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More hard words: Learning emotion and mental state adjectives from linguistic context

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ABSTRACT

How do young children learn the meanings of adjectives that label emotions and mental states, like *happy* or *confident*? The concepts behind these words seem easy to grasp, and yet the properties they denote are abstract and lack reliable visual correlates, much as with verbs such as *think* or *know*. There is robust evidence that the linguistic context in which mental state verbs appear supports their acquisition. Using a two-pronged approach, we explore whether the same is true for these adjectives. First, we present a comprehensive study of adjectives in child-directed speech (CDS) in CHILDES corpora, revealing that these adjectives have a unique distributional profile based on the semantics of co-occurring words, and the syntactic complements with which they appear, distinguishing them from other adjective types. Second, we present a word learning study with adults using a version of the Human Simulation Paradigm manipulating key variables from the corpus study (subject animacy and syntactic complements), while holding other features (morphosyntactic form and syntactic position of the adjective) constant. Participants' guesses demonstrate that they recruit these cues to constrain the meaning of novel adjectives to one corresponding to an emotion or mental state. By presenting a thorough comparison of adjective types across key linguistic contexts and providing evidence that such contexts constrain adjective meaning, we systematically extend syntactic bootstrapping to the adjectival domain in a way that goes well beyond previous work, and paints a vibrant picture of what supports the acquisition of adjectives.

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1. Introduction

In tackling the challenge of word learning, young children recruit information from a variety of sources. Some of the entities, actions, and categories that children learn labels for are perceivable in the world around them, and mapping form to meaning appears to be relatively straightforward. However, a great deal of research in the preceding decades has highlighted the indeterminacy of referential meaning (Quine 1960), and the insufficiency and the non-necessity of visual input for acquiring word meanings (Gleitman 1990, Gleitman et al. 2005, Landau & Gleitman 1985). Thus, sources beyond mere association of label and perceptible referent are necessary to acquire a complete lexicon of word meanings. The Syntactic Bootstrapping hypothesis proposes that these additional sources are reflected in the sentences in which words appear, as we explain in the following sections. The argumentation behind this work is by now well known in our field. It originated with Landau & Gleitman's (1985) documentation of blind children's successful acquisition of the meanings of verbs such as *look* and *see*, as well as the conceptual category of color, despite being unable to "look at" or "see" anything (see, also, Brown 1957).

Dozens of experimental studies conducted since this time, typically employing novel words in the stimuli, have demonstrated convincingly that children successfully arrive at verb meanings in large part based on the *linguistic* environment in which they appear—and specifically, the *argument*

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structure frames in which they are used (Fisher 1996, 2002; Fisher et al. 1994; Lidz et al. 2003; Naigles 1990, 1996). Children interpret verbs appearing with a direct object as having a meaning relating to causation or affectedness, or an action of an agent upon a patient, but interpret verbs with no direct object as labeling an action without causation or affectedness (Arunachalam et al. 2013, 2016; Arunachalam & Waxman 2010; Fisher et al. 1994; Lee & Naigles 2008; Messenger et al. 2015; Pozzan et al. 2016; Yuan & Fisher 2009; Yuan et al. 2012; also see Gertner & Fisher 2012 and Perkins 2019). In fact, argument structure in the form of a transitive frame appears to trump other language-specific salient morphosyntactic cues entailing causation (Lidz et al. 2003), to constrain both the meaning of the verb and the interpretation of novel nouns appearing as the direct object of a verb or of a preposition in an instrument phrase (Lidz et al. 2017), and to pave the way for subsequently-acquired lexicalized verb-specific subcategorization knowledge to exert an influence (White & Lidz 2022).

The bulk of this literature, which is known under the umbrella term *syntactic bootstrapping*, has focused on children's acquisition of verbs, and the important role that argument structure (that is, the constellation of Determiner/Noun Phrases and other lexical phrases directly connected to a verb's subcategorization frame) plays in constraining children's semantic interpretations of these words. Syntax can perform this crucial role of constraining a verb's meaning precisely because the number and syntactic positions of a verb's nominal arguments are linked to the number and thematic roles of event participants, giving rise to a structure-to-word window into lexical meaning. This focus on syntax as a 'mental zoom lens' into verb meaning came about largely because, in the words of Henry and Lila Gleitman, "Verbs do not as a rule directly encode actions and events . . . Instead, verbs encode acts and states of the world and of the mind under particular (and invisible) stances toward these adopted by the speaker. A further data source is therefore required to rein in the hundreds of salient interpretive choices made available by perceptual and pragmatic inference as to the speaker's intent. It is the infant's natural appreciation of syntactic structure and its mapping onto conceptual structure that provides this additional data source" (Gleitman & Gleitman 1992:35).

An important development within syntactic bootstrapping research has been the recognition that, as verb meanings become more abstract, such that they pertain to mental states like thinking or knowing as opposed to observable actions and events like throwing or kicking, the more informative argument structure cues become in directing learners to a verb's meaning (Gleitman et al. 2005, Snedeker & Gleitman 2004). This is so, because a learner cannot possibly look to the environment for perceptually reliable cues that someone is thinking, knowing, believing, wanting, understanding, or recognizing. The argument structure frames themselves, then, are claimed to help a child grasp the meaning of these words that have a more abstract meaning.

It is no coincidence that the verbs mapping onto these concepts take sentential (or clausal) complements, since these complements express propositions or possible states of the world (Anand & Hacquard 2014, Heim 1992, Stalnaker 1984). Verbs that take sentential complements—so-called 'propositional attitude verbs'—overwhelmingly have meanings related to knowledge, thoughts, desire, and perception (Hintikka 1962, Hooper 1975, Karttunen 1971). Sentential complements can in turn signal to young learners that a verb has such an abstract meaning (Harrigan et al. 2019, Hacquard & Lidz 2022, White et al. 2018). As noted by Gleitman and colleagues, "sentence complement constructions focus the listener's attention on mental aspects of a situation that otherwise are rarely salient to listeners, child or adult" (Gleitman et al. 2005:56). Research has shown that, indeed, both children and adult simulated learners take the appearance of a verb with a sentential complement as an indication that the verb expresses a mental state (Gleitman et al. 2005, Papafragou et al. 2007).

This approach to learning 'hard words' has been further refined and extended to differences between 'belief' verbs that select tensed, or finite, clause complements (e.g., *think/believe/know that S*), and 'desire' verbs that select for untensed, or non-finite, clause complements (e.g., *want to VP*), and those that systematically take both (e.g., *hope that/to S*) (Harrigan et al. 2019, Hacquard & Lidz 2019, 2022). For these verbs, not only the *presence* of a sentential complement, but also the *form* or *finiteness* of the complement, is a reliable cue to verb meaning. However,

even with these fairly consistent cues to differences within these abstract verb meanings, additional information beyond brute-force syntactic structure, such as whether the matrix clause is a declarative (and expresses assertive content as the speech act) or an interrogative (and asks a question), and whether or not the subject is a first person or second person pronoun takes (for example the contrast between *I think it's time for bed.* and *Do you know what time it is?*) provide additional informational support for verb categories (Dudley 2017, Hacquard 2023, Hacquard & Lidz 2022). And after all, verbs of saying and reporting (*say, claim*, etc.) also take sentential complements, and do not necessarily report on the subject's beliefs or desires (Dayal & Grimshaw 2009).

The preceding literature enumerates the ways in which verbal complements play a critical role in cueing verb meaning (presence vs. absence of DP object for transitive/intransitive verbs; presence and finiteness value of sentential complements for mental state verbs). At the same time, features of the sentence subject can also be highly informative about the semantics of the main predicate. Becker & Estigarribia (2013) argued for the importance of the animacy feature of the subject for cueing verb semantics through a study on the acquisition of so-called 'raising' verbs. 'Raising' verbs such as *seem* or *appear* are just as abstract in their meaning as *know* and *believe*, and yet, they are structurally opaque in that the surface structure does not permit an argument structure representation to be straightforwardly deduced. To illustrate this point, consider the examples in (1)-(2). In (1), the subject of the matrix sentence, which is an argument of a propositional attitude verb, is committed to the truth of the embedded proposition. Likewise, in (2), the matrix subject to whom the desire is attributed is interpreted as coreferential with the implicit PRO subject of the embedded clause (the agent who will be reading the novel).

(1) Anna {thinks/believes/knows} [that Agatha Christie was a talented mystery novelist]
(2) Anna$_i$ {wants/hopes} [PRO$_i$ to read an Agatha Christie novel]

Now consider the sentence in (3). Although the subject occupies the same syntactic position relative to the verb as in the previous examples, there is no semantic relation between the two. While the subject is semantically linked to the predicate in the non-finite embedded clause (Anna is the "liker" of mystery novels), it is not semantically linked to the matrix verb (Anna is not the "seemer" or "appearer" of anything). That is, the main verb in (3) does not "select" its subject in the same way that the main verb in (2) does (see Chomsky 1981, Williams 1980). Thus, raising verbs pose a learning puzzle partly because they sit adjacent to a subject that they do not select, and partly because sentences like (2) and (3) look linearly the same on the surface (*Subj V to VP*), yet have different syntactic structures.

(3) Anna$_i$ {seems/appears}[t$_i$ to like mystery novels.]

To illustrate the lack of semantic connection between the matrix subject (*Anna*) and matrix verb (*seem/appear*) in (3), note that the same propositional content can be expressed with a similar sentence that has an expletive *it* subject, with the subject now in an embedded finite clause, as in (4).

(4) It {seems/appears} that Anna likes mystery novels.

What then could allow for children to learn this class of verbs? Becker & Estigarribia (2013) proposed that for these 'harder' words, *subject animacy* plays a key role. Agents are typically projected in subject position. Since inanimate entities are rarely agents or causers of events, if a learner observes a verb with an *inanimate subject*, this is a powerful cue that the subject is likely derived from a different underlying position, and therefore *not* part of the argument structure of the matrix verb. Arguably, animacy is

a semantic aspect of sentential subjects, although in some languages, animacy is encoded morpho-syntactically and may be construed as a grammatical feature.[1]

Becker & Estigarribia (2013) presented evidence from adult learners using the Human Simulation Paradigm (Gillette et al. 1999) demonstrating the influence of subject animacy on verb interpretation above and beyond argument structure. Their results led them to propose a two-step probabilistic process for verb learning whereby the learner first constructs a surface parse of the argument structure and clausal boundary representation, taking into account semantic information such as subject animacy, then uses this structure to constrain the set of possible verb meanings. Becker & Estigarribia (2013) posit that this process should be general enough to apply not only to verbs, but to all abstract predicates, including adjectives.

In fact, there are adjectives that present a parallel type of puzzle. Given a structural template like the one in (5), the learner is faced with a conundrum.

(5) X is [adjective] to VP.

Is the adjective a *control adjective*, meaning something like *eager, happy, afraid*, or *ready*, in which case the subject of the matrix clause (X) is also the implicit subject of the embedded clause (as in (6))? Or, is it a 'tough' (or maybe another subjective) adjective, meaning something like *hard, good, fun*, or *delightful*, in which case X is the surface subject of the main clause, but *not* the underlying subject (and in this case, interpreted as the underlying object of the verb in the embedded clause), as in (7)?

(6) Jane$_i$ is {eager/happy/afraid/ready} [PRO$_i$] to go to the party.
(7) This book$_j$ is {hard/good/fun/delightful} [PRO$_{arb}$] to read [t$_j$].

With 'tough' adjectives, an inanimate subject can serve as an additional cue, together with the syntactic complement, to help to constrain the meaning of the adjective, and therefore the syntactic parse of the surface string. This is because an inanimate subject is very unlikely to be an underlying subject (agent), as required by the structure of (6).

To date, a minimal amount of research has studied whether a syntactic bootstrapping approach to word learning is viable for this grammatical category of meaning. However, recent studies hold promise for attending to argument structure and (subject) NP animacy in adjective learning. Becker (2015; see also Becker et al. 2012) showed that manipulating the animacy of the surface subject in sentences like (5) did push children to interpret the main clause adjective (presented as a novel word) as a control adjective or a *tough* adjective. Other work has shown that adult learners can recruit structural information to guide their interpretation of novel subjective adjectives (Gotowski 2022, Gotowski & Syrett 2022, under revision). What's more, independent evidence shows that semantic information beyond subject animacy can work in concert with syntactic bootstrapping to constrain word meaning (Babineau et al. 2021, Syrett et al. 2014).

In the present work, we build on these previous investigations to ask how children can combine the mechanism of syntactic bootstrapping with semantic information provided within a sentence to constrain adjective meaning. We focus our attention on one class of adjectives in particular—*adjectives denoting emotions and mental states*—setting these against the backdrop of other adjectives appearing in the input. Emotion and mental state adjectives serve as an optimal test case for a syntactic bootstrapping approach to adjective learning that also relies on semantic information, precisely because these adjectives not only take syntactic complements (as do, e.g., subjective adjectives), but also place animacy requirements on their subjects as experiencers of emotions and agents that have mental states (unlike subjective adjectives).

[1]For example, animate objects trigger differential object marking in several languages, including Spanish (Aissen 2003), and a number of Australian languages use a special Accusative marker for objects that are animate or human-denoting (Blake 1977). In addition, Navajo, Chamorro, Jacaltec, and Japanese either prohibit or disprefer inanimate subjects, or subjects that are 'less animate' than the object (Chung 1983, Craig 1976, Hale 1972, Kuno 1973; cited in Becker 2014).

An appropriate and reasonable question is why an adjective's occurrence in predicative position with an animate subject and a syntactic (and specifically, clausal) complement should indicate that the adjective labels an emotion or mental state, and, further, how learners could home in on these meanings on the basis of complementational co-occurrence patterns. Unlike the literature on verb meaning, which is vast in breadth and profound in depth (see, e.g., Dowty 2012; Levin 1993; Levin & Rappaport Hovav 1994, a.o.), there is no parallel literature of which we are aware that provides a comprehensive landscape of adjective categories according to semantic and subcategorization properties. Nevertheless, building upon the literature on verbs and starting from the position that, "grammatical parallelisms may be clues to conceptual parallelisms" (Jackendoff 1978:203), we propose that emotion and mental state adjectives are like mental state verbs in taking complements that convey 'aboutness' (e.g., finite clauses, *about*-headed PPs), or those that convey preference or intentionality (e.g., non-finite clauses) and, therefore, that the appearance of an adjective with such complements is a signal that the meaning of the adjective should be restricted to an animate entity's mental stance towards an entity, event, or proposition.

The aims of the current research are twofold. First, we seek to identify the informational sources of support for emotion and mental state adjective acquisition by tracking the syntactic complementation patterns and semantic properties of sentences in which these adjectives appear in child-directed speech (CDS), and in doing so, *systematically* extend syntactic bootstrapping to the adjectival domain (see, e.g., previous corpus studies by Blackwell 2005, Davies et al. 2020, Sandhofer & Smith 2007, Saylor 2000, and experimental work by Booth & Waxman 2009, Syrett & Lidz 2010, Waxman 1999, Waxman & Booth 2001, Waxman & Markow 1998). We tackle this goal with a Corpus Study of CDS. The focus of the corpus analysis is on building *a comprehensive picture* of the distribution of adjectives in CDS with the aim of identifying those properties of sentences that distinguish emotion and mental state adjectives from other types of adjectives (e.g., adjectives denoting size, color, physical sensation and perception, and so on), and those cues that could plausibly aid learners in homing in on the adjective's meaning as denoting an emotion or mental state. Because this study represents the first attempt (to our knowledge) to catalogue such a comprehensive array of syntactic and semantic features of sentences containing adjectives in CDS, and because we assume that learners must draw on an array of distributional patterns in the input in learning predicate meanings, the range of such features is necessarily broad.

Second, having mapped out the distributions of emotion and other types of adjectives, we seek to exploit a key subset of the linguistic cues found to be reliable predictors of emotion and mental state adjectives in CDS to determine whether learners can recruit them to constrain the meaning of novel adjectives to this predicate type. We do so by conducting an experiment in which we present adult "word learners" with novel adjectives in these linguistic contexts, and ask how they interpret the meaning of these adjectives. Our approach follows a research tradition that partially simulates the learning situation of children by placing adults in situations with varying amounts of information stripped away, and then asking them to "guess" words whose meaning is compatible with usage in these situations. This is known as the Human Simulation Paradigm (Gillette et al. 1999). An advantage of this approach is that we can hold conceptual knowledge relatively constant (that is, we assume that adults are already equipped with concepts such as 'happy', 'sad', 'afraid', 'confident', 'curious', etc.), while manipulating access to linguistic cues to meaning. If adults "learn" certain words in one linguistic context but not without that context, the pattern is presumed to be explained by the difference in the linguistic information provided and not, for example, the individual's knowledge of the underlying concept.

