

Developmental insights into gappy phenomena: Comparing presupposition, implicature, homogeneity, and vagueness *

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Abstract

In natural language, we encounter various sentence types that, under certain circumstances, are evaluated as neither true nor false. For instance, it is intuitively difficult to assess the *truth value* of a sentence whose *presupposition* is not satisfied in the context. A common theoretical approach is to characterize the status of such sentences with a third value of one kind or another. In this chapter, we consider children’s acquisition of four linguistic phenomena that can give rise to ‘gappy’ judgments that correspond neither to True nor False: scalar implicature, presupposition, homogeneity, and vagueness. We discuss how young children’s interpretations of such sentences can provide insight into how these phenomena should be treated within semantic theories.

Keywords: Scalar implicature; Presupposition; Homogeneity; Vagueness; Truth value gaps

1. Introduction

In the formal study of meaning, the notion of truth conditions – the conditions under which a sentence is true – plays a crucial role: to know the meaning of a sentence like (1) is to know under what conditions (1) would be true. A speaker of English can be expected, for instance, to recognize that (1) is true in a context in which it is in fact raining and false if it is not. Such a speaker can provide a *truth value judgment* for (1) on the basis of its *truth conditions* and knowledge about the situation in which (1) is evaluated.

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- (1) It is raining.

In order to understand whether children understand sentences in an adult-like way, one common methodology involves targeting children's knowledge of the conditions that must hold in order for the sentence to be true. For instance, the Truth Value Judgment Task involves presenting young children with short stories, after which they must judge whether a sentence is true or not given the events that unfolded in the story (Crain & Thornton 1998, 2000). This task has been used successfully with children as young as three years of age, to test their knowledge of a range of syntactic and semantic phenomena.

But now consider the sentence in (2), which is superficially not a huge leap from (1).

- (2) Jack knows it is raining.

Whether or not it is actually raining not only has a bearing on whether the sentence is true or false, but also on whether it can be uttered felicitously. The standard idea is that the sentence *presupposes* that it is raining, and *asserts* that Jack has knowledge of this state of affairs. In a context in which it is raining, we can evaluate whether (2) is true or false, depending on Jack's knowledge state. However, in a context in which it is not raining, the presupposition of the sentence is not satisfied, and it is intuitively more difficult to assess what the truth value of the sentence should be. A common theoretical approach to dealing with such cases of *presupposition failure* is to characterize the status of the sentence with a third value of one kind or another.

In addition to *presupposition failure*, there are various other phenomena in natural language that cause sentences to be neither clearly true nor clearly false in a given state of affairs. In this chapter, we will consider four such cases, and argue that young children's interpretations of sentences in such situations can provide insight into how these phenomena should be treated in a semantic theory of the adult grammar. We will begin by introducing the four phenomena, as well as an adult psycholinguistic study that will serve as a starting point for our discussion of the acquisition studies.

1.1. The phenomena

The phenomena we will address are presupposition, scalar implicature, homogeneity, and vagueness. Let us begin by considering examples of each that will be pertinent to our discussion of the acquisition studies. First, imagine a scenario in which Jack was a spectator at a race but never actually ran in the race. In such a scenario, the sentence in (3) is neither clearly true nor clearly false.

- (3) *Context: Jack did not run in the race.*
Sentence: Jack stopped running.

Such cases are standardly treated as examples of *presupposition failure*. Assuming the verb *stop* in (3) triggers the presupposition that *Jack was running* previously, the sentence is neither clearly true nor false when the presupposition is not satisfied.

Another example of lack of clear Truth or Falsity, much more widely studied in the developmental literature, involves the use of scalar terms. While the literal meaning of the sentence in (4) is in principle compatible with a situation in which four out of four apples are red, adult speakers

nevertheless generally find the sentence to be a dissatisfying description of the situation, which often leads to the rejection of the sentence.

- (4) *Context: Four of four apples are red.*
Sentence: Some of the apples are red.

This is usually taken to be the case because the sentence in (4) triggers the *scalar implicature* that *Not all of the apples are red* (Grice 1975). When the literal meaning of the sentence is true but the implicature is false, an oddness arises (for discussion, see Magri 2009, 2014).

A third case involving lack of clear Truth or Falsity involves so-called *homogeneity effects* that arise from the use of plural definite descriptions. In a scenario where two out of four apples are red, neither the positive (5a) nor the negative (5b) appear to be clearly true, or clearly false.

