless under-informative. In Experiment 2, I tested whether children could modulate these judgments based on contextual relevance by manipulating the visual alternatives present during labeling. Children's judgments were flexible: they reduced the penalty for superordinate labels when such labels were sufficient to distinguish the target from visually present alternatives of different superordinate categories. These findings provide strong evidence that children's difficulties with superordinate nouns may in fact reflect developing pragmatic competence. Rather than being limited by conceptual deficiencies, children may simply be experiencing various pragmatic pressures when interpreting superordinate nouns that are also active in adult comprehenders.

To summarize, the present findings show that the acquisition of hierarchical noun meanings is shaped by fundamental principles of human communication. Across both narrower subordinate categories (e.g., *dalmatian*) and broader superordinate categories (e.g., *animal*), learners utilize sophisticated inferences about informativeness, relevance, speaker perspective, and semantic alternatives to guide word meaning generalizations. Demonstrations of these abilities in young children thus highlight the central role of pragmatic reasoning in early word learning.

6.2 Theoretical implications

6.2.1 Pragmatic underpinnings of the basic-level bias

In studying word meanings beyond the basic level, I have largely side-stepped the basic level itself. One may wonder why I have not attempted to provide a satisfying answer to the glaring question: what makes a category "basic"?

This dissertation's lack of theorizing on the conceptual origin and nature of basic level *categories* is intentional, though perhaps not immediately obvious. To understand why, some historical context is helpful. In nearly half a century since the publication of Rosch et al.'s (1976) seminal paper "Basic objects in natural categories" (and millennia since the beginning of studies on object kinds; Aristotle, ca. 350 B.C.E/1938), the origin and nature of the basic level have remained surprisingly elusive to precise theoretical characterization (see discussion in Murphy, 2016). In searching for explanations, the traditional literature on conceptual categories has largely centered on the ostensively more fundamental question of whether the basic level is or is not *conceptually basic* from a developmental perspective: whether categories such as *dog* and *chair* are among the earliest primitives available in thought, whether they are the first quasi-categories to be promoted to the status of a conceptual kind in the primordial soup of associations that might represent the infant's mind, and so on. In Chapter 4 and Chapter 5, I briefly engaged with one big point of contention in this debate: whether it is the basic-level (e.g., Murphy, 2002, 2016) or the superordinate level (e.g., Mandler and McDonough, 2000; Mandler, 2008) that represent the earliest available concepts; this work typically involves studies on pre-linguistic infants, probing their inductive biases and abilities to understand early category representations (see review in Croteau et al., 2024). Here, I stress that this literature raises incredibly important questions about human cognition, the answers to which will propel entire disciplines forward. Yet, I continue to cautiously and deliberately set aside these difficult questions of why one category must be the "basic" one and what ontologically defines such categories.

That's because the crucial point that I wish to highlight is this: to the extent that basic-level categories – whatever their nature may be – give rise to a *bias* that finds itself in the domain of *language*, for not only young children but even adults, it helps to understand the bias through the fact that the basic level typically satisfies the informational needs of a generic addressee in a speech community. While such a characterization of the basic level as at least in part a pragmatically-motivated construct is not entirely new (e.g., Cruse, 1977; Callanan et al., 1994; Levinson, 2000), this perspective has often seemed to me underappreciated and overlooked in more recent years, especially in the domain of word learning. Thus, this dissertation aimed to bring the pragmatic perspective into the spotlight, and in doing so, also develop and precisely specify its presuppositions and empirical

predictions on the acquisition of hierarchical nouns by synthesizing recent theoretical advancements and empirical evidence from the literature on children's pragmatic development. On the basic-level bias, I have argued that due to the "generic addressee" status of the basic level and the Gricean expectation that speakers strive to be sufficiently informative, a speaker's choice of word on the scale of taxonomic specificity can give rise to a quantity implicature (Brown and Dell, 1987; Lockridge and Brennan, 2002; Grigoroglou and Papafragou, 2019a), owing to the entailment relationship between the subordinate, basic, and superordinate levels of categorization (Horn, 1972). These inferences are additionally subject to modulation and filtering via considerations of pragmatic relevance and interlocutor perspective, as I have demonstrated in the studies presented here, especially Chapter 3 and Chapter 5.