To preview our findings, our corpus study reveals that the syntactic position of an adjective and its ability to take syntactic arguments—and specifically clausal complements—combined with the frequent co-occurrence of an animate modified noun/ subject, are particularly robust distributional cues for emotion and mental state adjectives, in contrast to other adjective types. Our word learning experiment further demonstrates that by presenting adult learners with novel adjectives in linguistic contexts manipulating such syntactic environments and the animacy of sentential subjects, and asking

them to provide guesses of adjective meaning, we obtain reliable evidence bolstering the corpus data for which sources of information are the strongest probabilistic cues for learning these adjective types. These combined results set the stage, then, for developing word learning tasks with children focused on the acquisition of abstract adjectival predicates, and specifically those denoting emotions and mental states.

2. Why emotion and mental state adjectives?

We focus on adjectives denoting emotions and mental states in the current work for three main reasons. First, there are clear parallels between adjectives and verbs in their semantic properties and contributions to phrase structure. Adjective phrases (APs) are like verb phrases (VPs) in that many predicate a property of an individual as type ⟨*e,t*⟩ (see also Syrett et al. 2019).[2] As we noted previously, within both categories are predicates that express an abstract meaning. Emotion and mental state adjectives are like mental state verbs in describing an internal state that is largely imperceptible to individuals other than the experiencer. Although there may be some outward indicators of an emotion like feeling happy or angry, such as a facial expression like a smile or a grimace, emotions cannot be unambiguously inferred on the basis of visual cues alone (Reichenbach & Masters 1983; Widen & Russell 2003, 2010). For example, someone might adopt a facial expression to mask an underlying emotion, and the manifestation of a particular emotion can vary across individuals, or within individuals, depending on the context or cause. The same goes for mental states like being inquisitive or confident. Thus, emotion and mental state adjectives, like propositional attitude verbs like *to know* or *to think*, are particularly good candidates for vocabulary words that require support from syntax in order to be learned.

Second, there are parallels between adjectives and verbs in terms of their semantics, the structural environments in which they appear, and how intrasentential semantic information may further support the word learning process. Semantic literature has long compared 'emotive factives' like *be {glad/happy/surprised} that* to other complement-embedding verbs such as *regret, know*, or *love* on factors such as factivity, exhaustivity, and question-embedding (Cremers & Chemla 2017, Egré 2008, Giannakidou 2006, Karttunen 1977, Klinedinst & Rothschild 2011, Lahiri 2002). Anand & Hacquard (2014) point out that emotive factives taking a finite clause complement entail that their complement is true, that their subject has an emotional attitude towards the truth of the complement, and that the subject also believes that the complement is true (although, see discussion in Egré 2008). As with verbs of thinking and believing, predicates like *sad, afraid, happy*, or *confident* require the subject to be sentient, or animate. Syrett (2023) makes explicit the comparison between clausal complement-taking mental state verbs and a wide range of clausal complement-taking adjectives, among them emotion and mental state adjectives. In doing so, Syrett highlights the importance of packaging the syntactic complement together with conceptual, contextual, semantic, and pragmatic sources of meaning, including for example, subject animacy, standards of comparison, or adverbial modification.

As noted in the previous section, emotion and mental state adjectives label states that can be about something (e.g., *be sad/happy/angry/curious/worried about something*), like mental verbs (*think/wonder/worry about something*), and unlike adjectives that denote physical states (**be hungry/cold/fatigued about something*) or physical attributes (**be tall/red/bumpy/dirty about something*). A look at adult speech in the Kuczaj corpus in CHILDES (Kuczaj 1977, MacWhinney 2000) reveals that, putting aside expressions like *how about X?* and the 'approximately' meaning, the preposition *about* is

[2]Note that not all adjectives (or APs) or verbs (or VPs) denote properties of individuals. For example, raising predicates like *seem* and *tough* adjectives, both of which take an expletive, non-referential subject, but have very different meanings, certainly do not. This point is, in a way, tightly related to our discussion of animacy earlier, appearance with an inanimate subject signals that the adjective does not obligatorily denote a property of an individual, whereas consistent appearance of an animate subject, and no inanimate or expletive one, is a fairly reliable cue that this is the case. We thank our reviewers for gently pushing us on this point.

preceded by verbs of communication[3] (*tell X about* (38), *talk about* (5), *hear about* (2)); mental verbs (*think about* (16), *dream about* (5), *know about* (4), *forget about* (5), *worry about* (2); emotion/mental state adjectives (*happy about* (1), *sorry about* (1), *glad about* (1), *sure about* (1)); and nouns pertaining to concrete or abstract narrative content (*book about* (7), *story about* (6), *(TV) show about* (3), *movie about* (1), *dream about* (2)), with very few other instances (*We'll see about that; I don't know what to do about X*).

What all of these expressions have in common is that they indicate content (although see Rawlins 2013, for a more fine-grained position), and what the verbal and adjectival expressions with *about* have in common in particular—even the verbs of communication—is that they pertain to *mental content*. The reason *tell*, for example, has distributional overlap with verbs of transfer, like *give*, is that when "John tells a story to Mary," "the *story* is going from *John's* to *Mary's* mind" (Fisher et al. 1991:338; italics in original). Recognizing the limitation that these patterns are based on English data, and that claims about correspondence between semantic categories of verbs (or adjectives) and argument structure or selectional frames become robust only after they are confirmed across languages, we believe it is reasonable to predict that both mental state verbs and emotion and mental state adjectives that can be "about" something appear with complements that reveal the content of these mental states.

To this point, Shablack et al. (2020) showed that 4-year-old children were more likely to associate a novel adjective with an emotion than an action (and marginally more than with a physical state like hungry) when it was preceded by the verb *feels* or followed by an *about*-PP (e.g., *Palooza feels daxy (about something)*), compared to when the novel adjective simply preceded by the copula *be* and without a complement (e.g., *Palooza is daxy*). While these findings offer some preliminary evidence that learners' guesses about the meanings of adjectives are influenced by syntactic and semantic properties of the sentences in which they appear, there are a number of limitations of this study. For example, only a single syntactic complement was tested (*about NP*), and while the selection of the syntactic and semantic aspects controlled in the stimuli were based on corpus data of child-directed speech (Shablack 2017), that corpus analysis did not involve a systematic investigation of the presence of different syntactic complements across adjectives or within emotion adjectives, or a systematic comparison between emotion adjectives and other semantic types of adjectives in the input. Thus, the question remains *which* syntactic complements can support emotion and mental state word learning—or any adjective learning, for that matter, what other semantic cues occur with these adjectives, and whether these cues are useful to a word learner.

Third, emotion words are an important yet vexing category of words for learners. Experiencing positive and negative emotions is a shared experience of all neurotypical humans. Labeling emotions with words appears to be common to all languages: of the 2,474 languages surveyed by Jackson et al. (2019), all contained emotion words. Nevertheless, there is active debate about the universality of the emotion *categories* themselves. For one thing, there are emotion words in some languages that lack a direct non-periphrastic translation in other languages. For example, the term *kreng jai* in Thai, which refers to, "the combination of gratitude and guilt felt when offered an overly generous gift or favor" (Hoemann et al. 2022:71), lacks a simple lexical translation in English. For another, it is unclear whether speakers of different languages *mean* the same thing when they use the word for what might be considered the same emotion (compare, for example, *anger* in English and *Wut* in German).

Moreover, Jackson et al.'s (2019) study of colexification patterns among the languages surveyed found that language families exhibit a relatively high degree of variation in the set of labels they use for the same type of emotion, while they displayed significantly greater uniformity in their colexification of color concepts. And yet learning emotion labels may grant us access to the interpretation and categorization of emotions themselves: just as both nouns and adjectives are invitations to form object categories (Waxman & Markow 1995), so words expressing emotions may allow learners to organize conceptual knowledge from more diffuse feelings distinguished by positive vs. negative valence and

[3]We exclude a handful of occurrences of *remember about* and *like about*, which were in *wh*-questions in which there would have been a gap or trace between the verb and *about* (i.e., {*what do you remember/what did you like*} *t about X*).

high vs. low arousal into more discrete emotion categories (Lindquist, Satpute, et al. 2015). This process, in turn, enables humans to shape incoming perceptual information such as facial expressions to categorize the emotions of others, and also to interpret their bodily sensations to categorize their own emotions (Gendron et al. 2012, Lindquist, MacCormack, et al. 2015, Lindquist, Satpute, et al. 2015). These findings underscore an inherent challenge associated with learning emotion labels: even if a learner can infer that a new word labels *an emotion*, precisely *which* internal affective experience is it labeling? However this happens, the process begins with identifying *which words label emotions*, as opposed to other attributes or states of being, and exactly how this is done remains an open question, which is the focus of the current work.

This issue is especially relevant for neurodivergent populations—specifically autistic individuals—who struggle to recognize and categorize emotions and other mental states (Baron-Cohen 2001, Begeer et al. 2006, Davidson et al. 2019, Harms et al. 2010, Jemel et al. 2006, Jennings 1973, Lind & Bowler 2009, Weeks & Hobson 1987); to process and talk about emotions (Capps et al. 2000, Siller et al. 2014, Tager-Flusberg 1992); and to recruit social and pragmatic cues for word learning (Kissine 2021). Recent syntactic bootstrapping research demonstrates that young autistic children can recruit transitive frames to map onto causativity in verb meaning (Horvath et al. 2018, Naigles et al. 2011). Identifying the structural cues that support the acquisition of abstract adjectival predicates corresponding to emotions and mental states has the potential to support a range of neurodiverse individuals in their language and cognitive development and social interactions (Lindquist, MacCormack, et al. 2015, Lindquist, Satpute, et al. 2015). Thus, there is an authentic and meaningful clinical application of the research at hand.

3. Corpus Study

The purpose of the corpus study was to perform a systematic analysis of the distribution of adjectives in CDS, with an eye to emotion and mental state adjectives, to determine how syntactic and semantic distributional cues support adjective learning.

3.1. *Preparation*

We targeted 44 corpora from the CHILDES database (MacWhinney 2000), from the North American and British English language dialects. These included Wells (N = 32), Belfast (N = 2), Bliss, Bloom (Peter), Braunwald, Brown (Adam, Sarah), Clark, Gathercole, Kuczaj, Sachs, and Suppes. We homed in on a consistent child age range within each corpus, between 2;0-5;0 years, in order to target the age range in which children are most actively acquiring and producing words. We first downloaded the corpora from the CHILDES database, then used the command kwal +t%mor +s"adj|*" -w1 +w1 in CLAN to conduct a search in the morphological tier for all occurrences of tagged adjective tokens. We retrieved one utterance immediately before and after the target utterance in which the adjective appeared in order to obtain the immediate context surrounding production, and evaluate the conversational exchange for repetitions and imitations. The results were saved as txt files, converted to Excel spreadsheets, and cleaned for inspection of utterance components. Within each spreadsheet corresponding to a corpus, we reviewed and recorded the adjective in each target row, manually reviewing each hit. Given the significant number of tagging errors in the CHILDES transcripts for adjectives, this line-by-line inspection was necessary, and we caution future researchers against relying on the transcript tagging alone for analysis of adjectives in child-produced and child-directed speech.

There were two types of frequently encountered errors. The first was *errors of commission/false alarms*. These included sentence-final discourse markers like *okay, sure*, and *right*; adjectives in compounds like *high chair* or fixed temporal expressions like *last time*; actual mistakes in coding such as *live* as a verb coded as an adjective; possessives like *Daddy's*; measurement terms like *much* or *less*; and adverbs modifying verbs like *just wanted*. We excluded from analysis all such occurrences. A number of adjectives also double as adverbs or degree expressions (e.g., *real* as in *real fast* or *real heavy, pretty* as in *pretty sure* or *pretty good, little* as in *a little (bit), awful* as in *awful sleepy* or *an awful*

lot, right as in *right there* and so on). These cases were included in subsequent analysis (as they also appeared as adjectives), but marked as 'adverbial use'. Because the vast majority of these examples are subjective adjectives, and not emotion or cognitive/mental state adjectives, their inclusion does not affect our analysis of our target adjective types.

The second type was *errors of omission/misses*. To identify these, it was necessary to inspect both the morphological tier itself and the context immediately surrounding the utterance. These mistakes in tagging included color terms erroneously tagged as nouns (which were easily caught in cases of conjunction, lists, or multiple adjectives in prenominal position, where other color terms were tagged as adjectives), and adjectival passives tagged as past perfect (PASTP) like *spoiled* or *interested*. In only relying on manually inspecting the lines immediately before and after the target utterance with an adjective hit for retrieving errors of omission, we have been overly conservative in collecting all adjective hits across the corpora, which would have been a significant and time-consuming undertaking for this dataset.

We then coded each target line for the type of speaker (CHI for child or AD for adult), using the information for each corpus available on CHILDES. Because our current analysis focuses on CDS, we specifically targeted those productions by adult speakers (AD). We then conducted an analysis of the form and type of the adjective itself, and a thorough deconstruction of the utterance in which the adjectives appeared. We summarize each in turn in the following sections. The end product was an individual spreadsheet for each of the 44 corpora with a series of columns to the right of each utterance cataloguing each of the features outlined in the following section, which we then fed into subsequent analysis.

3.1.1. *Adjective type, form, and position*

3.1.1.1. ***Adjective type.*** We referred to the entire list of adjective hits, previous research on the semantics of adjectives, emotion and cognition, and the results of a pilot version of the word learning experiment reported below to write a conditional IF formula in Excel to automatically tag all adjective tokens by type, arriving upon these 10 conceptual/semantic types: Emotion (e.g., *happy, sad*), Cognition/Mental State (e.g. *aware, confident, sure*), Color (e.g., *red, blue*), Size (e.g., *big, little*), Subjective (e.g., *good, pretty, hard*), Physical Sensation (e.g., *tired, sleepy*), Physical Perception (e.g., *heavy, smooth, wet*), what we will term 'Comparatives' (e.g., *same, different*), Adjectival Modals (e.g., *allowed, able*), Other Gradable Adjectives (*full, empty, new, old*).

When categorizing adjectives into each of these conceptual/semantic types, we also used surface-level diagnostic cues. For example, Emotion, Cognitive/Mental State, and Subjective adjectives can all occur with clausal syntactic complements. To be included as an Emotion, Physical Sensation, or Physical Perception adjective, a necessary (but not sufficient) condition was that the adjective had to be able to occur with the verb *feel* (i.e., *feel sad, feel wet*). Many, but not all, Cognitive/Mental State adjectives can also occur with *feel*, although many of these can also occur with verbs like *act* or *behave* (e.g., *act suspicious/brave*), and they are not associated with affect. Some adjectives may be seen as falling into multiple classes when taken on their own. For example, *tired* appears to have two senses: one corresponding to a physical sensation ('fatigued'), and another corresponding to an emotion or mental state meaning ('fed up'). These two senses can be teased apart when *tired* is encountered taking a syntactic complement (e.g., *tired of doing X*) and therefore corresponds to the latter sense. Similarly, a word like *guilty* could correspond to a mental state meaning (e.g., *to feel guilty*) or a judicial status (e.g., *to be guilty (of a crime)*). Based on our review of specific instances in the corpora, we decided to conservatively classify all such cases as non-emotion/mental state adjectives and consistently classify them into *one* type, and not have classification of an adjective depend on the adjective's appearance with a complement, since doing so would lead to circularity.[4] To be included as a Subjective adjective, the adjective had to be able to occur in contexts of faultless disagreement, whereby one speaker's

[4]Our approach classifies a given adjective as labeling an emotion or mental state in part based on an intuitive definition of emotion words as labeling internal *affective* states, and we recognize that there may be disagreement over certain boundary cases (e.g., is *interested* an emotion or a non-emotion mental state?). However, in the absence of established truth-conditional diagnostics for discriminating emotion words from non-emotion words, we adopt this approach here and work toward outlining clear inferential diagnostics in the near future.

assertion with an adjective (e.g., *This is easy*) and the negation of the same assertion uttered by a different speaker (e.g., *This is not easy*) can both simultaneously be true without contradiction. The full list of all adjectives included in these Adjective types is included in Online Supplemental Appendix A.[5]

3.1.1.2. *Morphosyntactic form.* Each adjective was coded for morphological form, using three main categories: Positive (e.g., *good, big, fast, happy*), Comparative (e.g., *better, bigger, faster, happier, more/less jealous/beautiful*), or Superlative (e.g., *best, biggest, fastest, happiest, most comfortable*). We also coded for any novel forms, which were typically, but not always, produced by children (e.g., *bestest, (more) gooder*).