- (5) *Context: Two of the apples are red and two of the apples are green.*
 a. *Sentence: The apples are red.*
 b. *Sentence: The apples aren't red.*

Finally, certain instances of *vague* predicates also give rise to a similar effect. Vague predicates are typically described as having fuzzy boundaries and, as a consequence, it is possible to observe borderline cases within these fuzzy regions. As illustrated in (6), “big” appears to be a vague predicate (it is not clear what precise size is required to qualify as big), and a bear that is slightly above average-sized can constitute a borderline case for “big”. In turn, the sentences in (6) are neither clearly true nor clearly false.

- (6) *Context: The bear is slightly above average-sized.*
 a. *Sentence: The bear is big.*
 b. *Sentence: The bear is not big.*

The examples above provide us with four kinds of sentences that, in certain situations, do not correspond clearly to either of the two truth values True and False. Following terminology in Cremers, Križ, & Chemla (2015), we will refer to the contexts described above as ‘gappy’ contexts, and the sentences that they render neither true nor false, as ‘gappy’ sentences.

1.2. *The starting point*

Each of the phenomena outlined in Section 1.1 has been studied in great detail in previous theoretical research. While we describe them in a uniform way with respect to the ‘gappiness’ that they can give rise to, much of the existing theoretical research has investigated the phenomena independently of each other. One main reason to consider children’s development of these phenomena together, however, stems from some recent theoretical attempts to unify subsets of them; for instance, Chemla (2009) and Romoli (2014) attempt to unify certain cases of presupposition and scalar implicature, Magri (2014) attempts to unify scalar implicatures with homogeneity, and Zehr (2014) explores potential unifications of presupposition and vagueness. These are areas where careful, theoretically informed empirical research can be highly informative, and indeed recent experimental research has offered new ways of empirically characterizing the relationships among these phenomena. Such empirical methods and data are useful for assessing whether some or all of the phenomena above should receive a unified treatment within linguistic theories.

One example of such empirical research is a study reported in Cremers, Križ, & Chemla (2015). These authors collected probability judgments from adult native speakers, using the treatment of gaps as a diagnostic for differentiating gappy phenomena (the paper, dataset, and R analysis script for this study are available online at: <http://semanticsarchive.net/Archive/DZjNWY0N/Cremers-Kriz-Chemla-ProbabAndGaps.html>). For example, participants would see contexts like (7a), represented in the form of three cards: one card would contain a yellow square, another would contain a green square, and the third would contain an orange circle. Participants were told that one of these three cards would be selected at random. The question was what the probability would be that the randomly selected card would correspond to the one described by the test sentence, e.g., (7b). In our example in (7), the presuppositional sentence in (7b) would be clearly *true* of the card with the yellow square, and it would clearly be *false* if describing the card with the green square. Importantly, the sentence would be *gappy* if it were meant to describe the card with the non-square shape: the orange circle.

- (7) a. *Context: The card will either contain a yellow square, a green square, or an orange circle.*
 b. *Sentence: The square is yellow.*

Participants were given a multiple choice task in which they had to select the probability of the sentence being true for the randomly selected card. The participants' choice of probability would crucially reveal how the participant treated the gap case, i.e. the orange circle in (7). For instance, if the participant decided the probability of selecting a yellow square was $1/3$, then the gap case of the orange circle counted as a failure to make (7b) true; that is, the sentence was considered *false* of the orange circle, just as it was false of the green square. If the participant said the probability was $1/2$, then one could infer that for that participant, the gap case (the orange circle) was ignored for the purposes of calculating the probability; only the two squares were under consideration. But if the participant said the probability of selecting a yellow square was $2/3$, then the gap case presumably counted as a success; that is, the sentence would be considered *true* of both the yellow square and of the orange circle.

Analogously with the above example, Cremers et al. (2015) investigated how participants treated potential truth value gaps associated with *presupposition*, *implicature*, *homogeneity*, and *vagueness*. They found that implicature and presupposition patterned differently from each other and from vagueness and homogeneity, whereas vagueness and homogeneity patterned together. That is, participants treated 'gappy' instances of vagueness and homogeneity in the same way, whereas they treated gappy instances of implicature and presupposition distinctly from each other, and distinctly from the gappy instances of vagueness/homogeneity.

Such results are *prima facie* at odds with accounts that attempt to unify scalar implicature and presupposition, such as Chemla (2009) and Romoli (2014). On the other hand, the results also suggest a parallel between vagueness and homogeneity, which is unexpected on both presuppositional (Gajewski 2005) and scalar implicature (Magri 2014) accounts of homogeneity.