It is not lost on me that most existing explanations of the basic-level bias are considerably more parsimonious than the pragmatic account that I have argued for in this dissertation. For example, as I have discussed at length in Chapter 2, one prominent account argues that the basic-level bias emerges from lower-level perceptual mechanisms of object construal, which privilege basic-level features (e.g., Samuelson and Smith, 1999; Smith and Samuelson, 2006). Under usual circumstances of observation, a typical dog appears as *dog* owing to features that are most "salient" (for various reasons), such as the shape of its snout, ears, and tail; these happen to be the features that define the meaning of *dog* as a taxonomic category (as opposed to, say, *retriever* or *animal*). Such forces shaped by perception are undoubtedly strong and well-documented, and add to the appeal of mechanistic accounts which allow one to make very few assumptions about the resources that must be available for learning, whether they're internal to the child's mind or external in the environment. Against this backdrop, a rich pragmatic perspective might have seemed like a non-starter. Yet, this dissertation asked: "Under the assumption that the pragmatic considerations are indeed significant and pervasive, how far do they take us?" And indeed, they take us remarkably far. The evidence presented here reveals a distinct and non-trivial pragmatic foundation to the basic-level bias that exerts unique pressures on the acquisition, comprehension, and use of words beyond the basic level – pressures that emerge at ages previously hypothesized to be too young for children to experience them at all. As summarized in the previous section of this chapter, my findings show

that the pragmatic perspective not only accounts for a wide range of both the well-attested and the seemingly contradictory kinds of empirical data, but also generates novel predictions about how and why children struggle or succeed with non-basic categories.

Of course, I do not wish to claim that pragmatic considerations are solely responsible for the basic-level bias and the various phenomena surrounding it. At the same time, I take seriously the notion that pragmatic considerations are pervasive in linguistic reasoning including early word learning, and so should complement and refine even some very well-established data on this issue which are not traditionally understood to be subject to such higher-level forces of communication. To discuss just one example, we know that there are robust perceptual atypicality effects on people's categorization and naming preferences (see review in Emberson et al., 2019). To briefly highlight a few key findings, atypical exemplars from a category (e.g., a blowfish as a kind of fish), owing to their statistically rare perceptual features, are often found to resist generalizations to the basic level for both natural (e.g., Meints et al., 1999) and artificial (e.g., Mervis and Pani, 1980) kinds, and lead to on-line processing difficulties in classification tasks (e.g., Dale et al., 2007). It is clear that these effects are deeply tied to the observable facts about an exemplar's atypicality (since these effects are absent for typical exemplars) and rely on an individual's perceptual knowledge about category features and their distribution; however, one does not need to posit an explanation for the effect within the realm of low-level perception. Instead, atypicality effects may also be conditioned by the kinds of pragmatic forces explored in this dissertation, involving considerations of informativeness, relevance, and speaker knowledge. To take an example from anecdotal observation, bugs, to the extent that they are talked about in language around me, are seldom referred to by their more specific names beyond "bug" (e.g., "Come quick and help me! There's a *bug*[centipede] on the wall!"). This may be due to reasons of relevance (Grice, 1975): what matters is not identifying the specific type of bug by name, but communicating the surprise of finding a bug where bugs don't belong (e.g., in a clean home). For this reason, using a specific name for even atypical and highly nameable bugs may in fact be pragmatically infelicitous and even impolite, as names for bugs could also be taboo for those scared of bugs (and hence the preference for the superordinate level in these contexts; Levinson, 2000). At the same time, different pragmatic pressures may operate

in other contexts such that the choice of the word "bug" could instead signal lack of knowledge or unwillingness to cooperate; for example, when teaching a child about the different creatures that live in the garden. In exploring this and other related phenomena in naming and categorization, a pragmatic perspective may again prove fruitful in reinterpreting prior data and generating novel predictions. I leave these issues for future work.