3.1.1.3. *Syntactic position.* We coded the syntactic position of the adjective relative to the verb and modified noun, using four categories: Prenominal (occurring before a noun, in 'attributive' position), Postnominal (immediately following a nominal expression), Predicative (following the copula *be* or linking verb as in *taste, seem, look*), or Other (e.g., in an utterance with no verb or noun, or an adverbial position, as previously mentioned).[6] Prenominal position included instances of adjectives appearing to the left of a noun they modified, either directly adjacent to, or to the left of, another adjective (e.g., *new babysitter, little piece of cheese, sharp knife, delicious yummy wholewheat toast*). Postnominal position included noun-adjective constituents and reduced relative clauses (e.g., *I didn't do anything bad, you wanna say something special, I saw something green, a dish full of sausages, there's a couple missing, I've seen a lot worse*); instances where the verb was omitted (e.g., *you sure it's not there?; your hands clean?*); as well as small clauses, resultatives, and expressions of change of state (e.g., *make you mad, that makes it really easy, get it nice and cold, let's get it all flat*). Predicative position included examples such as *she is old, are you still hungry, he looks hungry, he feels very sad*, and *that sounds nice*. We required there to be a verb in the utterance for an adjective to be coded as being in Predicative position; otherwise, it was coded as Postnominal (as in the *you sure* example above, which is structurally different than a noun-adjective constituent). Polar questions containing a verb in which the adjective immediately followed the nominal expression due to subject-auxiliary inversion (e.g., *is dolly hungry?* or *is it red?*) were coded as Predicative. All examples noted above are taken directly from the Sachs, Braunwald, or Clark corpora.

3.1.2. *Semantics and syntax of the utterance context*

We also examined the other lexical expressions co-occurring with the adjective. We documented the following semantic information: the nouns modified by the adjective (which was equivalent to the

[5]To be clear, these differences among adjective types, which are driven by conceptual and distributional differences, track deeper semantic differences. While this is a topic to be explored in more depth in a separate line of research, we note here specifically that for emotion and mental state adjectives, there are further distinctions that may or may not tightly parallel verbs as embedding predicates. Hacquard & Lidz (2019) divide attitude verbs into representationals (which take clauses that have the hallmarks of declarative clauses, such as finite clauses in English, e.g., *know*) and preferentials (which take clauses that have the hallmarks of imperatives, such as non-finite clauses, e.g., *want*). Some mental state adjectives (e.g., *aware, confident*) pattern with the former, and others with the latter (e.g., *interested, reluctant, willing*). However, some emotion/mental state adjectives appear with both (e.g., *amazed, excited, happy, relieved, worried*), and these predicates fall into the category of veridical preferential predicates, in that they are responsive, and when accompanied by *about*, can take an interrogative *who/which* complement. When they take a finite clause complement expressing a proposition *p* in English, they not only presuppose the truth of *p*, but also express that the subject believes that *p*, and that the degree to which the subject prefers that *p* at world *w* is greater than a standard threshold of a set of focus alternatives (see, e.g., Uegaki & Sudo 2019). We would like to propose that the commonality among all emotion/mental state adjectives, regardless of further divisions within these categories, is that they all express a relationship or stance between an experiencer (and therefore obligatorily animate) subject, and an eventuality expressed by the complement—and further, that for emotion adjectives in particular, the content of the complement can be taken as the cause of the affective state of the subject.

[6]We use *postnominal* in the same way as Blackwell (2005). In their analysis of adjectives in child-directed speech in British English, including free play, book texts, and shared book reading, Davies et al. (2020) used the terms *prenominal* as we do for attributive uses, *postnominal* for predicative uses, *postpositive* for adjectives immediately following a noun, and *isolated* for adjectives appearing alone.

subject for all adjectives in predicative position), the matrix verb in the clause in which the adjective appeared, and adjunct clauses (e.g., *when, because*). We also catalogued all adverbial modifiers, although we do not include them in our analysis here, since while they may be informative about gradability in general, they were not informative about adjective types. When coding verbs, auxiliary verbs in verbal expressions in present or past progressive aspectual form (i.e., *was telling*) were not included. We listed the verb root in parallel for each observed verb form, to capture lexemes separately from conjugated tokens (e.g., *bring* vs. *bringing, brings, brought; be* vs. *am, are, is, was, were*). Finally, for each adjective, we manually catalogued any and all syntactic arguments or complements following the adjective. These syntactic complements were further categorized post-hoc based on their form. See Online Supplemental Appendix B.

3.2. *Results of corpus search*

We begin by reporting on the types of adjectives observed in the corpora, documenting their morphosyntactic form and syntactic position. We then turn to examining semantic and syntactic aspects of the linguistic context of the utterance.

3.2.1. *Adjective type, form, and position*

3.2.1.1. ***Adjective type.*** The distribution of adjectives in CDS across our pre-specified adjective types is presented in Table 1. See Online Supplemental Appendix B for the count of all adjectives in each corpus (B.1.), for all Emotion adjectives (B.2.), Mental State (B.3.), Subjective (B.4.), and Adjectival Modals (B.5.) observed in CDS across corpora. We list these, in particular, since these are the types that take syntactic complements. For a list of those complements, see Online Supplemental Appendix B.6.

Emotion and mental state adjectives combined account for only 5% all adjective productions in CDS. This low number relative to all other adjective types makes it that much more critical to track information concerning the linguistic and extralinguistic context in which these adjectives appear, in order to distinguish their distributional signature from other adjectives, particularly those that also take syntactic complements.

3.2.1.2. ***Morphosyntactic form.*** We coded each adjective for its morphosyntactic form, to see if there were any differences among adjectives with respect to comparative morphology. This appears not to be the case. It is well worth noting that comparative and superlative forms are *exceedingly rare* in CDS, as previously noted by Arii et al. (2017). Ninety-five percent of all adjectives appear in the positive form

Table 1. Type-token summary of all adjectives observed in CDS across all corpora.

Adjective Types	# of tokens	% of all Adjective types	% of All Adjectives
Emotion	945	3.7	2.6
Mental State	872	3.4	2.4
Subjective	9,003	35.9	24.8
Adjectival Modals	160	0.6	0.4
Color	1,747	6.8	4.8
Size	8,123	31.5	22.4
Physical Sensation	913	3.5	2.5
Physical Perception	1,196	4.6	3.3
Comparative Adjs	1,285	5.0	3.5
Other GAs	1,542	6.0	4.3
Categorized above	25,784	100.0	71.0
Not categorized	10,538		29.0
Total	36,332		100.0

Abbreviations: CDS = child-directed speech; GA = Gradable Adjective.

with no overt morphology. Accordingly, 99.3% of emotion, and 99.9% of mental state adjectives appear in the positive (non-comparative/non-superlative) form.

3.2.1.3. *Syntactic position.* We now turn to the syntactic position of each of our target adjective types in CDS, presented in Table 2, which begins to reveal how they can be distinguished from one another in terms of syntactic distribution. Table 2 reveals that Emotion and Mental State adjectives, Adjectival Modals, and adjectives of Physical Sensation and Physical Perception are all most likely to appear in Predicative position. By contrast, adjectives denoting Color or Size, and other GAs are likely to appear in Prenominal position. Subjective and what we are calling 'Comparative' adjectives (*same, different*) are split in their distribution between Prenominal and Predicative position.

Note that while *some* Emotion and Mental state adjectives are unable to appear in prenominal position (e.g., *afraid* or *aware*, members of the set of so-called '*a*-adjectives') (Boyd & Goldberg 2011, Prasada 1992), these specific tokens account for a very small proportion of our target adjective types.

In order to compare the distribution of Emotion and Mental State adjectives across the four syntactic positions to the distribution observed for adjectives overall, a Chi-Square Goodness of Fit Test was performed. The test showed that the distribution for both types of adjectives was significantly different from adjectives overall (Emotion: χ^2 (3, N = 945) = 764.12, $p < .0001$; Mental State: χ^2 (3, N = 872) = 680.5, $p < .0001$), with both less likely to appear in Prenominal position and more likely to appear in Predicative position. This pattern stands in contrast, for example, to that of Color and Size adjectives, whose distribution also differed from adjectives overall, but with an increased likelihood to appear in Prenominal, and not Predicative, position (Color: χ^2 (3, N = 1747) = 314.55, $p < .0001$; Size: χ^2 (3, N = 8123) = 3376.72, $p < .0001$), and to Subjective adjectives, which appear in both, though slightly less often (Prenominal) and more often (Predicative) than adjectives overall (χ^2 (3, N = 9003) = 725.74, $p < .0001$).

Now, while the syntactic position of the adjective (e.g., as prenominal vs. predicative) does not point *directly* to the adjective's meaning, it is one source of information learners can use in service of discriminating different types of adjectives and important aspects of their interpretation. To illustrate this point, note the contrast between asserting (a) and (b) in (8).

(8) a. That girl is {happy/ confident}.
b. She is a {happy/confident} girl.

The latter seems to convey a more generic, enduring property of the girl than the former, a point that is further illustrated by the contrast in (9).

(9) a. Anna was scared, if just for a moment.
b. ?Anna was a scared girl, if just for a moment.

Table 2. Syntactic position of all adjective types observed in CDS across all corpora, each row summing to 100%.

	Prenominal n (%)	Postnominal n (%)	Predicative n (%)	Other n (%)
Emotion	87 (9.2)	49 (5.2)	777 (82.2)	32 (3.4)
Mental State	23 (2.6)	69 (7.9)	621 (71.2)	159 (18.2)
Subjective	3207 (35.6)	124 (1.4)	4073 (45.2)	1599 (17.8)
Adjectival Modals	1 (0.6)	0 (0)	158 (98.8)	1 (0.6)
Color	1072 (61.4)	16 (0.9)	372 (21.3)	287 (16.4)
Size	6346 (78.1)	82 (1.0)	1304 (16.1)	391 (4.8)
Physical Sensation	36 (3.9)	29 (3.2)	798 (87.4)	50 (5.5)
Physical Perception	173 (14.5)	90 (7.5)	824 (68.9)	109 (9.1)
Comparative Adjs	580 (45.1)	53 (4.1)	472 (36.7)	180 (14.0)
Other GAs	957 (62.1)	72 (4.7)	419 (27.2)	94 (6.1)
All Adjectives	16,752 (46.1)	1,015 (2.8)	14,470 (39.9)	4085 (11.3)

Abbreviations: CDS = child-directed speech; GA = Gradable Adjective.

The difference appears to translate into a stage-level versus individual-level predicate distinction, where the former expresses a transitory or accidental property and the latter property that is stable and enduring over time (Carlson 1977, Kratzer 1995). This split can be made clearly through adverbial modification, as shown in (10). Certain 'temporary' temporal adverbial expressions appear to combine better with adjectives in predicative position than with those in prenominal position.

(10) a. {Currently/Usually/In general} she is happy/confident {right now}.
b. {?Currently/Usually/In general} she is a happy/confident girl {?right now}.

This observation aligns both with previous corpus work in acquisition, and with cross-linguistic patterns. For example, in her analysis of adjective distribution in the Brown corpora, Saylor (2000) found that 'time unstable' adjectives were more likely to appear in predicative position, and 'time stable' adjectives in prenominal position. Davies et al. (2020) conducted an analysis of adjectives appearing in British English in free play with pre-selected props provided (the Tommerdahl corpus), shared book reading, and book texts. There, they found that adjectives were *overall* more likely to appear in prenominal than predicative position, and even more so in book texts. Quite a large percentage of their observed adjectives were size predicates, which we also found to occur predominantly in prenominal position (Table 2). Moreover, the *vast* majority of adjective uses were *descriptive* ('only one potential referent in the context, and where they denote a finer-graded meaning of the noun under discussion without contrasting the referent to a competitor'), versus *contrastive*. This pattern is consistent with Prasada's (1992) claim that prenominal adjectives signal a state that necessarily holds of an entity and modifies the object kind, while adjectives in predicative position signal a property caused by something (e.g., their internal argument), which may or not be made explicit (i.e., with a complement clause).

Cross-linguistically, it is also the case that human propensity adjectives (of which Emotion and Mental State adjectives are members) (Dixon 2010; Stassen 1997, 2013) are significantly more likely to appear in predicative position. It is also worth noting that in their search of the TED Parallel Corpus of nearly 177,000 parallel sentences across languages, Becker & Guzmán Naranjo (2020) not only found that the most frequent type of 'psych construction' overall were predicative adjectives, followed by transitive verb constructions, but also that the concepts of 'fear', 'happy', 'interested', and 'worry' were mainly expressed by predicative adjectives rather than prenominal, or attributive, ones. This correlation between adjective position and temporal interpretation is supported by analyzing predicates in languages that may or may not have an adjectival category, and in which predicates may host morphosyntactic markers of agreement. Stassen (1997, 2013) observes that (adjectival) predicates that exhibit verbal agreement have a more contingent or non-permanent interpretation, while those with nominal agreement are more 'time stable'. The prevalence of emotion and mental state adjectives in *predicative* position (where verbs also appear), as opposed to occurring as a modifier within a NP, thus may signal to the learner that the property may not necessarily hold of the person as an enduring property, but *may* hold true at some point in time.

Note that here, we are highlighting a correlation between adjectival position and temporal semantics, or temporal stability of the property, and observing that emotion adjectives, or psychological predicates, are significantly more likely to occur in predicative position, signaling a temporary state. However, as Diesing (1992) argued, this does *not* mean that these adjectives *are* (only) stage-level predicates, as they can appear with bare plural subjects with a generic reading (11), and resist appearance in postnominal position in existential *there* constructions (compare (a)-(b) to (c) in (12))—a pattern consistent with individual-level predicates and not stage-level predicates.

(11) a. Contrabassoonists are cheerful. (Diesing 1992, (50a))
b. Basenjis are nervous. (Diesing 1992, (50b))
c. Peasants are angry. (Diesing 1992, (50c))
(12) a. *There are contrabassoonists cheerful. (Diesing 1992, (53a))
b. *There are Basenjis nervous. (Diesing 1992, (53b))
c. There are pumpkins visible on the vine. (Diesing 1992, (48c))

And yet, they often allow for the copula in the predicative construction to take on the present progressive form (*being*)—a pattern consistent with stage-level predicates.

Finally, we note that while we focused on the prenominal:time stable::predicative:time unstable correlation here, there is something to be said about which adjectives can appear postnominally, what kind of syntactic constituency permits this occurrence, and what semantic meaning this position signals. We note briefly that an independent analysis of the postnominal adjectival occurrences (discarding those that are linearly adjacent due to the absence of a verb (*you sure?*)) allows them to be divided into roughly five main categories: (a) indefinites and the class of *some-* pronouns (*someone, something, no one, nothing*) followed by an adjective (*something special, nothing wrong*), which have been analyzed as involving underlyingly a prenominal adjective and a raised N (e.g. some [special thing] → some[thing]$_i$ [special t$_i$]; Kishimoto 2000), or seem to signal a reduced relative clause; control or ECM constructions with an implicit non-finite clause (e.g., *I want it quiet in here, I like it closed*); (c) expressions with *call* (e.g., *call you stupid*); (d) a description of the (desired) state of an entity (*he's got his mouth open, you have your hair different today, you just like it that salty*), and (e) small clauses signaling maintaining a state (e.g., *keep my ears warm*) or a change of state (e.g., *make me angry, get your hands dirty*) (see Basilico 2003, Safir 1983). Taking into account exclusions such as *you sure*? (pseudo predicative occurrences with no verb), and examining those tokens remaining, we note that *all but one* of the 44 emotion adjectives and most of the 26 mental state adjectives (all featuring *ready*) are in a small clause signaling a change of state (the former predominantly with *make* and the latter always with *get*)—a structural distribution consistent with the temporal semantics we previously describe.

3.2.2. *Semantics and syntax of the utterance context*

We now turn to the linguistic context in which these adjective types appear, tracking both semantic and syntactic information in the utterance in which they are featured. We look first at the modified nouns (which for emotion and mental state adjectives is overwhelmingly the subject by virtue of their frequently appearing in predicative position), then turn to the main verb in the clause, both of which represent semantic information. We then focus on syntactic complements, and in doing so also highlight adjunct phrases that also follow the adjective.

3.2.2.1. ***Modified nominal expressions.*** Given that emotion and mental state adjectives call for an animate experiencer subject, we predicted that the modified nominal expressions for these adjectives would be more likely to be animate. Note that when an adjective is in predicative position, the modified nominal expression is by default the subject, and the vast majority of the emotion and mental state adjectives occur in predicative position. Thus, since these adjectives are most likely to appear in predicative position, in most instances, the modified nominal expression for these adjectives will translate to an animate subject.