Psycholinguistic work with adults is one way to get at potential parallelisms and differences among the various gappy phenomena. With successful experimental designs and methods, researchers can draw out existing differences among the phenomena, as reflected in different behavioral and/or processing measures from adults. Yet another rich source of information that can allow us to get at the same questions is child language data. Child language provides a useful tool

for investigating the nature of these semantic phenomena, and also has the potential to adjudicate between competing analyses. The time course of acquisition, for example, can provide hints to common underlying interpretive mechanisms across phenomena. In the remainder of this chapter, we will discuss recent studies that have turned to acquisition to shed light on the potential connections between subsets of the gappy phenomena described in Section 1.1. In particular, two recent studies have respectively compared scalar implicature with presupposition, and homogeneity with scalar implicature. We also describe how developmental data may shed light on the potential connection between vagueness and presupposition.

For each study that we describe in the subsequent sections, we will begin by introducing the two phenomena being compared, present a brief theoretical background, describe the relevant acquisition experiments, and end with the implications of the study for the relevant theories. As we move through these studies, we will touch upon questions (8a) and (8b), and in passing, (8c).

- (8)
- a. How are similarities and differences among gappy phenomena reflected in child language?
 - b. Are young children sensitive to truth value gaps, or do they display strictly bivalent truth values?
 - c. What methods allow us to tap into children’s sensitivity to truth value gaps?

2. Presupposition and implicature

Let us start with an experimental comparison of presupposition and implicature. Bill, Romoli, Schwarz, & Crain (2016) set out to compare scalar implicatures such as the one in (9) and presuppositional sentences such as the one in (10). The goal of obtaining such comparative data was to test theories such as those put forth in Chemla (2009) and Romoli (2014), both of which attempt to provide a unified explanation for the two phenomena.

- (9)
- a. Not all of the giraffes have scarves.
 - b. \rightsquigarrow *At least some of the giraffes have scarves*
- (10)
- a. The bear didn’t win the race.
 - b. \rightsquigarrow *The bear participated in the race*

2.1. Theoretical background

The traditional perspective on scalar implicatures and presuppositions treats them as very different from each other: scalar implicatures are traditionally considered to arise from reasoning about the speaker’s intentions (see Grice 1975 and much subsequent work), while presuppositions are typically analyzed as appropriateness conditions to be satisfied in the conversational context (see Stalnaker 1974; Karttunen 1974; Heim 1982, among others).

For presuppositions, the idea is that a sentence like (10a) is only felicitous in a context in which the presupposition in (10b) is already assumed to be in the common ground (Stalnaker 1974; Karttunen 1974; Heim 1982, 1983; Beaver & Geurts To appear). According to this perspective, presuppositions are always present in sentences where their triggers (e.g., “win”) are used.

In some cases it appears possible to suspend the presupposition, as in (11a), where the continuation directly contradicts the presupposition that the bear participated in the race. This suspension

of the presupposition gives rise to a meaning that can be paraphrased as in (11b).

- (11) a. The bear didn't win the race... he didn't even participate!
 b. It's not true that the bear both participated in and won the race.

To account for this possibility of suspension, the approaches mentioned above assume an extra mechanism, through which the presupposition is 'locally accommodated' in the scope of negation (Heim 1983; see also von Stechow 2008). The application of this mechanism gives rise to the meaning paraphrased in (11b), which is compatible with the continuation in (11a).

Turning to implicature, traditional approaches treat scalar implicatures as an independent phenomenon, following works like Grice (1975) and Horn (1972). On the traditional approach, the source of scalar implicatures involves general principles that are invoked when we interact with each other in conversation, in the following manner. Consider the implicature in (12b), which arises from the use of "some" in (12a). The hearer will assume that the speaker is being as informative as she can be. Given this, the fact that the speaker uttered (12a) rather than the more informative utterance in (13) leads the hearer to infer that the speaker's reason for not uttering the stronger alternative containing "all" is that the speaker believes this stronger alternative to be false. A further step of strengthening leads to the conclusion that (13) must be false, hence the inference in (12b).

- (12) a. Some of the giraffes have scarves.
 b. \rightsquigarrow *Not all of the giraffes have scarves*

- (13) All of the giraffes have scarves.

Implicatures also arise when strong scalar terms like "all" are embedded under negation, as illustrated in (14). (14b) is referred to as an *indirect scalar implicature*, and its derivation can be explained analogously with that of the direct scalar implicature in (12): replacing the negated universal "not all" with a negated existential "not some" effectively yields the "none" alternative in (15). This alternative is stronger than (14a), and when negated (*It's not the case that none of the giraffes have scarves*), yields (14b).

- (14) a. Not all of the giraffes have scarves.
 b. \rightsquigarrow *At least some of the giraffes have scarves*

- (15) None of the giraffes have scarves.