6.2.2 The mapping problem and word learning at scale

A recent paper by Gleitman and Trueswell (2020) coined the term *easy words* in acquisition. These include concrete nouns such as "dog" and "ball" which are acquired within the first-year-or-so of life and appear to be learnable through simple associations between linguistic forms and their physical referents in the world. Easy words contrast with the *hard words* (Gleitman et al., 2005) which include mental state verbs such as "think" and "believe"; these word meanings are elusive to direct observation and are helped by language-internal cues such as the word's syntactic distribution (Gleitman, 1990; Papafragou et al., 2007). Given the different facts about their acquisition, it is tempting to posit separate theories for each kind of word: perhaps the former involves a strictly observation-based procedure for discovering word meaning – a private enterprise between the child and the world – whereas the latter necessitates more sophisticated linguistic knowledge backed by late-emerging conceptual abilities such as Theory of Mind. As reviewed in Gleitman and Trueswell (2020), that has indeed been a popular approach, exemplified by data-hungry models of early word learning in which easy words are acquired by averaging information that is accumulated over many learning instances (e.g., Samuelson and Smith, 1998; Yu and Smith, 2007; Fazly et al., 2010). But such a procedure is complicated by the fact that even the supposedly easy words present formidable challenges: the referential world is "malevolent" and full of informational junk, littered with mentions of an object when the child is not looking at it and sometimes even in the object's absence, entirely (Gillette et al., 1999; Medina et al., 2011; Cartmill et al., 2013; Trueswell et al., 2013). Thus, what matters instead are the rare "gems" with clear referential intent, established via attending to socio-pragmatic cues from caregivers like joint attention and the timing of labeling (e.g., Baldwin, 1991, 1993; Tomasello, 1995; Trueswell et al., 2013). On one interpretation, these

early abilities in infancy bootstrap later pragmatic competences which drive the acquisition of hard words and beyond (Grigoroglou and Papafragou, 2017, 2021).

On this distinction, hierarchical noun meanings for object kinds occupy an interesting position. They are, in a sense, easy because they also refer to concrete, observable entities. For example, the superordinate noun "animal" seems like a word that could be learned from seeing just a few diverse instances of animals labeled as such, upon which word meaning hypotheses at the basic and subordinate level are trivially ruled out via logical induction (If $A \supseteq \{B, C\}$ and $B \neq C$, then $A \neq B$). But as I have reviewed in detail, all the empirical facts about the acquisition of these words suggest otherwise: it's hard for children to learn words beyond the basic level. This raises a question which has also helped set the stage for this dissertation: are these words simply a harder case of easy words, or are they "hard" as in hard words? Some have argued for the former, by positing that difficulties of hierarchical nouns are due to the typically unfavorable circumstances of observation, the sparsity of input, the instability of the underlying concepts, and so on. However, I have argued for the latter by reasserting the pervasiveness of the mapping problem: learning these nouns involves a non-trivial challenge of identifying not just a (set of) meaning(s) that is logically true and consistent with what is observed, but critically, the meaning that is *specifically intended* by the speaker. On this perspective, mapping succeeds when the convergence of evidence from the physical and social world allows children to expect the meaning ANIMAL to be talked about in precisely those moments when speakers indeed choose to say "animal" over other alternatives.

What mechanism might allow for such learning to take place at scale, given that this is just one piece of the word learning puzzle? The so-called hypothesis-testing models of word learning offer a promising framework (see review in Gleitman and Trueswell, 2020). Rather than aggregating information over many learning instances, these models propose that learners form and track a limited number of discrete hypotheses about a word's meaning. In the Propose-but-Verify model (Trueswell et al., 2013), when the learner encounters a word in a referentially ambiguous context, they select one possible referent as the hypothesis for the word's meaning but crucially discard all other information from that learning episode. On subsequent encounters, the model retrieves the original hypothesis and tests whether it is consistent with the current situation, proposing a new

hypothesis if it fails. This mechanism is refined in the Pursuit model (Stevens et al., 2017) which allows discarded hypotheses to return for reconsideration under certain conditions of accessibility and sufficient activation, including considerations of working memory (Soh and Yang, 2021; Yue et al., 2023). A particularly exciting development from this line of research is the extension to cases of meaning ambiguity under referential certainty, such as homophones (Li et al., 2024), expanding the scope of the learning problem beyond those that simply involve establishing reference. For these and other word learning models that seek to operate at large scales in naturalistic environments, tackling the ubiquitous problem of hierarchical noun meanings that I have investigated here will serve well towards developing a unified theory of learning words, both easy and hard, across the time course of language acquisition.