To test this hypothesis, we began by examining the pronouns serving as the modified expression, targeting those that necessarily signal an animate referent (*I, you, we, (s)he*), and those that do not (*they, it, that*). We predicted emotion and mental state adjectives would be more likely to occur with the former rather than the latter. We compared the occurrence of pronouns as nominal expressions for these two target adjective types to the other types that are likely to occur in predicative position as shown in Table 2 (adjectival modals, adjectives of physical sensation and perception, and subjective adjectives). The distribution of pronouns for these adjective types and all adjectives overall is presented in Table 3.

Note that for adjective types that are most likely to appear in predicative position (emotion, mental state, adjectival modals, physical sensation and perception) with the exception of subjective adjectives, which take expletive *it* and gerund subjects, among others, pronouns account for the vast majority of the modified nominal expressions, a pattern that lies in stark contrast to adjectives overall. Within these pronouns, emotion and mental state adjectives and adjectival modals occur with *they, it*, or *that* a very small percentage of the time. Note that documenting occurrences of *it* does not disambiguate

Table 3. Pronouns as the modified nominal expression for adjective types likely to occur in predicative position in CDS across all corpora, accounting for the total percentage of nominal expressions modified by that adjective type.

	I n (%)	*You* n (%)	*We* n (%)	*(s)he* n (%)	*They* n (%)	*It* n (%)	*That* n (%)	Total n (%)
Emotion	226 (24.6)	128(13.9)	12 (1.3)	224 (24.4)	43 (4.7)	11 (1.2)	4 (0.4)	648/918 (70.6)
Mental State	179 (25.0)	209 (29.2)	16 (2.2)	22 (3.1)	8 (1.1)	34 (4.8)	2 (0.3)	470/715 (65.7)
Subjective	40 (0.5)	272 (3.7)	3 (0)	267 (3.6)	200 (2.7)	1,083 (14.6)	1,727 (25.3)	3592/7413 (48.5)
Adjectival Modals	25 (15.7)	64 (40.3)	19 (11.9)	18 (11.3)	4 (2.5)	1 (0.6)	0 (0)	131/159 (82.4)
Physical Sensation	92 (10.6)	193 (22.3)	3 (0.3)	163 (18.8)	34 (3.9)	111 (12.8)	101 (11.7)	697/864 (80.7)
Physical Perception	17 (1.6)	110 (10.1)	0 (0)	73 (6.7)	56 (5.1)	377 (34.6)	43 (3.9)	676/1090 (62.0)
All Adjectives	1,036 (3.2)	2,056 (6.4)	91 (0.3)	1565 (4.8)	773 (2.4)	3,267 (10.1)	3,087 (9.6)	11,875/32,298 (36.8)

whether the interpretation of *it* is expletive or referential, only what surface form is occurring and where; either way, it is not animate.

In order to compare distribution of those pronouns that necessarily signal an animate referent (*I, you, we, (s)he*) to those that do not (*they, it, that*) out of all pronouns as modified nominal expressions, we performed a Chi-Square Goodness of Fit Test (corrected for continuity). The following adjective types in the table above were more likely to occur with animate pronouns than were adjectives overall (Emotion: χ^2 (1, N = 648) = 701.5, $p < .0001$; Mental State: χ^2 (1, N = 470) = 500.05, $p < .0001$; Adjectival Modals: χ^2 (1, N = 131) = 169.96, $p < .0001$; and Physical Sensation: χ^2 (1, N = 697) = 176.23, $p < .0001$). By contrast, subjective adjectives and adjectives of physical perception were more likely to occur with pronouns *not* marked for animacy (Subjective: χ^2 (1, N = 3,592) = 846.59, $p < .0001$; Physical Perception: χ^2 (1, N = 676) = 30.12, $p < .0001$).

We then focused *specifically* on emotion and mental state adjectives in CDS, coding all instances of a modified nominal expression for *animacy*. We performed our calculation two ways: one including all occurrences of an implicit subject from an imperative, an instance of syntactic control (PRO), or an instance of subject drop (as illustrated in (13)), and the second excluding all such occurrences and counting only those occurrences of an overt modified nominal expression. Animacy coding was easily accomplished: we coded as animate all proper names (e.g., *Shem, Peter, Lisa, Emily, Renee, Maggie*), kinship terms and familial titles (e.g., *Mummy, her mom, our Mum, my husband*), animacy-marked quantifiers (e.g., *somebody, everyone*), animals (e.g., *old dogs, this little tiger, the rooster, the bunny, the cow*), and referential expressions signaling a human referent (e.g., *that girl, this little boy*). Other subjects clearly did not fall into this category (e.g., *the bowl, the game, this train, that*).

(13) a. don't ⟨~~you~~⟩ get angry . (Suppes)
b. there's no needta ⟨~~you~~⟩ be grumpy . (Wells, Neville)
c. I love children ⟨~~children~~⟩ coming in and ⟨~~children~~⟩ being happy . (Belfast, Conor)
d. you want Arthur ⟨~~Arthur~~⟩ to get mad at me ? (Brown, Sarah)
e. I don't wanna hafta ⟨~~I~~⟩ get angry with you this morning . (Suppes)
f. ⟨~~I am~~⟩ glad you like it . (Brown, Sarah)

Doing so, we find the following. For emotion adjectives, including implicit nouns, there were 918 occurrences with an explicit or implicit modified nominal expression. Of these, 870 (94.8%) were animate. Excluding implicit nouns, 849/896 (94.8%) were animate. For mental state adjectives, there were 714 occurrences with an explicit or implicit modified nominal expression. Of these, 609 (85.3%) were animate. Excluding implicit nouns, 486/595 (81.7%) were animate. Thus, emotion and mental state adjectives are highly likely to occur with animate-marked pronouns and animate-marked nominal modified expressions, which in the vast majority of cases, are animate subjects.

3.2.2.2. *Verbs.* Given the pattern of emotion and mental state adjectives being more likely to occur in predicative position, and their expression of an affective or cognitive state of an experiencer, we predicted

that the matrix verb of the clause in which they appear might be likely to be a copula or linking verb. We therefore targeted these verbs out of all verbs across productions in CDS to determine their representation among the matrix verbs in sentences with our target adjectives, comparing their frequency to that observed with all documented adjectives in CDS (see Table 4). Perhaps, unsurprisingly, *to be* occurs commonly throughout adjectives. That said, it is most common as a main verb among emotion and mental state adjectives. Moreover, the combination of all of these verbs accounts for 94-96% of the documented verbs occurring with these adjectives, compared with 73% of adjectives overall.

3.2.2.3. ***Syntactic complements.*** We now turn to syntactic complements, the main feature that links certain argument-taking adjectives to verbs, and makes a syntactic bootstrapping story viable. As we have observed, not every adjective type can take a syntactic complement as an argument. A subset of adjective types do—most notably emotion, mental state, subjective, and adjectival modals. (We return to size and comparative adjectives shortly, since more can be said about these separately.) For these complement-taking adjective types, the syntactic argument can come in different forms, depending on the selectional restrictions of the adjective (much as with verbs). The complement can typically be a Prepositional Phrase (*about X, at X, of X)* or a sentence/clause in either non-finite or finite form (again, depending on the adjective). We therefore manually coded each occurrence of a complement following an adjective, categorized these by complement type, and analyzed the percentage of time the adjective types occurred with each of these complement types. The results are summarized in Table 5. The most frequent complement types in CDS are in the top row, along with the percentage of time each of the adjective types appears with that complement. The 'Total' at the end represents the overall percentage of time each adjective type appears with *any* of these complements out of all occurrences of that adjective type.

Table 4. Verb roots for target adjective types observed in CDS across all corpora.

	be n (%)	feel n (%)	look n (%)	seem n (%)	become n (%)	get n (%)	make n (%)	Total n (%)
Emotion	672 (76.1)	13 (1.5)	37 (4.2)	1 (0.1)	0 (0)	67 (7.6)	43 (4.9)	833/883 (94.3)
Mental State	581 (84.9)	0 (0)	0 (0)	0 (0)	0 (0)	70 (10.2)	7 (1.0)	658/684 (96.2)
All Adjectives	19,069 (63.6)	177 (0.6)	531 (1.8)	26 (0.1)	2 (0.0)	1454 (4.9)	616 (2.1)	21,875/29,974 (73.0)

Abbreviation: CDS = child-directed speech.

Table 5. Most frequent complements in CDS across all adjective types (including number of occurrences and percentage out of all occurrences for that adjective type).

	about X n (%)	at X n (%)	of X (to VP) n (%)	finite clause n (%)	non-finite clause n (%)	if clause[7] n (%)	Total n (%)
Emotion	13 (1.4)	31 (3.3)	36 (3.8)	143 (15.1)	46 (4.9)	10 (1.1)	279 (29.5)
Mental State	2 (0.2)	0 (0)	4 (0.5)	111 (12.7)	85 (9.7)	7 (0.8)	209 (24.0)
Subjective	12 (0.1)	29 (0.3)	44 (0.5)	33 (0.3)	265 (2.9)	10 (0.1)	393 (4.4)
Adjectival Modals	0 (0)	0 (0)	0 (0)	0 (0)	150 (93.8)	0 (0)	150 (93.8)
Color	0 (0)	0 (0)	0 (0)	1 (0.1)	2 (0.1)	1 (0.1)	4 (0.2)
Size	0 (0)	0 (0)	8 (0.1)	5 (0.1)	90 (1.1)	0 (0)	116 (1.4)
Physical Sensation	1 (0.1)	0 (0)	7 (0.8)	0 (0)	7 (0.8)	10 (1.1)	25 (2.7)
Physical Perception	0 (0)	0 (0)	0 (0)	4 (0.3)	26 (2.2)	0 (0)	30 (2.5)
Comparative Adjs	2 (0.2)	10 (0.8)	0 (0)	4 (0.3)	10 (0.8)	5 (0.4)	31 (2.4)
Other GAs	0 (0)	2 (0.1)	27 (1.8)	2 (0.1)	9 (0.6)	0 (0)	40 (2.6)
All Adjectives	65 (0.2)	99 (0.3)	195 (0.4)	378 (1.0)	713 (2.0)	75 (0.2)	1525 (4.2)

Abbreviations: CDS = child-directed speech; GA = Gradable Adjective.

[7]We include *if* clauses in this table to be thorough and accurately represent syntactic structures immediately following these adjective types, although we clarify in the following that not all of these *if* clause instances should be treated as the same sort of syntactic argument as the other complements. We therefore do not include these clauses in our experiment. We also leave aside the difference in interrogative/declarative status between *if* and other finite clause complements here.

As the table shows, emotion and mental state adjectives are observed with a range of syntactic complements, and most frequently with a clausal complement. Although the absolute numbers of occurrences are small, the table indicates that *between 24 and 30% of the time, whenever these adjectives appear in CDS, they are occurring with a syntactic complement*. It is illustrative to compare these patterns with that of adjectival modals and subjective adjectives, both of which have also been highlighted as taking syntactic complements. Adjectival modals such as *allowed* take a non-finite clause complement, and when they occur, appear with one *nearly 94% of the time in CDS*. By contrast, while subjective adjectives also do take syntactic complements, their appearance in CDS is only marked with a complement *less than 5% of the time*. And yet, because subjective adjectives are so abundant in CDS, the nearly 3% of the time that they take a non-finite clause is comparable in absolute numbers to the total number of occurrences of emotion and mental state adjectives.

In what follows, we provide concrete representative examples of the individual emotion and mental state adjectives appearing with each complement type. Note that in each of the cases below, the complement serves the role of specifying the cause of, or reason for, the predicate (potentially) holding true of the entity it modifies, or the internal argument.

about X appeared with *angry, glad, happy, nervous, sad*, and *upset*, as shown in (14)-(17). With the mental state adjectives, the only two instances were from *sure*, and both involved an adult asking a child if they were *sure about* something.

(14) were you *happy* or were you *sad* about that ? (Braunwald)
(15) yes [= ! laughs] I'm sure you would be very *upset* about that . (Braunwald)
(16) what are you getting *angry* about ? (Braunwald)
(17) I'm already *nervous* about getting your little face wet . (Clark)

at X appeared with a constrained set of adjectives: *angry, happy*, and predominantly *mad*, as shown in (18)-(21). Of these, *angry* and *mad* were anticipated, but *happy* was not. To us, *happy at* does not seem natural, but we highlight an occurrence from a parent-child exchange from the Kuczaj corpus in (22), which demonstrated that the use was not a repetition or imitation of a preceding child-produced utterance.

(18) but you can feel very *angry* at him . (Braunwald)
(19) (be)cause Arthur will get *mad* at me . (Brown, Sarah)
(20) why is Shem *mad* at daddy ? (Clark)
(21) who is she getting *mad* at ? (Suppes)
(22) CHI: uhhuh (.) you yelling .
FAT: well ‡ I didn't mean to yell at her .
MOT: Abe (.) Mommy and Daddy were just real *cranky*. we had an argument
MOT: but we're okay now we're *happy* .
CHI: I'm not !
FAT: and we're *happy at Abe* !

of X: The vast majority of instances of emotion adjectives taking an *of* complement were represented by *afraid*, with a handful of instances from *frightened, glad*, and *scared*. Some examples are listed in (23)-(28). To us, *glad of* does not seem natural, but it appears to be licensed outside of our dialects of American English, as this combination appeared in both Belfast corpora, and in one of the Wells corpora (Abigail).

(23) they're not *afraid* of the dark ? (Kuczaj)
(24) but what if I was *afraid* of an injection . (Braunwald)
(25) I'm *glad* of your company . (Belfast, Conor)
(26) all the other animals are *afraid* of a dinosaur because he's so big . (Brown, Adam)
(27) and I was scared of him overloading his stomach after being sick (Belfast, Conor)
(28) that's right (.) you're right (.) (be)cause they'd be *scared* of a bunny . (Clark)

The four instances of mental state adjectives with an *of* complement included *aware* and *careful*, as shown in (29)-(31). (Note that while *being careful* may translate into a certain manner of behaving or acting, one cannot say *act careful*.)

(29) that way you won't be so *aware* of the time . (Kuczaj)
(30) *careful* of these pictures . (Suppes)
(31) you hafta be *careful* of this book (.) because it's Maggie's book . (Suppes)

finite clause: Emotion adjectives in CDS taking a finite clause included *afraid, amazed, angry, disappointed, glad, happy, mad, sad, surprised, upset*, and *worried*. Examples with a complement headed by *that* are listed in (32)-(35) and those with a bare clause complement are listed in (36)-(42).

(32) they're *afraid* that the tiger will bite them (.) I bet . (Suppes)
(33) I'm *glad* that it doesn't hurt (.) Abe . (Kuczaj)
(34) and he'll be *mad* that you didn't save the gum for vacation village (Braunwald)
(35) and I'm *worried* that I don't have enough food, you_know ? (Belfast, Barbara)
(36) I'm *afraid* the horse may get hurt driving into a truck . (Brown, Adam)
(37) Peter (.) I'm *afraid* you're getting a little bit out_of hand now (be)cause you're gonna lose things for me and that won't be good (.) okay ? (Bloom, Peter)
(38) how *amazed* I was to hear that from Shem . (Clark)
(39) I'm sorry you're *disappointed* your doll didn't come to xxx . (Braunwald)
(40) I'm *glad* there're limits . (Brown, Sarah)
(41) I'm *glad* you love me . (Kuczaj)
(42) I'm so *happy* Jean found our stuff . (Kuczaj)

The only mental state adjective appearing with a finite clause (with or without *that*) was *sure*, with one sole appearance of *careful*, as illustrated in (43)-(49).

(43) are you *sure* those [//] these other people wouldn't fit ? (Bloom, Peter)
(44) oh I'm *sure* you were as good as punch ! (Belfast, Barbara)
(45) in fact (.) I'm pretty *sure* that I do have some pennies . (Clark)
(46) are you *sure* that's yellow ? (Brown, Sarah)
(47) are you *sure* that's a pear ? (Suppes)
(48) now ‡ you be very very *careful* that doesn't go all over those good clean clothes . (Belfast, Conor)
(49) Ian are you *sure* you want any of these ? (Wells, Frances)

non-finite clause: Emotion adjectives in CDS taking a nonfinite complement clause included *afraid, anxious, cranky, glad, happy, sad*, and *scared*. Representative examples are listed in (50)-(53).