In contrast to this traditional approach to scalar implicatures and presuppositions, recent accounts of these inferences have attempted to bring them closer together. In particular, some accounts treat certain presuppositions, such as the presupposition associated with the verb "win" (10b), as a scalar implicature of some kind (Simons 2001; Abusch 2002, 2010; Chemla 2009; Romoli 2012, 2014). The main argument for this analysis comes from differences that have been observed between the presupposition of "win" and those of other presupposition triggers, related to the ease with which the different presuppositions can be suspended, and to their behavior in quantificational sentences (see Abusch 2010 and Romoli 2014 for discussion).

The basic idea is that the inference (10b) is derived from (10a) as a scalar implicature, following the same line of reasoning as above. On this approach, a stronger alternative to (10a) is (16). Given that the speaker chose to utter the weaker (10a) rather than the more informative (16), the hearer

infers that the latter must be false, deriving the inference in (10b).

(16) The bear didn't participate in the race.

This approach unifies scalar implicatures like (12b) and (14b) with presuppositions like (10b), deriving the two kinds of inferences using the same line of reasoning. It therefore predicts that, everything else being equal, the two should display similar developmental trajectories in young children. Of course, the assumption that *everything else is equal* is crucial in formulating such *uniformity predictions*, and indeed the assumption may turn out to be untenable in certain cases. Such cases can nevertheless be informative for understanding the respective developmental trajectories of two phenomena (see Tieu et al. 2016 for an example of how divergent performance on standard implicatures vs. *free choice inferences* provides information about the role of *lexical alternatives* in children's development of scalar inferences). We turn next to a study that tested one such uniformity prediction for scalar implicatures and presuppositions.

2.2. Experiment: Bill, Romoli, Schwarz, & Crain (2016)

Bill, Romoli, Schwarz, & Crain (2016) tested 20 monolingual English-speaking adults and 30 monolingual English-speaking children on the interpretation of sentences like those in (10), (12), and (14). The children were split into two age groups, consisting of sixteen 4- to 5-year-olds and fourteen 7-year-olds. The experiment used a *covered picture task* (Huang et al. 2013), with participants being shown a series of scenes involving cartoon animals participating in races.

Each trial consisted of three pictures: a first picture that set the scene and made the subsequent use of negation felicitous, and then two test pictures side by side. On the left was a visible picture, and on the right was a covered picture (an image that was hidden by a black box). The participant was presented with a short description of the context picture, followed by a test sentence that participants were told described only one of the two test pictures (either the visible one or the covered one). The participant's task was to decide which of these two test pictures the test sentence was describing, and then to provide a short justification for their decision. In the covered picture task, the participant can only see one of two possible situations depicted; the participant cannot see what is hidden by the black box. The rationale is that the participant will consider whether the visible picture is an adequate match for the target sentence. If they can imagine a scenario that is a 'better' match for the sentence – whether in terms of truth or in terms of felicity/appropriateness – they should choose the covered picture.

Examples of Bill et al.'s presupposition and direct scalar implicature targets are provided in (17) and (18), respectively.

(17) *Context (Visible test picture):* The bear is at home and did not participate in the race.
Sentence: The bear didn't win the race.

(18) *Context (Visible test picture):* All of the elephants are holding balloons.
Sentence: Some of the elephants have balloons.

Crucially, the visible pictures in the test trials, while consistent with the literal meaning of the test sentences, were incompatible with the relevant inference. For example, the visible picture paired with (18) depicted all of the elephants having balloons, and so was not consistent with the scalar implicature *Not all of the elephants have balloons*. Selection of the covered picture on such

trials was thus interpreted as evidence for generation of the associated inference. The authors also included control trials to make sure that participants were capable both of selecting the covered picture and of selecting the visible picture, when these were consistent with the relevant inferences.

Bill et al. (2016) reported that adults selected the visible picture in the presupposition condition more so than in the scalar implicature condition; children, in contrast, were more likely to select the covered picture in the presupposition condition, compared to the scalar implicature condition. These results indicate that neither group treated presupposition and scalar implicature alike.

2.3. *Implications*

The data reported in Bill et al. (2016) show that children and adults do not treat presupposition and implicature alike. While children treat the two phenomena differently from the way that adults do, however, the two groups nevertheless differentiate between the two phenomena in their respective behavioral patterns. Children's selections of the covered pictures indicate that they generated the presupposition at much higher rates than the scalar implicature interpretation. On the other hand, adults appeared to generate scalar inferences much more often, while in the presupposition condition they responded as though the presupposition were not present. Bill et al.'s explanation of the presupposition results is that adults, but not children, were able to locally accommodate the presupposition under negation, leading to the interpretation in (19b).

- (19) a. The bear didn't win the race.
 b. It's not true that the bear both participated in and won the race.