6.3 Final thoughts

Pragmatics is not an afterthought to observation. Instead, I have argued for precisely the opposite: pragmatics circumscribes the kinds of meanings that learners hypothesize to be present in the input. Crucially, this remains true for even the seemingly simple case of acquiring concrete nouns that denote taxonomic categories for everyday objects, such as "dalmatian" and "animal." I have demonstrated that these word meanings which appear to us as simply observable, tangible, and transparently given by the physical world are, in fact, mediated by children's pragmatic reasoning about when and why certain meanings rise to the level of being talked about in language. In highlighting the fundamental principles of human communication as an inescapable driving force of language acquisition, comprehension, and use, this dissertation offers new insights into children's linguistic and cognitive development and the mechanisms by which children discover meaning from the linguistic input embedded into the social world.

Appendix A

Appendix

A.1 Applying a detailed coding scheme to Chapter 2 data

Note: Figures in section A.1 show the distribution of responses at test for each experiment with a detailed breakdown of the Other category: "Inc. Basic" and "Inc. Subordinate" indicating incomplete responses (partial selections of subordinate and basic-level members) and "Mutually Exclusive" responses (selections of all basic-level members except the alternative when it was present in the learning phase) are now marked separately.

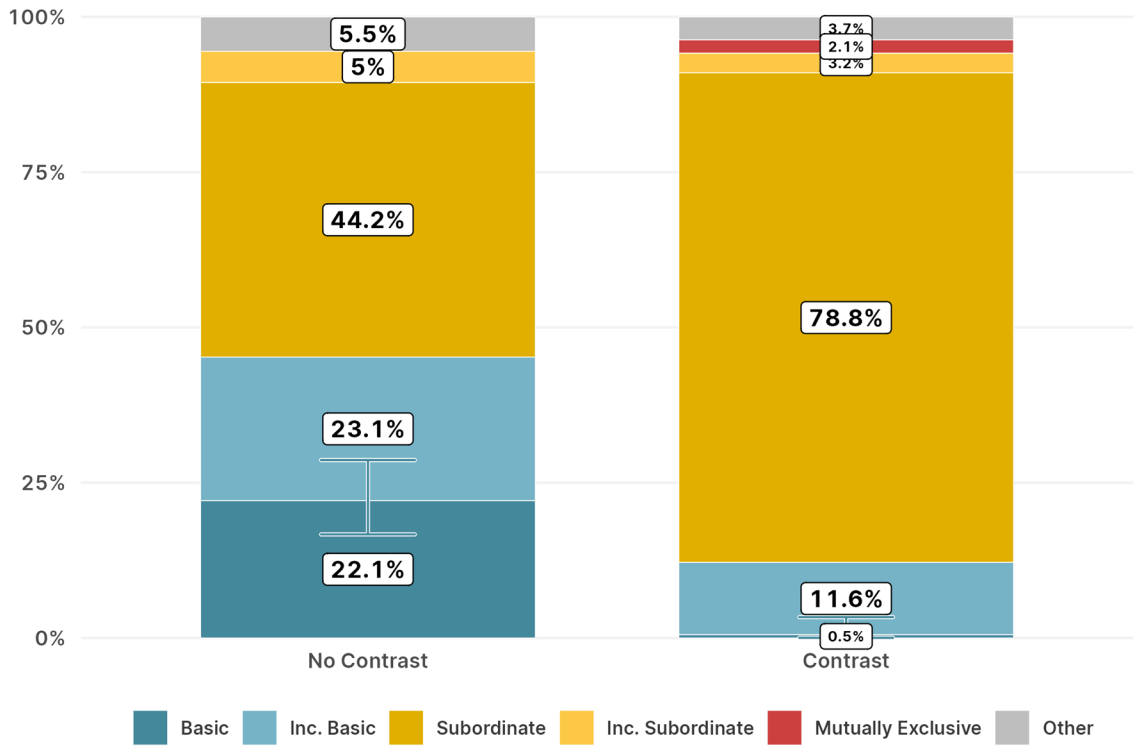

Figure A.1: Detailed responses at test for Experiment 1 of Chapter 2.