(50) I'm a little *afraid* to have my hair washed . (Braunwald)
(51) was I *glad* to get rid of that . (Brown, Sarah)
(52) I'm *happy* to do that too . (Belfast, Barbara)
(53) are you *happy* to come home to all these animals ? (Suppes)
(54) you'd be *scared* to touch it . (Belfast, Conor)

Note that while gerundive complements were infrequent, they did appear with emotion adjectives on occasion, as in (55)-(56). We take these to be a form of clausal complement in which the implicit embedded subject is connected to the subject of the matrix clause, as with non-finite clauses.

(55) she wasn't *happy* being alone (.) she knew Shem was doing something interesting (.) hm: ? (Clark)
(56) she's *happy* playing with the money at the moment (Wells, Harriet)

The lion's share of mental state adjectives taking non-finite clause complements belongs to *ready*. Others that make an occasional appearance are *brave, careful, eager, reluctant, sure*, and *willing*. Some examples are listed in (57)-(62).

(57) you all *ready* to do your house work ? (Brown, Sarah)
(58) okay ‡ let's start getting *ready* to go to Bumpa and Ninny's house . (Kuczaj)
(59) now we hafta be *careful* to keep it on the paper . (Clark)
(60) she hasta be *careful* not to fall out ? (Suppes)
(61) was she *willing* to marry Batman ? (Brown, Sarah)
(62) and I think you're very *brave* to cope with it . (Wells, Abigail)

if X: The emotion adjectives appearing with an *if* clause included *afraid, glad, happy, mad, sad*, and *scared*, as shown in (63)-(67).

(63) I'm *afraid* if it's not (,) she'll not get another chance . (Belfast, Barbara)
(64) I think he'd really be *happy* if you did that . (Kuczaj)
(65) your cat has that same kind of whiskers (.) and he would be very *mad* if you cut them off. (Clark)
(66) do you think that would make him *sad* if you called him a baby ? (Kuczaj)
(67) I'm going to get *sad* if you tease me . (Suppes)

For mental state adjectives, the only adjective appearing with an *if* clause was *sure*, with one sole appearance of *impatient*, as captured in (68)-(70).

(68) let's see (.) I'm not *sure* if it's still working . (Bloom, Peter)
(69) well (.) I'm not really *sure* if it's long enough . (Clark)
(70) but they're going to get *impatient* if they sit here forever . (Suppes)

We share here a word of caution about the *if* clauses following emotion and mental state adjective. Although the adjective is immediately followed by an *if* clause, it is not necessarily the case that the adjective is actually taking the *if* clause as a syntactic complement in the same way as with the other arguments we highlight. Consider rogative verbs that take *if* clauses (e.g., *wonder: I wonder if it is time for bed*). The examples with *sure* in (68)-(69) are similar. By contrast, other examples (e.g., (64)-(67), (70)) appear to be conditionals in which the *if* clause is the antecedent, and the adjective appears in the consequent. Still other examples are ones where the adjective is taking a finite clause with no overt complementizer, which is actually a conditional statement itself (e.g., (63)).

It may seem surprising that there were 90 occurrences of a non-finite complement clause, and a handful of finite clause complements, with size adjectives in Table 5. These are indeed grammatically licensed occurrences. In most of these cases, there appears to be a long-distance dependency with another standard marker, coming in the form of *too* preceding the adjective, or *enough* following it, as illustrated in these examples from Adam's files in the Brown corpus.

(71) I think that one's too *large* to go in the window .
(72) I'm too *big* to jump through that hole.
(73) you aren't *big* enough to play that game
(74) then perhaps you're not *big* enough to play with those if those are dangerous things.

There are occasional instances in which the size adjective appears with a non-finite clause on its own, as shown in (75)-(78).

(75) the hall and stairs is a *big* thing to do, isn't it ? (Belfast, Barbara)
(76) you could have your own room with a *big* chalkboard to draw on . (Kuczaj)
(77) a *little* seat to sit on . (Clark)
(78) you got t(o) have a *big* mouth to eat all that (.) in one bite . (Brown, Sarah)

We note that there are some occurrences, like those in (75)-(78) and others, in which the adjective is in prenominal position, with the complement occurring to the right of a noun. These occurrences are typically instances of subjective adjectives, as shown in the examples in (79)-(86).

(79) some thing dying is an *alright* reason to cry . (Braunwald)
(80) okay ‡ let's figure out the *easiest* way to do it . (Kuczaj)
(81) this is a *funny* way to read a story, isn't it ? (Braunwald)
(82) that's a *good* one to jump on. (Brown, Adam)
(83) monkey is a *big hard* word to learn . (Belfast, Barbara)
(84) that would have been a *hard* one to kick anyway . (Kuczaj)
(85) I thought that was the *logical* thing to do . (Brown, Sarah)
(86) because that's a *nice* place to go . (Brown, Adam)

3.2.2.4. *Adjuncts.* In addition to syntactic complements following adjectives as arguments, there are also other adjunct expressions immediately following adjectives that could be informative to the learner. For example, a *for* phrase may provide information about a standard of comparison for gradable adjectives; a *because* clause provides information about a cause of a current state; a *when* clause and other temporal expressions like *now* signal that a state is stage-level and not enduring over time, and therefore could combine with predicates such as *sad, angry, funny looking, different*, or *better* rather than, for example, *tall* or *friendly*.

We predicted that while the occurrence of these expressions would be infrequent in CDS, across adjective types, these semantic features would be reflected in the distribution of these expressions across adjectives. Indeed, this is what we found, albeit in very small numbers (see Table 6). As in Table 5, we track the percentage of time that each adjective type appears with such an expression; therefore, the numbers should not add to 100% and should only represent a small percentage of all occurrences.

As predicted, the numbers are admittedly small, and while the individual occurrences could be informative to the child sorting between different types of adjective meaning, they might not always signal the same meaning when they occur. For example, *for* phrases are likely to occur with size, subjective, and mental state adjectives. For the two former types, the *for phrase* signals a standard relative to a norm, function, or context-dependent comparison class, as illustrated in (87)-(89) (see, e.g., Ebeling & Gelman 1994). For the latter (mental state) the vast majority of instances are with a specific adjective, *ready*, in the fixed expression *ready for X*, as shown in (90). This, too, is a context-dependent expression in that it relativizes what the subject is ready for, and yet it means something different than a *for an X* standard phrase.

(87) that other one's much too *small* for the babies . (Sachs)
(88) that's a terribly *small* horse for you to ride. (Brown, Adam)
(89) that's a *funny* name for a kitty . (Brown, Adam)
(90) you've got to get *ready* for school (.) honey . (Sachs)

The one documented occurrence of a *for* phrase with an emotion adjective is from Adam's files in the Brown corpus (see (91)), with a licensed use of this phrase, which is also not a standard-denoting instance.

Table 6. Select adjunct expressions following adjectives in CDS across adjective types (including number of occurrences and percentage out of all occurrences of that adjective type).

	for DP n (%)	for DP + non-finite clause n (%)	because clause n (%)	when clause n (%)	temporal expression n (%)
Emotion	1 (0.1)	0(0)	11 (1.2)	13 (1.4)	13 (1.4)
Mental State	42 (4.8)	2 (1)	0 (0)	0 (0)	6 (0.7)
Subjective	97 (1.1)	9 (0.1)	1 (0)	25 (0.3)	13 (0.1)
Adjectival Modals	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.6)
Color	0 (0)	0 (0)	0 (0)	2 (0.1)	5 (0.3)
Size	86 (1.1)	7 (0.1)	0 (0)	1 (0)	12 (0.1)
Physical Sensation	7 (0.8)	3 (0.3)	0 (0)	5 (0.5)	9 (1.0)
Physical Perception	12 (1.0)	3 (0.3)	1 (0)	3 (0.3)	11 (0.0)
Comparative Adjs	10 (0.8)	0 (0)	0 (0)	2 (0.2)	19 (1.5)
Other GAs	4 (0.3)	0 (0)	0 (0)	0 (0)	6 (0.4)
All Adjectives	295 (0.8)	59 (0.2)	41 (0.1)	74 (0.2)	127 (0.3)

Abbreviations: CDS = child-directed speech; GA = Gradable Adjective.

(91) I'll be *happy* for two of them . (Brown, Adam)

Examples of *when* clauses and temporal expressions with emotion and mental state adjectives are provided in (92)-(96). Most of the occurrences of mental state adjectives with temporal expressions are *sure yet* and *ready now*. These uses are consistent with our earlier observation that emotion and mental state adjectives appearing in predicative position support a stage-level predicate interpretation.

(92) were you *happy* when the baby got born ? (Braunwald)
(93) Peter were you *happy* when you were a baby ? (Bloom, Peter)
(94) she was *happy* when the scab came off ? (Kuczaj)
(95) I'll be *glad* when summer comes . (Brown, Sarah)
(96) are you *happy* now that you're eating ? (Kuczaj)

3.3. *Discussion*

The Corpus Study revealed the following patterns about emotion and mental state adjectives in CDS. First, emotion and mental state adjectives are highly likely to appear in predicative position, rather than prenominal (attributive) position, following a copular verb (particularly *be*). In this way, they align with adjectival modals like *able* or *allowed* and adjectives of physical sensation and perception, and differ from adjectives denoting color or size. Subjective adjectives like *easy* or *good* appear in both positions often. The predicative position appears to be linked to a semantic aspect of these 'human propensity' predicates—namely that they are typically interpreted as stage level and not 'time stable'.

Emotion and mental state adjectives are also highly likely to appear with an animate-marked pronoun as the modified nominal expression, and because of their position, as the subject. This pattern again aligns with adjectival modals, and stands in stark contrast to e.g., subjective adjectives and adjectives of physical perception, which regularly appear with pronouns that are not marked for animacy modified nominal expressions. Beyond pronouns, emotion and mental state adjectives are also extremely likely to occur with animate nominal expressions, as predicted by the semantics of these adjectives, which require an animate or experiencer subject.

Finally, while emotion and mental state adjectives are relatively infrequent in CDS, accounting for less than 10% of overall adjective production, approximately a quarter of the time when they do appear, they do so with a syntactic complement. The more frequent syntactic complements are finite and non-finite clauses, and prepositional phrases, which express the cause of the internal state or the internal argument. Other adjunct phrases such as *for*, causative, or temporal phrases may serve to signal the semantic nature of these predicates, but are highly infrequent and do not necessarily share a common constituency.

Knowing that these semantic and syntactic cues are present to some observable degree in CDS for learners to pick up on when acquiring adjectives, we turn now to our experiment, in which we directly assess whether learners can recruit the presence of these cues to arrive at emotion or mental state adjective meaning, which cues are most informative, and whether there is an additive influence of these linguistic factors. As such, our approach is reminiscent of Fisher et al.'s (1991) series of experiments subjecting theoretical proposals concerning the tight correspondence between syntactic structure and verb semantics (based on Gruber 1965, Jackendoff 1972, and many others) to psycholinguistic testing.[8]

4. Experiment

Our aim in the experiment was to determine whether the key distributional properties of emotion and mental state adjectives in the input—predicative syntactic position following the copula *be*, animate

[8]We are grateful to a reviewer for highlighting this connection.

modified nominal expression/subject, and presence of syntactic complements—can be harnessed to narrow the space of possible word meaning in support of learning these adjectives.

4.1. *Stimuli and procedure*

155 adults were recruited from Prolific online, all fluent speakers of English. There were no exclusions. Participants were compensated for their participation at a Prolific-approved rate. We employed the Human Simulation Paradigm, a methodology that has been successfully recruited by a number of researchers to assess the power of the linguistic context in constraining meaning (Fitch et al. 2021, Gillette et al. 1999, Gomes et al. 2023, Piccin & Waxman 2007, Snedeker & Gleitman 2004). In this task, adults serve as proxies for the word learning process, allowing us to control for conceptual and lexical knowledge. If the nature of word learning differs between children and adults as a function of a conceptual gap, then we should not be able to model young word learners with adults. If, however, we carefully control what information is withheld (here the visual scene, and the actual word nestled in a linguistic context), and which information is provided (the actual linguistic context) then we may successfully highlight the role of information in supporting word learning. We implemented the 'dialogue version' of the Human Simulation Paradigm (HSP) (Gotowski 2022, Gotowski & Syrett 2022, under revision), in which participants are exposed to a novel word placed in controlled, scripted dialogues without any visual scenes (see Arunachalam & Waxman 2010, Arunachalam et al. 2016, Yuan & Fisher 2009), and are then asked to posit a guess as to the word's meaning, and rate their confidence in doing so.

We created scripts of dialogues between two speakers incorporating novel adjectives taking syntactic arguments. See Table 7 for an example trial. Within these dialogues, novel adjectives always appeared in predicative position, following *be*. We manipulated two factors between subjects to evaluate the contribution of semantic information in concert with the syntactic complement: Subject (±Animate/Human) and semantic content of the Complement (±Semantic). In one condition, the Subject was either a determiner phrase headed by a first person possessive, later followed by a demonstrative determiner (e.g., *my tulver . . . that tulver*), then subsequently referred back to with the pronoun *it*, thereby favoring interpretation of the noun as an inanimate or non-human entity. In another, the Subject was headed by the phrase *my friend* (e.g., *my friend Tulver*), then referred back to anaphorically with a singular third-person gendered pronoun (*s/he*), thereby favoring interpretation of the entity as a human, and thus animate. To further reinforce the animacy distinction, in the Inanimate condition, Speaker A asked about the entity using *what* and referred to it with demonstrative *that* (e.g. *What is that over there?*) and Speaker B mentioned that the entity was found, made, or given to the speaker. We will therefore refer to this condition as the Inanimate condition, even though it is conceivable that participants may have considered the novel noun as referring to an animal (e.g., my cat).

By contrast, in the Animate condition, Speaker A asked about the entity using *who*, and Speaker B mentioned that the entity knew the speaker or liked to do certain things (e.g., go swimming, eat cupcakes). The Complement either contained semantically bleached information (e.g., *about something, that something is happening, at someone because they did something*) (see White & Rawlins 2016, 2018) or semantically contentful information (e.g., *about the cold weather, of animals, that it's sunny today*). These factors were fully crossed yielding four between-subjects conditions: Animate-Semantic, Animate-Bleached, Inanimate-Semantic, and Inanimate-Bleached.

We targeted the six most frequent complements occurring with emotion and mental state adjectives observed in the Corpus Study (see Table 5). These complements included the following: PPs (*about DP, about [gerund]* [see *about X* in Table 5], *at DP, of DP*), non-finite clauses, and finite clauses. This design resulted in four distinct sets of stimuli, as captured in the example trial in Table 7. The full set of stimuli is included in Online Supplemental Appendix C (control items) and D (target items).

Videos were filmed in a quiet space in the first author's lab with trained research assistants as actors, subsequently edited in iMovie, posted on the lab's YouTube channel, then embedded via html code into trials in Qualtrics. Participants took the study online in their own time, and were asked to

[8]We are grateful to a reviewer for highlighting this connection.

Table 7. Structure of stimuli for an example trial in Experiment with a finite clause complement.

A asks B a question. B responds to A. A repeats content from B each time.

	Inanimate Subject	Animate Subject
Introduction	A: **What** is that in the box?	A: **Who** is that opening up a box?
	B: That is **my cheemo**. I bought it yesterday.	B: That is **my friend Cheemo**. He likes to sing songs.
	A: Ah ha, you bought **that cheemo** yesterday.	A: Ah ha, **your friend Cheemo** likes to sing songs.
	B: This cheemo **is spoovy**.	B: My friend Cheemo **is spoovy**.
	A: Ah, this cheemo is spoovy.	A: Ah, your friend Cheemo is spoovy.
Bleached Comp.	B: Yep, this cheemo is spoovy **that something is happening**.	B: Yep, my friend Cheemo is spoovy **that something is happening**.
	A: Mm hmm, [repeats]	A: Mm hmm, [repeats]
Semantic Comp.	B: Yep, this cheemo is spoovy **that it's sunny today**.	B: Yep, my friend Cheemo is spoovy **that it's sunny today**.
	A: Mm hmm, [repeats]	A: Mm hmm, [repeats]

complete the study in one session, in approximately 20 minutes. The experiment took on average approximately 15 minutes to complete.

There were six target emotion-mental state adjective trials, each featuring a different syntactic complement. There were four control trials, including a count noun trial and a trial with a verb in a transitive frame with a DP object bookending the experiment session, and two non-emotion, subjective adjective control trials interspersed within the session. The latter were chosen for their surface-level similarity with the emotion/mental state adjectives in taking a syntactic complement, and their ability to take expletive and gerundive subjects, which should be a cue that these trials do *not* support an emotion-mental state adjective meaning. Manipulating these surface aspects, we therefore predicted that participants would be significantly less likely to provide emotion/mental state adjective guesses for novel adjectives used in these two control trials. After each video sequence, participants were prompted to guess the meaning of the novel word, then rate their confidence on a 4-point scale.