As mentioned earlier, a unified approach to these phenomena would seem to predict that, all else being equal, participants might have computed the inferences at similar rates across the two conditions. As we have seen, however, this prediction was not borne out by the results. On the other hand, the present findings are more in line with the traditional perspective, which treats presupposition and implicature as distinct phenomena, derived through different mechanisms. This approach is compatible with an asymmetry in participants' behavioral responses to the two kinds of inferences. Children access the basic meanings of the relevant sentences: sentences containing scalar terms are interpreted literally, on the weak meaning of the scalar expression, and sentences containing presupposition triggers are interpreted presuppositionally. Adults, on the other hand, can access derived meanings, computing scalar implicatures from the scalar expressions, and accommodating presuppositions locally under negation. As things stand, unified approaches cannot capture this discrepancy between the two groups.

In sum, the developmental data reported in Bill et al. (2016) do not provide support for analyses that unify the derivation of scalar implicatures and presuppositions; rather, they appear to favor treating the two distinctly. Minimally, unified theories would have to be supplemented with additional assumptions.

3. **Homogeneity and implicature**

The next developmental comparison we turn to involves homogeneity and scalar implicature. Sentences containing plural definite descriptions give rise to so-called *homogeneity* effects (see, among others, Löbner 1987; Schwarzschild 1994; Breheny 2005; Gajewski 2005; Büring & Križ 2013;

Spector 2013; Magri 2014). Imagine some scenarios involving four colored toy trucks, as described in (20).

- (20) Critical contexts
- a. *4 of 4 trucks are blue*
 - b. *0 of 4 trucks are blue*
 - c. *2 of 4 trucks are blue*

The positive (21a) is clearly true in a context like (20a), while the negative (21b) is clearly true in a context like (20b).

- (21) a. The trucks are blue.
b. The trucks aren't blue.

But there is a gap between these two possible situations, namely the case in (20c): imagine that two of the trucks are blue and two are yellow. In such a context, the positive (21a) and negative (21b) are considered to be neither true nor false, corresponding either to a third truth value or to none at all. Križ & Chemla (2015) provide experimental evidence for such a *truth value gap*. Their experiment, conducted with adult English speakers, reveals that adults perceive sentences like (21a) and (21b) as neither completely true nor completely false descriptions of contexts that violate homogeneity, e.g., (20c).

3.1. Theoretical background

The earliest proposals regarding homogeneity treat it as a presupposition (Schwarzschild 1994; Löbner 2000; Gajewski 2005). On such accounts, sentences like (21a) and (21b) carry a presupposition that either all of the trucks are blue or none of the trucks are blue. In a gap context, this presupposition is not satisfied, and therefore the sentences are associated with a truth value gap.

An alternative approach is to say that the definite description itself is either existential or universal, but crucially its interpretation involves a kind of indeterminacy or vagueness. On such approaches, a sentence only has a definite truth value if it has that same truth value no matter how this indeterminacy is resolved (Spector 2013; Križ & Spector 2017). For example, assume “the trucks” in (21) has the two possible interpretations in (22), an existential one and a universal one.

- (22) a. Some of the trucks are blue.
b. All of the trucks are blue.

The sentence in (21a) would then be true if both (22a) and (22b) are true, i.e. if all of the trucks are blue, and false if both (22a) and (22b) are false, i.e. if none of the trucks are blue. In a gap scenario, neither condition is satisfied, and so (21a) can be neither true nor false. Likewise, (21b) can be neither true nor false, since the negations of (22a) and (22b) would be neither both true nor both false.

Yet another approach treats homogeneity as a kind of scalar implicature. According to Magri (2014), plural definites have a literal existential meaning that can be strengthened to the universal meaning through an implicature. As we have seen, scalar implicatures arise through the comparison of assertions with alternatives that could have been uttered but were not. One way to formally capture this process is to invoke the application of a covert, grammaticalized exhaustification oper-

ator EXH (Fox 2007; Chierchia, Fox, & Spector 2011). Consider its application in (23), using our scalar implicature example from (12):

- (23) EXH(Some of the giraffes have scarves)
 = Some of the giraffes have scarves and NOT(all of the giraffes have scarves)

In (23), EXH takes the proposition containing “some” and affirms this proposition while negating the stronger alternative containing “all” (for further discussion, see Groenendijk et al. 1984; van Rooij & Schulz 2004; Spector 2007; Fox 2007; Chierchia et al. 2011). In the case of plural definite descriptions, Magri assumes that “some” is an alternative to the definite (just as “all” is an alternative to “some” in (23)). By applying the exhaustification process recursively, he derives what is effectively a universal meaning for the plural definite description:

- (24) EXH(EXH(The trucks are blue))
 = EXH(The trucks are blue) and NOT(EXH(some of the trucks are blue))
 = Some of the trucks are blue and NOT(some but not all of the trucks are blue)
 = All of the trucks are blue

Of the three existing accounts of homogeneity, the scalar implicature account makes a very specific and testable prediction with respect to the timecourse of acquisition: given that the “some-but-not-all” implicature is a *subcomputation* of the implicature required for homogeneity, this implicature should emerge in development *at least as early* as homogeneity. That is, we might expect to observe the concurrent emergence of the “some-but-not-all” implicature and homogeneity, or we might observe the “some-but-not-all” implicature emerge prior to homogeneity, but crucially we should not observe homogeneity emerging prior to the implicature.