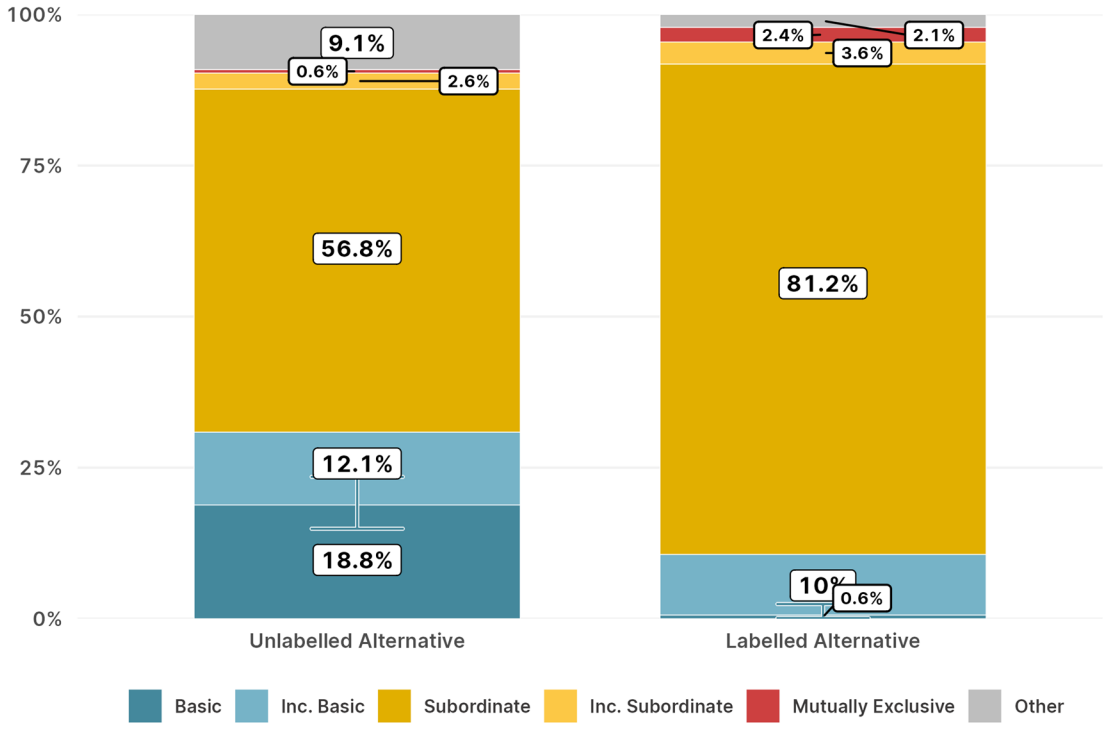

Figure A.2: Detailed responses at test for Experiment 2 of Chapter 2.