4.2. *Data preparation*

The two authors independently reviewed each of the guesses provided by each of the participants for each trial, and excluded those trials in which a participant did not report a guess, indicated they did not know, or were clearly providing nonsensical answers across controls or target items. There was a small percentage of such items (2.3%). We then independently coded each guess for grammatical category according to trial type (i.e., noun, verb, or adjective for the four control trials, and adjective for the target trials), then for a finer-grained subcategory (i.e., count noun, transitive verb for the two non-adjective trials, and emotion/mental state adjective for the two non-emotion adjective control trials and the six-target emotion/mental state adjective trials). Disagreements in coding were infrequent (2.8% of responses), and were easily reconciled through discussion.

We used the following semantic diagnostics for emotion/mental state adjective: could the adjective appear with *feels*, and did it require an experiencer subject? We further consulted lexical items referenced in previous work on affect, emotion, emotive factives, and psych predicates to cross-check against this list. Although we instructed participants to provide *one* guess, on occasion, a participant provided multiple guesses. When a participant listed multiple words, we included each guess in our analysis, and therefore, if one of the guesses was an emotion or mental state adjective, we included this guess towards the proportion of emotion/mental state adjective guesses (and, conversely, if any of those guesses were not emotion or mental state adjectives, they counted against this proportion). Across all guesses from participants, there

were 80 instances of multiple guesses, accounting for only 6.8% of all guesses. Of these, there were only 8 instances of multiple guesses where only one of the guesses was an emotion/mental state adjective (treated as indicated above), accounting for 0.7% of all guesses. There were 28 instances (2.4% of all guesses) of multiple guesses, *none* of which was an emotion/mental state adjective. Twenty-three of these guesses were from the two control non-emotion adjective types with an expletive or gerund subject. In the remaining multi-guess responses, (44) all guesses were emotion/mental state adjectives.

4.3. *Results*

4.3.1. *Control items*

We begin with the count noun and transitive verb control items. For each of these, 99% of the guesses were of the correct grammatical category. The overall proportion of count noun guesses was 93% for that trial, and 98% transitive verb guesses for the transitive verb trial. Thus, participants recruited the linguistic context to successfully narrow the space of meaning as we intended.

For the two control non-emotion adjective trials, recall that while these adjectives appeared with a syntactic complement, the stimuli included an expletive *it* subject or a gerund subject (i.e., *It is gormy for a wazu to be around kids; Playing games with this bosa is pilky*), thereby excluding as a possibility an emotion/mental state adjective interpretation, since the latter adjectives require an experiencer subject. Accordingly, participants provided adjective guesses 98% of the time, but provided emotion/mental state adjective guesses 0% of the time. Their guesses included subjective adjectives such as *comforting, dangerous, difficult, exciting, fun, good, interesting, normal, relaxing*, and *therapeutic*. Note that each of these adjectives allows for an expletive or a gerund subject, and gives rise to instances of faultless disagreement, categorizing them differently from emotion or mental state adjectives.

4.3.2. *Effects of subject animacy and complement semantics*

With our control items as a backdrop, we now turn to the six-target emotion/mental state adjective trials. With these items, participants provided adjective guesses 94% of the time, and emotion/mental state adjective guesses on average 74% of the time. In order to determine the probability of guessing an emotion adjective, both a Bayesian and a frequentist binomial multilevel logistic regression were run. The models had the same fixed and random effects structures. In the models, the fixed effect predictors were Subject (2 levels: animate, inanimate), Complement condition (2 levels: bleached, semantic), and their interaction. There were also random intercepts for participant and complement type. All model priors were the default in brms, a student's T distribution with 3 degrees of freedom. All models were fit with 4,000 iterations (1,000 warm-up). Hamiltonian Monte-Carlo sampling was carried out with 4 chains distributed between 4 processing cores. The frequentist model used a significance level of .05 and was fit using the lme4 function in R using maximum likelihood estimation. In the frequentist model, nested model comparisons revealed a main effect of Subject Animacy ($\chi^2(1) = 47.7$; $p < .001$), but no main effect for either the Complement ($\chi^2(1) = 2.11$; $p = .15$) or an Animacy*Complement interaction ($\chi^2(1) = 2.79$; $p = .10$) The full model summary can be found in Table 8.

Participants were *least* likely to guess an emotion/mental state adjective with Inanimate/Non-Human subjects and semantically Bleached complements. That said, the percentage of emotion/mental state adjective guesses in this condition was still over 50% on average (ranging from 23%-86%, depending on the complement, a result we return to in the following section). These results demonstrate that *even with an inanimate-favored subject, the syntactic complement strongly favored emotion/mental state adjective guesses*. At the same time, the fact that the emotion/mental state adjective guesses were most likely with an Animate/Human subject (on average 85%, ranging from 54%-98% across complements) demonstrates *the cumulative power of syntax and semantics*: the restrictive syntactic complement and the semantically-encoded subject (along with the adjective consistently being presented in predicative position) worked together to reinforce an emotion/mental state adjective interpretation.

Table 8. Full model summary for the frequentist binomial logistic regression model.

	Odds Ratios of an emotion adjective guess		
Predictors	Odds Ratios	CI	p
(Intercept)	16.73	4.96 – 56.37	<0.001
subject animacy condition [inanimate]	0.08	0.04 – 0.19	<0.001
complement content condition [semantic]	0.87	0.38 – 2.02	0.752
subject animacy condition [inanimate] × complement content condition [semantic]	2.58	0.85 – 7.88	0.096
Random Effects			
σ2		3.29	
τ00 prolific_id		1.41	
τ00 word_col		1.61	
ICC		0.48	
N word_col		6	
N prolific_id		155	
Observations		918	
Marginal R2/Conditional R2		0.150/0.557	

Abbreviations: CI = confidence interval; ICC = intraclass correlation coefficient.

These results are captured visually in the graphs that follow. Figure 1 reveals that when the Subject was Animate, the probability of guessing an emotion/mental state adjective was always high, and comparable for both complement types. When the subject was inanimate, a semantically-informative complement was more likely to elicit emotion/mental state adjective guesses. However, in all four conditions, the probability of guessing an emotion/mental state adjective was over .50, indicating that *the presence of the complement signaled this kind of predicate meaning, regardless of the semantic status of the subject*.

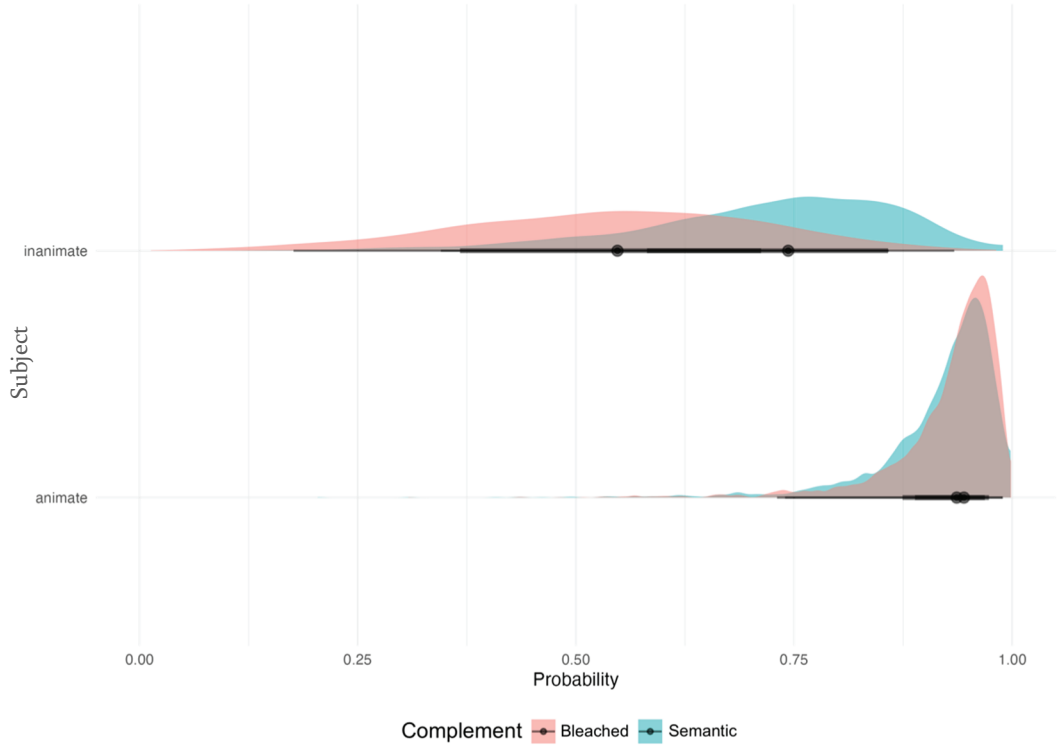

Figure 1. Posterior distribution of the probability of guessing an emotion/mental state adjective for each of the four between-subject conditions: Subject (Animate/Inanimate) and Complement (Bleached/Semantic).

We also compared the effect size for each of these conditions (see Figure 2 and the modeling in Table 9). The number inside the distribution is the probability of the effect being positive, going from a Bleached to a Semantic Complement. The numbers below the data points are the mean of the distribution (or the most probable effect size), and the upper and lower bounds of the 95% highest density interval (HDI). We are 98% sure that the posterior distribution was positive: that is, when the subject is inanimate, the semantic content of the frame raises the likelihood of participants guessing an emotion/mental state adjective, presumably because the semantic content introduces a strong cue to animacy where the subject did not. By contrast, for the Animate condition, the probability of a positive effect is .38, suggesting that we are unable to conclude that the semantics of the complement made any difference here, consistent with Figure 1: when the subject is animate and the adjective takes a syntactic complement, the probability of an emotion/mental state adjective guess is consistently high.

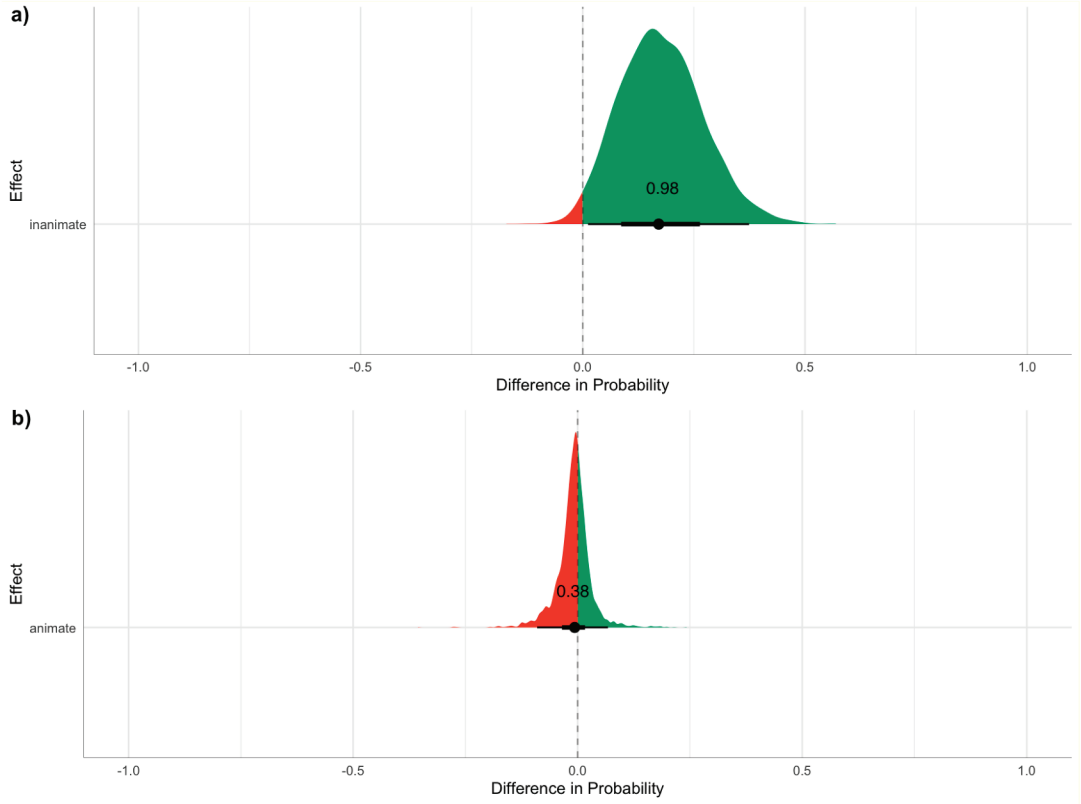

Figure 2. Effect size plot of the difference between the posterior distributions, contrasting going from Bleached to Semantic Complement in the Inanimate (a) and Animate (b) Subject conditions.

Table 9. Summary of the posterior distribution modeling of the log odds of guessing an emotion/mental state adjective as a function of the factors Subject Animacy and Complement.[a]

Parameter	Median	HDI	% in ROPE	MPE	Rhat	ESS
Intercept	2.84	[1.04, 4.52]	0.00	1.00	1.01	716.00
animate	-2.65	[-3.62, -1.78]	0.00	1.00	1.00	1,387.00
lexical	-0.15	[-1.04, 0.78]	0.29	0.62	1.00	1,533.00
animate:lexical	1.02	[-0.23, 2.24]	0.07	0.95	1.00	1,330.00

Abbreviations: HDI = highest density interval; ROPE = Region of Practical Equivalence; MPE = maximum probability of effect; Rhat = R-hat convergence diagnostic; ESS = Effective Sample Size.

[a]The table includes posterior medians, the 95% HDI, the percentage of the HDI within the ROPE, and the MPE.

Given these overall effects of the factors, we then looked at the effects of the factors for each of our six syntactic complement types. We hypothesized that a complement that serves as a more powerful cue might manifest a higher proportion of emotion/mental state adjective guesses, requiring less support from an animate subject. We begin with an overall average of the proportion of emotion/mental state adjective guesses by factor for each complement in Figure 3. As expected from the summary of the results above, the highest averages are found with the complements in the Animate Subject-Semantic Complement condition (far left), and the lowest in the Inanimate Subject-Bleached Complement condition (far right). Within these conditions, however, we can see that some complements were more evocative of an emotion meaning than others.

It may be surprising to see how weakly the non-finite clause complement (*to VP*) elicited emotion guesses. We think that this is precisely because not only emotion and mental state adjectives take a non-finite clause complement, but also (overwhelmingly) adjectival modals and (more weakly) subjective and physical perception adjectives (see Table 5). Participants' guesses reflected this fact, and included entirely reasonable and syntactically-compatible responses such as *able, designed, fun, helpful, known, likely, made, programmed, useful*, among others. Featuring an animate subject with this complement gave the proportion of emotion/mental state adjective guesses a significant boost. Something similar is observed with the *of DP* complement, although for this complement, including semantic content helped.

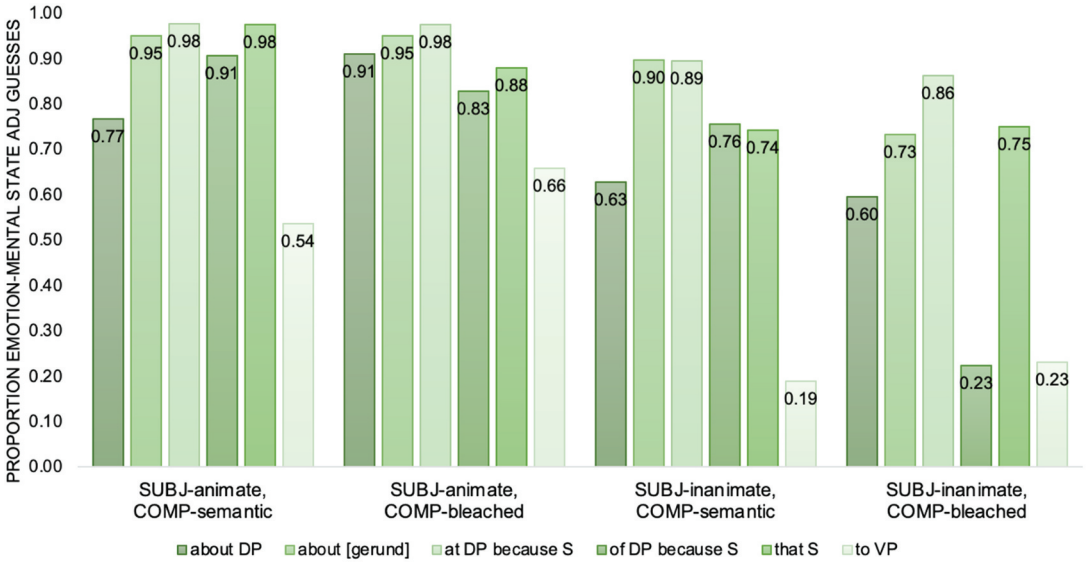

Figure 3. Proportion of emotion/mental state adjective guesses by factor for each complement.