3.2. Experiment: Tieu, Križ & Chemla (2015)

Tieu, Križ, & Chemla (2015, 2017) report two experiments conducted in French, one using a standard Truth Value Judgment Task (TVJT), and one using a ternary judgment task (Katsos & Bishop 2011) (the paper, dataset, and R analysis script for this study are available online at: <http://semanticsarchive.net/Archive/DM5YjA1M/Tieu-Kriz-Chemla-AcqHomogeneity.html>). We will describe the materials here in English. Tieu et al. presented 4- and 5-year-old children with pictures of simple objects of different colors. On critical homogeneity target trials, children saw pictures depicting gap contexts like the one in (20c), and were asked to judge sentences containing plural definite descriptions like those in (21).

If children do not initially treat plural definite descriptions as imposing homogeneity, one might expect them instead to interpret the definite descriptions as existential or universal, and to interpret negative sentences containing the definite description in a negation-preserving manner. For instance, in a GAP context, children might interpret the pair in (21) along the lines of (25) or (26).

- (25) a. Some of the trucks are blue.
 b. None of the trucks are blue.
- (26) a. All of the trucks are blue.
 b. Not all of the trucks are blue.

This means that we could expect three possible outcomes for children’s interpretation of the plural

definite description in gap contexts, as indicated in Table 1 (Križ & Chemla 2015 report that adults judge homogeneity-violating sentences as *non-true*; in a binary *yes/no* judgment task, this typically manifests itself as *rejections* of the relevant sentences, hence the Reject-Reject pattern for the homogeneous interpretation).

Interpretation	Positive gap sentence	Negative gap sentence
<i>Homogeneous</i>	Reject	Reject
<i>Existential</i>	Accept	Reject
<i>Universal</i>	Reject	Accept

Table 1: Expected responses to positive and negative gap sentences, according to the interpretation of the plural definite description.

Collecting children’s *pairs of responses* to positive and negative gap sentences therefore allows us to determine what interpretation(s) children assign to the plural definite description (see Karmiloff-Smith 1979, Munn et al. 2006 and Caponigro et al. 2012 for relevant data pertaining to children’s interpretation of plural definite descriptions; crucially, these previous studies did not include plural definite descriptions under negation, and therefore do not allow us to determine whether children start out with homogeneous, existential, or universal interpretations of plural definite descriptions). To assess Magri’s (2014) scalar implicature theory of homogeneity, Tieu et al. (2015, 2017) included a comparison with scalar implicature targets. On scalar implicature target trials, children would see pictures of four blue trucks, for example, and be asked to judge existentially quantified sentences such as “Some trucks are blue.”

Recall that the implicature theory of homogeneity derives homogeneous interpretations by strengthening a literal existential meaning of the plural definite description to a universal one through an implicature, which includes as a sub-computation the *not all* implicature of “some”. Given this, we should not expect to see homogeneous readings of plural definite descriptions occurring less often than the *not all* scalar implicature (especially given the experimental materials for the two conditions were made as visually comparable as possible). Yet Tieu et al. observed that children and adults alike rejected the positive plural definite descriptions in gap contexts significantly more often than they rejected the underinformative scalar implicature targets, suggesting a greater presence of homogeneity effects than of the scalar implicature. This would appear to run counter to the predictions of the implicature theory.

The implicature theory of homogeneity also makes the further developmental prediction that homogeneity effects can only emerge as early as the *not all* scalar implicature; it should not arise prior to the implicature, since the *not all* implicature is a required sub-computation of the implicature that derives homogeneity effects. Yet Tieu et al. observed the presence of a group of children who displayed homogeneity effects while at the same time failing to compute the scalar implicature of “some”. The presence of such a group of children would appear to run counter to the predictions of the implicature theory.