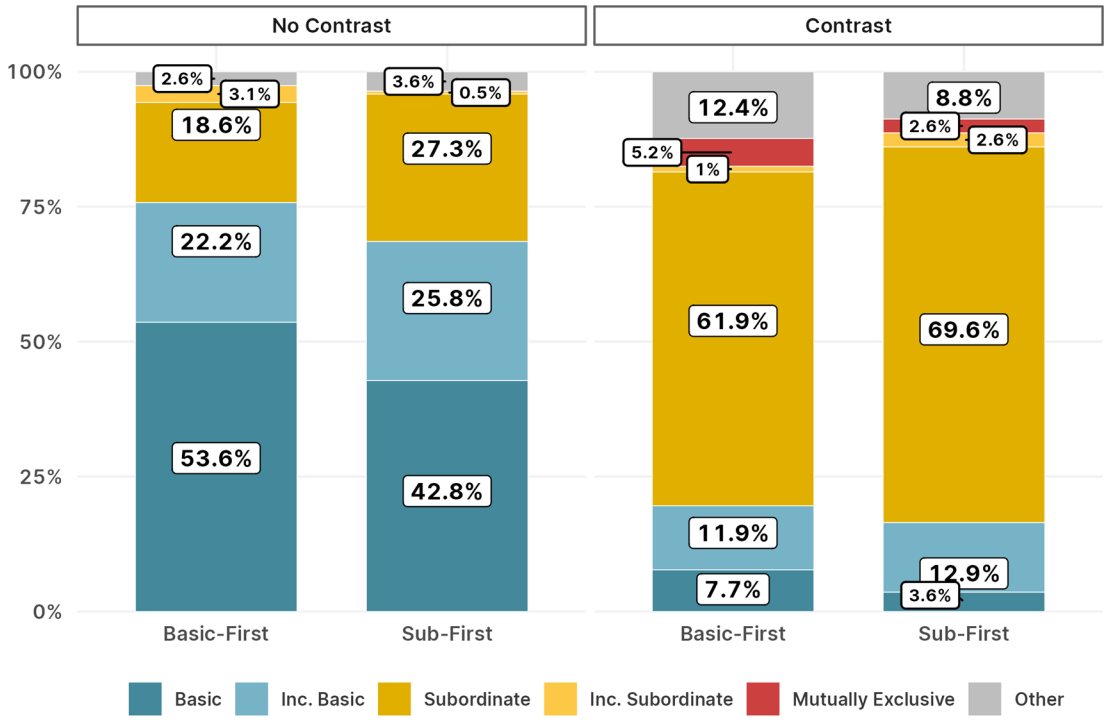

Figure A.3: Detailed responses at test for Experiment 3 of Chapter 2.

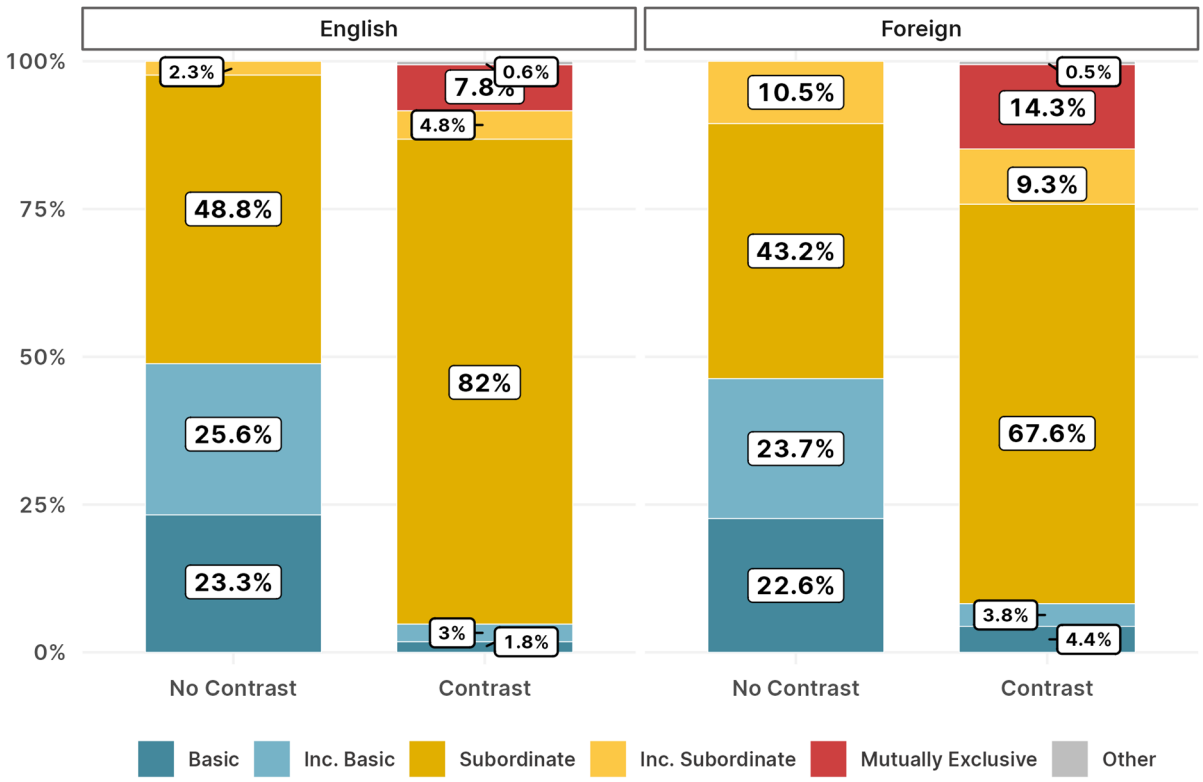

Figure A.4: Detailed responses at test for Experiment 4 of Chapter 2.