We then looked more closely at the probability of emotion/mental state adjective guesses for each of these complements in each of the four conditions using the random effect of the model, to see the effects of our two factors of Subject and Complement, as shown in Figure 4. These same effects are drawn out further, and the effects of an animate subject (seen in blue) are more visible. Numerical estimates for each point in Figure 4 are available in Table 10. The full model summary of the ordinal model is in Table 11.

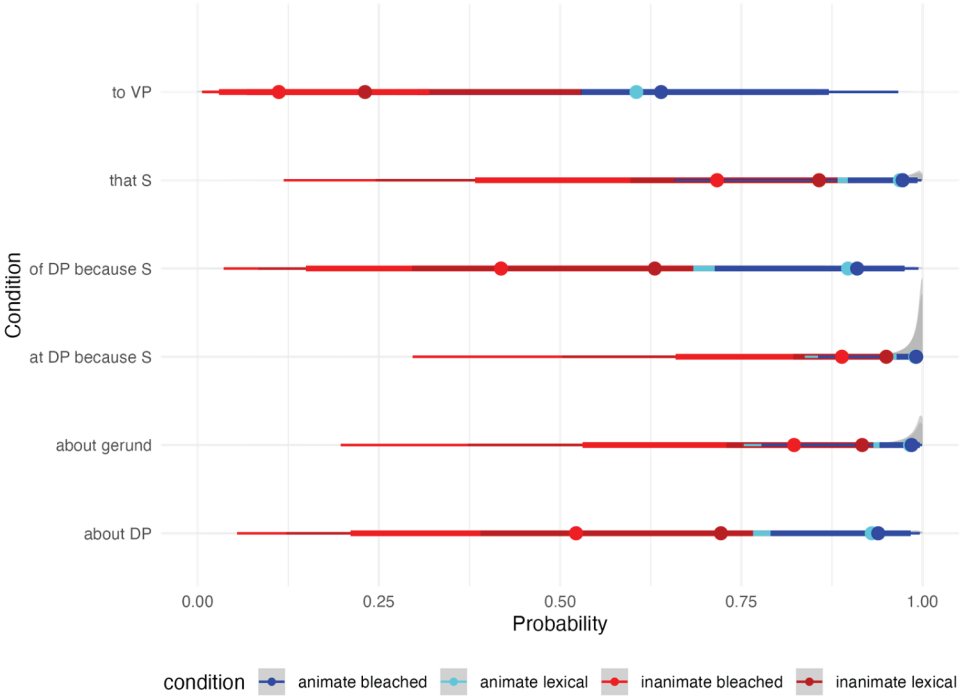

Figure 4. Probability of guessing an emotion or mental state adjective in each of the 4 conditions for all 6 complements.

Table 10. Random effect point estimates corresponding to Figure 4.

complement	condition	estimate
about DP	animate bleached	0.88
about DP	animate semantic	0.87
about DP	inanimate bleached	0.51
about DP	inanimate semantic	0.66
about gerund	animate bleached	0.96
about gerund	animate semantic	0.96
about gerund	inanimate bleached	0.75
about gerund	inanimate semantic	0.85
at DP because S	animate bleached	0.98
at DP because S	animate semantic	0.97
at DP because S	inanimate bleached	0.82
at DP because S	inanimate semantic	0.90
of DP because S	animate bleached	0.85
of DP because S	animate semantic	0.83
of DP because S	inanimate bleached	0.44
of DP because S	inanimate semantic	0.59
that S	animate bleached	0.94
that S	animate semantic	0.93
that S	inanimate bleached	0.66
that S	inanimate semantic	0.79
to VP	animate bleached	0.60
to VP	animate semantic	0.57
to VP	inanimate bleached	0.17
to VP	inanimate semantic	0.29

4.3.3. *Emotion and mental state adjective guesses for complements*

To further examine the power of each individual complement for cueing a *particular* emotion or mental state adjective meaning, and to compare how those guesses might be influenced by the semantic content of the complement clause, we evaluated the *actual* emotion/mental state adjective guesses for each individual complement, and their frequency, tracking those guesses offered at least twice. We hypothesized that some complements

would be more restrictive in the specific adjective meanings they supported, and others license a broader range of supported adjective meanings. Indeed, this is what Figures 5–10 illustrate for the PP complements *about DP, about [gerund], at DP, of DP* and the finite (*that S*) and non-finite (*to VP*) clausal complements. Note that the y-axis varies from figure to figure, because the number of hits per adjective token varies.

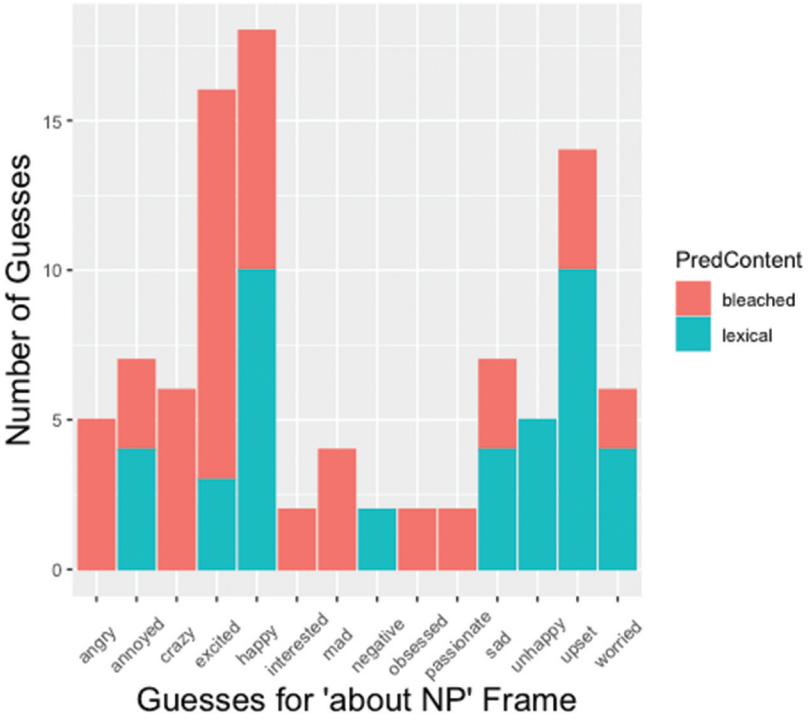

Figure 5. Individual emotion/mental state guesses with frequency for 'about D" complement.

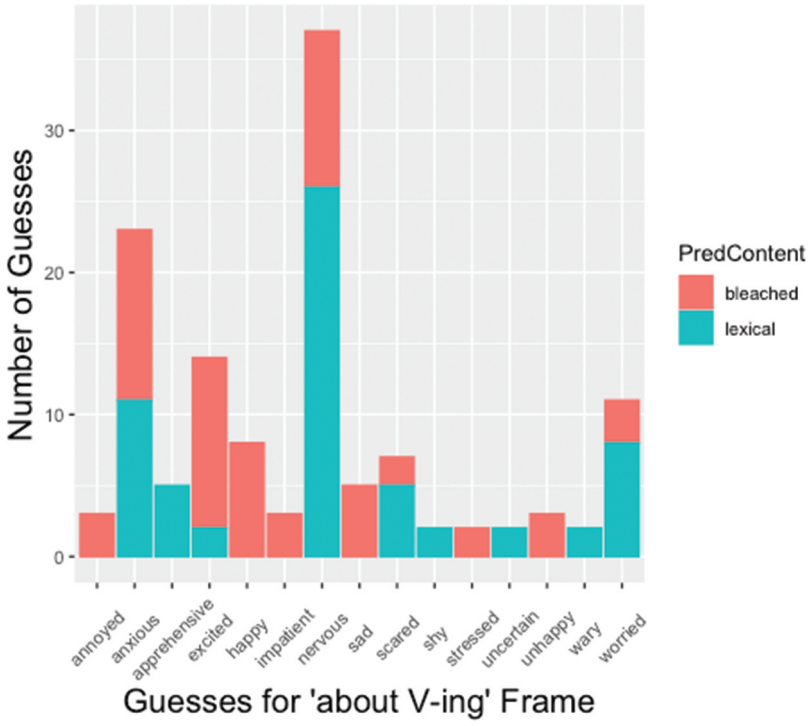

Figure 6. Individual emotion/mental state guesses with frequency for "about gerund" complement.

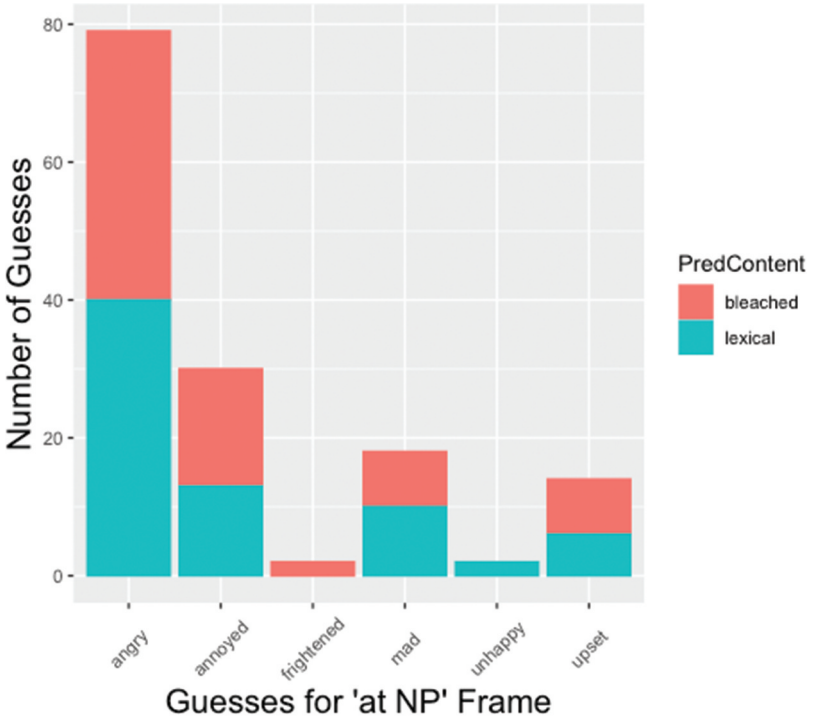

Figure 7. Individual emotion/mental state guesses with frequency for "at DP" complement.

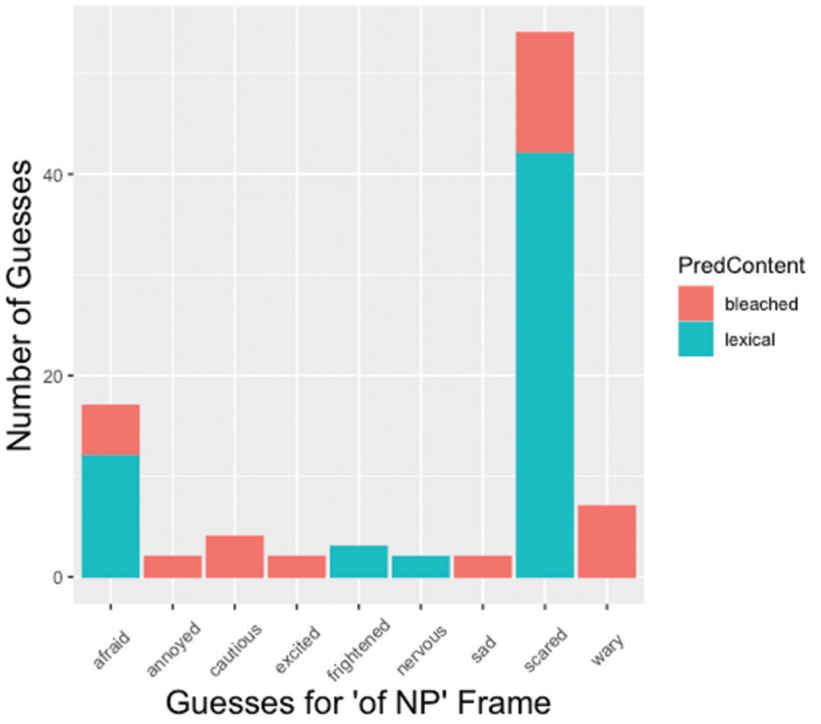

Figure 8. Individual emotion/mental state guesses with frequency for "of DP" complement.

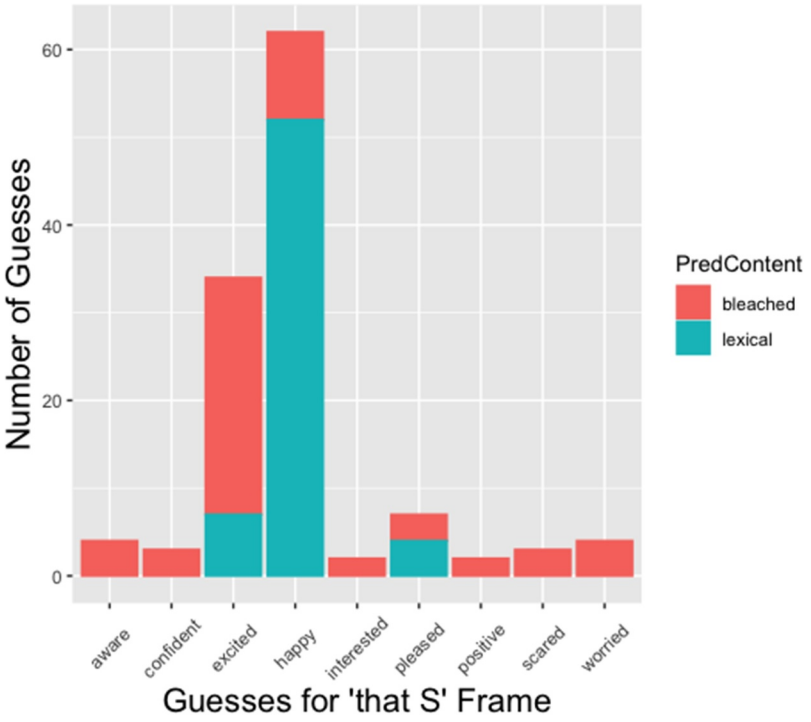

Figure 9. Individual emotion/mental state guesses with frequency for "that S" complement.

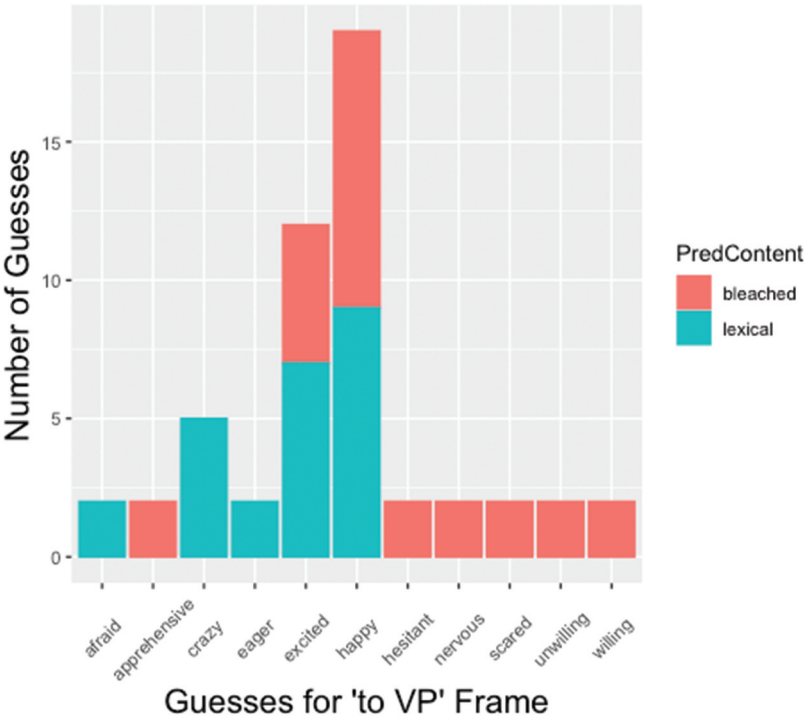

Figure 10. Individual emotion/mental state guesses with frequency for "to VP" complement.