Some recent research has suggested that binary judgment tasks like the TVJT may not be sensitive enough to assess children’s ability to compute scalar implicatures. Specifically, Katsos & Bishop (2011) argue that binary tasks cannot distinguish between a greater pragmatic tolerance for underinformative descriptions and a true inability to compute implicatures. They report that when 5-year-olds are presented with three response options (a small strawberry, a medium strawberry,

and a big strawberry), they consistently choose the intermediate reward for literally true but underinformative scalar implicature targets. In order to get a more sensitive measure of children's knowledge of homogeneity and scalar implicatures, Tieu et al.'s second experiment made use of a ternary judgment task adapted from Katsos & Bishop (2011). Children were given the option to reward the puppet with one strawberry, two strawberries, or three strawberries. Adapting the expected binary responses in Table 1 to a ternary judgment task, participants were categorized as displaying a *homogeneous* response pattern if they gave minimal or intermediate rewards to positive and to negative homogeneity targets; they were characterized as giving *existential* responses if they gave maximal rewards to positive homogeneity targets and minimal rewards to negative homogeneity targets; and finally, they were characterized as giving the *universal* response pattern if they gave minimal rewards to positive homogeneity targets and maximal rewards to negative homogeneity targets. As in the first experiment, children and adults were also given a scalar implicature test, on which minimal or intermediate rewards were counted as evidence of implicatures.

The results of the ternary judgment task experiment replicated the essential findings of the binary truth value judgment task experiment: collapsing minimal and intermediate rewards in the ternary paradigm, the authors again observed a subgroup of children with homogeneous readings of plural definite descriptions and, nonetheless, no implicatures.

3.3. Implications

On Magri's implicature theory of homogeneity, the "some-but-not-all" implicature is a required subcomputation of the implicature that generates homogeneous readings of plural definite descriptions. This theory therefore makes the prediction that homogeneity should not emerge in acquisition earlier than the more basic "some-but-not-all" implicature. Tieu et al.'s experimental findings are inconsistent with this timecourse prediction, revealing that at least some children manage to display homogeneity effects even without the "some-but-not-all" scalar implicature. While such results do not tell us what *is* the adult means of generating homogeneity, they do allow us to assess the plausibility of one existing proposal, and thereby narrow down the theoretical possibilities in light of the data. In this case, the developmental data appear to speak against the implicature account as the means of deriving homogeneity.

4. Presupposition and vagueness

Let us now turn to a final comparison that has begun to receive attention in the adult psycholinguistics literature, but has been very little investigated in acquisition work. As we saw in the Introduction, borderline instances of vague predicates (27) and cases of presupposition failure (28) are two examples where adult native speakers are typically unwilling to qualify a sentence as clearly true or clearly false; instead, the four sentences provided in (27) and (28) are seen as *inappropriate* in some sense. As in the preceding cases we have discussed, these positive and negative sentences are *gappy* in the given contexts.

(27) *Context: The bear is slightly above average-sized.*

- a. The bear is big.
- b. The bear isn't big.

(28) *Context: The bear didn't participate in the race.*

- a. The bear won the race.
- b. The bear didn't win the race.

While vagueness and presupposition have traditionally been treated distinctly in the theoretical literature, some recent approaches attempt to unify the two phenomena, in light of certain observable commonalities.

4.1. *Theoretical background*

Both in cases of vagueness (Mehlberg 1958; Fine 1975; Tye 1994) and of presupposition (van Fraassen 1966; Fox 2012; George 2008), the lack of a clear truth value judgment has been analyzed with the help of trivalent logics. In these systems, sentences like those in (27) and (28) are modeled with propositions that receive a third, non-bivalent truth value in the described contexts. Despite appealing to the same tools to account for these two phenomena, however, vagueness and presupposition have traditionally been conceived of as clearly distinct phenomena (Fine 1975 analyzed vagueness with the supervaluationist system previously developed by van Fraassen 1966 for presuppositions, but did not suggest any connection between the two phenomena; Tye 1994 may have been the first to explicitly compare the two within such a perspective).

Recent approaches diverge from the traditional view, and more closely investigate the interactions between the two phenomena. Zehr (2014) models the two phenomena within a single truth-functional system containing five logical values: in addition to the traditional values *true* and *false*, three additional values correspond to the set of propositions that involve unsatisfied presuppositions, borderline cases of vagueness, or both. A principle then states that infelicity occurs whenever a proposition of any of these non-bivalent values is used.

Importantly, the five values proposed by Zehr (2014) are ordered and thus define one dimension of logical truth, and a set of semantic principles determines which of these values a given proposition receives, based on whether it is about borderline cases or unsatisfied presuppositions. An alternative proposal can be found in Spector (2015). Spector derives a 7-valued system meant to handle interactions between vagueness and presupposition. Spector provides a semantics for presuppositional expressions on the one hand, in terms of *true*, *false*, and a specific value representing presupposition failures; on the other hand, he models vague predicates as potentially generating ambiguity, resulting in four additional values representing possible combinations of the other three.