A.2 Replication of Chapter 5 Experiment 2 with adults

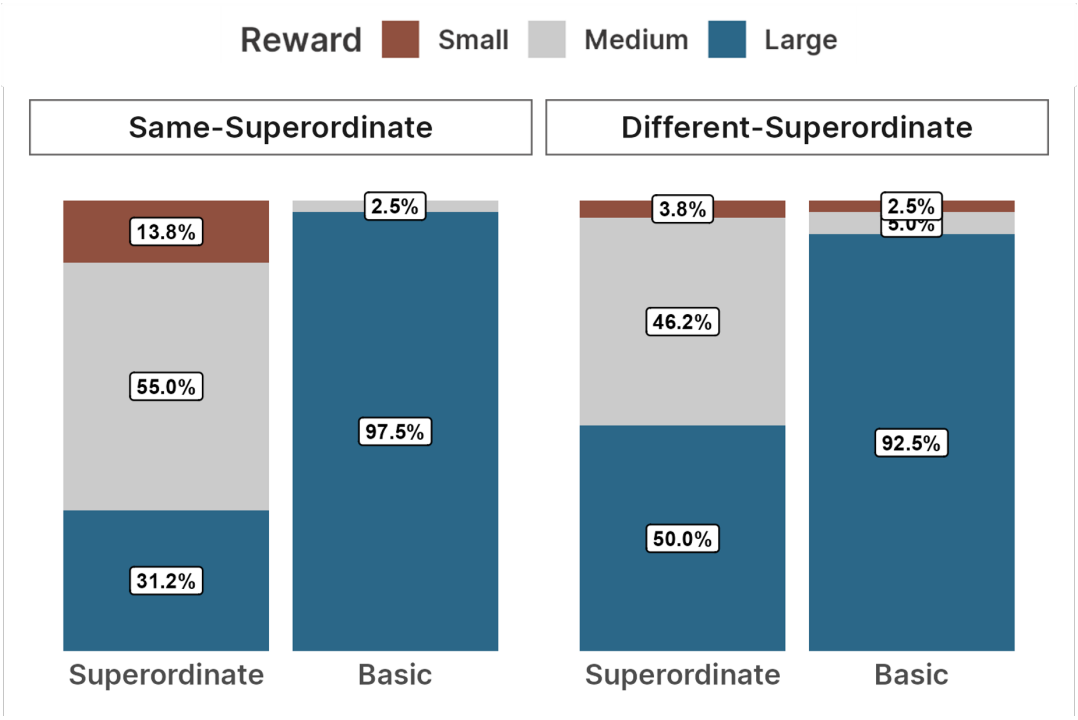

Figure A.5: Chapter 5 Experiment 2 replication: distribution of rewards (critical trials) in adults.

Table A.1: Chapter 5 Experiment 2 replication: logistic mixed-effects model for mid-size rewards (critical trials) in adults.

	β	SE	t	p
(Intercept)	-3.088	0.741	-4.120	<0.001
Alternatives	-0.025	1.399	-0.178	1.000
Label	6.273	1.216	5.161	<0.001
Alternatives * Label	-1.789	2.418	-0.740	0.919

Table A.2: Chapter 5 Experiment 2 replication: logistic mixed-effects model for large-size rewards (critical trials) in adults.

	β	SE	t	p
(Intercept)	2.776	0.888	3.126	0.003
Alternatives	0.457	1.750	0.267	1.000
Label	-7.873	1.452	-5.421	$<$0.001
Alternatives * Label	3.733	2.902	1.286	0.397

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