About X allowed for the widest range of guesses, in either form, while *at DP* accounted for the fewest, and all negative valence, regardless of the lexical content of the complement. The influence of complement content is most keenly observed in Figures 6, 8, and 9. It is perhaps not surprising that there is a wider range of adjectives observed overall here than in the CDS documented in the Corpus Study, given the nature of CDS. By contrast, there is a wider range of adjectives observed in CDS with a finite clause complement than observed here, presumably because of the range of contexts in which emotive factives are produced. (For reference, see the discussion following Table 5.)

4.3.4. *Confidence ratings*

Finally, we turn to participants' confidence ratings (see Figure 11). We ran a Bayesian ordinal regression on the confidence ratings. The outcome of this model was the probability of a confidence rating as a function of the same fixed effect predictors from the logistic model: Subject animacy (2 levels: animate, inanimate) and Complement condition (2 levels: bleached, semantic) and their interaction. The random effects for this model included random intercepts for participant and complement type. All model priors were the default in brms, a student's T distribution with 3 degree of freedom. All models were fit with 4,000 iterations (1,000 warm-up). Hamiltonian Monte-Carlo sampling was carried out with 6 chains distributed between 6 processing cores. See Table 11 for a full model summary. Participants were *most* confident in the Animate/Human Subject-Semantic Complement condition (upper right), and *least* confident in the Inanimate Subject-Bleached Complement condition (lower left). See Table 12 for probability estimates and HDI ranges for each condition.

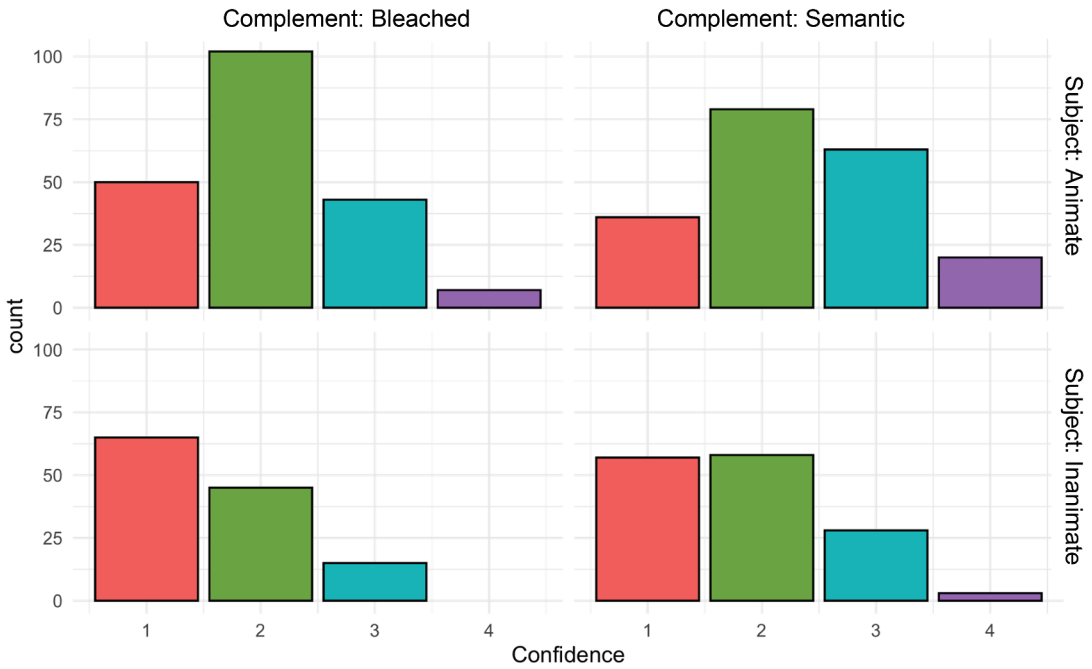

Figure 11. Histograms of the confidence ratings in all four experimental conditions.

Table 11. Full model summary of the ordinal model.[a]

Parameter	Median	HDI	% in ROPE	MPE	Rhat	ESS
Intercept[1]	-1.51	[-2.72, -0.43]	0.00	0.99	1.00	885.00
Intercept[2]	1.33	[0.18, 2.43]	0.00	0.98	1.00	908.00
Intercept[3]	4.15	[2.94, 5.33]	0.00	1.00	1.00	1,057.00
animate	-1.75	[-2.69, -0.89]	0.00	1.00	1.00	1,057.00
semantic	0.80	[0.00, 1.64]	0.04	0.98	1.00	1,060.00
animate:semantic	0.08	[-1.19, 1.36]	0.23	0.55	1.00	1,010.00

Abbreviations: HDI = high density interval; ROPE = Region of Practical Equivalence; MPE = maximum probability of effect; Rhat = R-hat convergence diagnostic; ESS = Effective Sample Size.
[a]Parameter estimates represent the change in log odds as a function of complement type and animacy.

Table 12. Summary of the Bayesian ordinal regression model of the adjusted confidence ratings as a function of the factors Subject and Complement in the word learning experiment, including probability estimates, and the HDI CI range, for each ranking.

Subject	Complement	Confidence	estimate	hdi.CI	hdi.CI_low	hdi.CI_high
animate	bleached	1	0.28	0.95	0.22	0.33
animate	bleached	2	0.45	0.95	0.41	0.49
animate	bleached	3	0.23	0.95	0.18	0.27
animate	bleached	4	0.04	0.95	0.03	0.06
animate	lexical	1	0.17	0.95	0.13	0.21
animate	lexical	2	0.42	0.95	0.37	0.46
animate	lexical	3	0.34	0.95	0.28	0.39
animate	lexical	4	0.08	0.95	0.05	0.11
inanimate	bleached	1	0.52	0.95	0.44	0.60
inanimate	bleached	2	0.36	0.95	0.31	0.42
inanimate	bleached	3	0.10	0.95	0.07	0.14
inanimate	bleached	4	0.02	0.95	0.01	0.02
inanimate	lexical	1	0.38	0.95	0.30	0.44
inanimate	lexical	2	0.43	0.95	0.39	0.47
inanimate	lexical	3	0.16	0.95	0.12	0.21
inanimate	lexical	4	0.03	0.95	0.02	0.04

Abbreviations: HDI = high density interval; CI = confidence interval.

While confidence ratings generally hovered around 2, and 4 was consistently the least probable rating (most likely because even if participants deduced the general meaning of the adjective, they could not be sure that was the *actual specific* meaning intended), in the Inanimate Subject-Bleached Complement condition, the most probable rating was 1, while in the Animate/Human Subject-Bleached Complement condition it was 2, and the inclusion of a Semantic Complement pulled ratings to 3, such that this was the only condition where 3 was the second most probable rating. Thus, not only were there more emotion and mental state adjective guesses in the conditions with an Animate subject, participants were also more confident in those guesses.

4.4. *Discussion*

Our Human Simulation Experiment with adult word learners was designed to recruit precisely those distributional cues that surfaced in the Corpus Study supporting an emotion or mental state adjective meaning, and determine their ability to constrain the meaning of novel adjectives accordingly. We placed novel adjectives that were in a positive morphosyntactic form in predicative position following a copular verb, and presented them with either an animate/human-cued subject or an inanimate-leaning one, and syntactic complements that encoded either semantic information or were semantically bleached. The syntactic complements we featured were those that frequently occurred with emotion and mental state adjectives in CDS.

Our findings revealed that adult learners take the semantic cue of an animate subject and the mere presence of an adjectival syntactic complement, to signal an emotion/mental state meaning. Moreover, even with a non-animate/human-cued subject, and the presence of a complement, participants were still highly likely to make emotion/mental state adjective guesses. Thus, if there is a chance of interpreting a subject—even one not marked as animate—as potentially animate to render it compatible with a syntactic complement that signals an experiencer interpretation, participants will do so. At the same time, the findings placed guardrails on this process, indicating that the moment there is an unambiguous cue to the *lack* of an experiencer subject, participants take the linguistic environment to be incompatible with an emotion/mental state adjective meaning. This conclusion arises from the control trials, in which adjectives co-occurred with an expletive or gerund subject, which still took syntactic complements. In these trials, the rate of emotion/mental state adjective guesses plummeted to floor level. These findings from adults thus underscore the viability of a syntactic bootstrapping approach to the acquisition of emotion and mental state adjectives.

5. Conclusions and implications

We started this article by laying out the challenges of learning abstract words—those for which there is no reliable visual indicator of meaning. A robust line of research has shown that for these vexing words —and specifically verbs—the linguistic context in which the word appears can provide the learner with a powerful information source to constrain meaning. Semantic cues such as subject (in)animacy and syntactic cues such as the argument structure and complementation patterns narrow the hypothesis space about what a new verb could mean, and how to categorize it with other verbs one encounters in the input. Given conceptual and linguistic parallels in abstract meaning and complementation patterns between mental state (attitude) on the one hand, and emotion and mental state adjectives on the other, we reasoned that the linguistic context might also serve to similarly constrain adjective meaning and support the acquisition of these predicates for young children.

Using a two-pronged approach, we tested our hypothesis by conducting a thorough examination of adjectives occurring in CDS in a large set of CHILDES transcripts, and implementing a word learning study with adults using the human simulation paradigm, which manipulated key variables from the corpus study (subject animacy and syntactic complements), while holding other features (morpho-syntactic form and syntactic position of the adjective) constant. Our corpus study revealed that emotion and mental state adjectives have a unique distributional profile based on the semantics of co-occurring words, and the syntactic complements with which they appear, distinguishing them from other adjective types (e.g., those denoting size, color, physical sensation and perception, and subjective adjectives). The guesses provided by the adult participants in our word learning study demonstrated that the semantic and syntactic cues we manipulated are recruited to both individually and additively constrain the meaning of novel adjectives to a meaning corresponding to an emotion or mental state.

Our goal in future work is to unify the corpus data and experimental studies in computational modeling by training a logistic regression on the cues to test how robustly they can predict the class membership of adjectives. The performance of the model could then be compared to human performance in a learning task, which we have already seen a glimpse of. Such an extension of this line of research is an important next step in understanding the relationship between potentially observable distributional patterns in the input and the meanings learners derive from those patterns. A related goal is to establish independent, reliable criteria by which we can classify adjectives as labeling emotions as opposed to non-emotional internal states, to more robustly determine the correspondence between these semantic classes and their syntactic distributions.

The combined findings of our corpus work and experimental study not only highlight striking similarities between verbal and adjectival predicates in the lexicon, they allow us to systematically extend the syntactic bootstrapping approach to the adjectival domain in a way that goes well beyond previous work and enriches our understanding of the informational sources that support word

learning. Some aspects of this process overlap with verbs, while other aspects are unique to adjectives. For example, as with verbs, adjectives that take syntactic arguments signal a relation between the subject or speaker and the content of the embedded complement. Unlike verbs, though, the finite clause complement of an adjective may not necessarily signal an assertion or proffered content: we sure hope it does in (97) and are relieved that it doesn't in (98) and especially (99) (examples (41), (35), and (32), respectively, repeated from our corpus study findings).

(97) I'm *glad* you love me . (Kuczaj)
(98) and I'm *worried* that I don't have enough food, you_know ? (Belfast, Barbara)
(99) they're *afraid* that the tiger will bite them (.) I bet . (Suppes)

Likewise, the non-finite clause may or may not necessarily signal desire or preference, depending on whether it is embedded by a negative valence emotion adjective like *afraid* as opposed to a positive one like *happy*. What these adjectival clausal complements do consistently signal (semantically and pragmatically) and how they compare with those of verbs is a question for future investigation (see Syrett 2023).

Interestingly, the frequency with which emotion and mental state adjectives appear with finite clause complements, and the fact that when they do, they are taken to presuppose the truth of their complement, may contribute to a puzzle pointed out by Hacquard & Lidz (2019)—namely, that young children consistently mistake a speaker's utterance with *think* (a mental state, or attitude, verb that takes a finite clause complement, but is *not* factive like *know*) as an indication that the speaker is proffering that content (e.g., rejecting a statement like *Mom thinks Andy is going to bed* in a scenario where Andy stays up late and his mom's belief is false, because they interpret the utterance as asserting that Andy is going to bed). Hacquard & Lidz (2019) note that their inclination to do so appears to be at odds with children's notoriously overly-literal interpretive tendencies, and yet it is consistent with the way that this verb is *used* by parents in speech to convey indirect assertions (e.g., a mom who says, *I think it's time for bed* intends to convey, 'I know and assert that it is time for bed'). Thus, the question becomes, how do they move from this assumption about intended meaning to one consistent with the correct underlying semantics of *think*? Our data add to this puzzle, since not only are children getting bombarded with that input from verbs, they are also getting a smattering of input from finite-clause-taking adjectives that could lead them deduce that finite clauses signal a subject's or speaker's commitment to the truth of the embedded proposition across the board.

A related open question is how children go from the constellation of complements an emotion or mental state adjective occurs with to a *particular* adjective meaning. That is, how does a child come to distinguish the meanings of *happy, sad, mad*, among all the others? We suggested above that words that take finite clause and *about*-PP complements convey 'aboutness', and that 'aboutness' in turn expresses a propositional thought (see also Rawlins 2013 and Uegaki & Sudo 2019:350). Therefore, an adjective that both predicates a property of an animate entity, *and* conveys aboutness, expresses a property of the mental stance of the one holding the propositional thought (i.e., a mental and perhaps affective property).[9] But this relationship barely scratches the surface of lexical meaning and does little to finetune the individual categories of emotions beyond scales of valence and arousal.

We surmise that a next step would be to draw on the procedure described in Lederer et al. (1995) to do something like obtain a set of syntactic similarity scores and a set of semantic similarity scores, among adjectives, and then to discover the clusters that emerge from areas of overlap in the matrix that results from their comparison. For example, it is conceivable that some semantic partitioning can be found among adjectives that admit specific PP complements but do not admit infinitival complements (e.g., *mad/angry at NP*, but **mad/angry to VP* v. **sad/happy at NP* but *sad/happy to VP*). Whatever the precise role of the syntactic complements is, the findings from our word learning study make it clear

[9]The extent to which this correspondence between syntax and semantics for emotion adjectives is universal, so as to be a reasonable expectation that any learner holds about whatever language they are presented with, must await future crosslinguistic comparison.

that they perform the function outlined in Gleitman et al. (2005): they act as a zoom lens to focus the learner's attention on mental aspects of the situation that are otherwise not salient and outwardly observable. As children add to their lexicon, they are tracking which verbs and adjectives appear with syntactic arguments, what shape those arguments take for different kinds of verbs and adjectives, and how speakers use them to convey meaning.

Emotion and mental state words typically do not appear isolated in speech. Rather they are nestled in a linguistic context featuring semantic and syntactic cues that alert the word learner as to who is experiencing them, and why. These contextual cues in the linguistic input act in tandem with cues from the discourse and firsthand-experienced social situations and interactions. Together, they support a mapping from label to meaning, allowing the child to gradually amass in their lexicon a network of predicates that help them recognize, process, and express affective and cognitive states in themselves and others. It is not that emotions and mental states are not salient to the learner. A child who has dropped their ice cream on the ground, been tripped or cut in line, received a loving hug from their parent, or had their artwork displayed for everyone to admire knows *exactly* what it means to *experience* an abstract emotional or mental state. Rather, it is that much as with color, other properties (like shape) and categorical information (like object kind) win out, and are thus easier to acquire, and are acquired earlier. The linguistic cues we have highlighted are evidential sources of word meaning that serve to focus the learner's attention on abstract properties.

In this paper, we have highlighted the power of both semantic cues, such as animacy, and syntactic cues, such as position in the syntactic structure and complementation patterns—"multiple conspiring cues" (in the words of Papafragou et al. 2007)—that are recruited across the board in the acquisition of both verbal and adjectival predicates. It is only when the learner has accumulated enough knowledge of the language that these cues can be systematically recruited, building upon what they have gleaned from observation and variable situational cues, to probabilistically narrow the hypothesis space of meanings. It is not surprising, then, that the acquisition of adjectives—and particularly emotion and mental state adjectives—is protracted in general, and is particularly challenging for certain neurodiverse populations of learners. And yet language itself appears to be a powerful cue in learning them.

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Declaration of Interests

The authors report there are no relevant competing financial or non-financial interests to declare.

Supplemental material

Supplementary materials can be found online at: https://osf.io/s2mrf/?view_only=1343bed6828742b78c05aff6765f134e

Data availability

The authors will share source data upon request.

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