More generally, these two formalisms can be thought of as exemplifying two radically opposed positions. On Zehr's *monist* treatment, vagueness and presupposition are simultaneously processed by a single mechanism. On Spector's *dualist* treatment, vagueness and presupposition are processed by distinct mechanisms. A monist view along the lines of Zehr (2014) might lead us to expect that certain linguistic operations can affect that single mechanism, and thus be applicable to both vague and presuppositional expressions; for instance, some form of local accommodation could convert any non-bivalent proposition (resulting from vagueness or presupposition) to a bivalent one. Given that the same mechanism would deal with the infelicity of a borderline usage of a vague predicate and with the infelicity arising from a presupposition failure, one might expect that children's sensitivity to the 'gappiness' of the two phenomena might emerge concurrently.

In contrast, a dualist view along the lines of Spector (2015) might lead us to expect linguistic operations like local accommodation to be phenomenon-specific. Since vagueness and presupposition would be dealt with by distinct mechanisms, we might expect differences between the

two phenomena to be reflected in language development, with no predicted relation between the acquisition of one and the acquisition of the other.

4.2. *Experimental background*

As we have just seen, unified approaches to vagueness and presupposition have only recently developed, and as a consequence, few experiments have compared the two phenomena. To investigate vagueness and presupposition, Zehr (2014) adapted Križ & Chemla's (2015) paradigm, originally conceived to identify truth value gaps associated with homogeneity. Zehr's aim was twofold: first to elicit truth value gaps arising from vagueness and presupposition, and second to test the prediction of the 5-valued system that presuppositions should yield different truth value judgments depending on the polarity of the sentence, whereas vagueness should be insensitive to negation.

Zehr (2014, 2015) presented adult participants with positive and negative vague and presuppositional sentences like (27) and (28), accompanied by pictures depicting borderline cases or cases of presupposition failure. As in Križ & Chemla (2015), participants were asked to assess the sentences as one of the following: *Completely false*, *Completely true*, or *Neither true nor false*. Zehr (2015) reports that participants made use of the *Neither true nor false* option in response to both presuppositional and vague sentences, regardless of polarity. In this experimental context then, speakers' behavior suggests that vagueness and presupposition share a certain 'gappiness' in truth value.

Although *Neither true nor false* responses were observed for both vagueness and presupposition, however, the two nevertheless differed with respect to the distribution of the selected response options. While vagueness predominantly triggered *Neither true nor false* judgments across both polarities, the judgments for positive presuppositional descriptions (cf. (28a)) were evenly distributed between *Completely false* and *Neither true nor false*. This contrast experimentally supports a distinction between vague and presuppositional sentences, but doesn't by itself rule out the possibility that certain linguistic operations (like local accommodation) may target both vagueness and presupposition.

In fact, the following aspect of the results is in line with just this possibility: negation yielded an increase in *Completely true* answers for both types of descriptions. To understand how this suggests the existence of a general operation of local accommodation, recall that a positive vague or presuppositional proposition receives a non-binary value in the critical gappy contexts. The operation of local accommodation would turn the non-binary propositions into false propositions, and negation would in turn yield a true proposition. More descriptively, this result might reveal that negation can target 'borderline-ness' in the same way that it can target a presupposition. If negation can indeed target both types of content in the same way, this would provide further evidence that vagueness and presupposition can be given a similar representation, at least at the level at which a process like local accommodation operates.

These similarities in responses to presupposition and vagueness stand in contrast to the results of Cremers et al. (2015). As discussed in the Introduction, Cremers et al. (2015) compared vagueness and presupposition (in addition to homogeneity, implicatures, and conditionals) in a probability assignment task, and observed that participants displayed different response patterns for presupposition failures and borderline instances of vagueness, in particular treating presupposition failures as negative outcomes, while treating borderline instances of vagueness as ambiguous between positive and negative outcomes.

4.3. *Potential insights from acquisition*

The two alternative views of vagueness and presupposition discussed above make different predictions for child language development. If vagueness and presupposition involve a single mechanism operating on representations of the same type (as in Zehr's (2014) ordered 5-valued system), one might expect to see the effects of this mechanism on presupposition and vagueness emerging around the same time. On the other hand, if vagueness and presupposition are dealt with by distinct mechanisms (as in Spector (2015)'s unordered 7-valued system), one might instead expect no particular relation between children's treatment of vague sentences and of presuppositional sentences.

A potential future investigation involves adapting the design of Zehr (2014) (already adapted from Križ & Chemla (2015)) for use with children. Building on the data from adults, two developmental observations would be of particular interest: whether children give any non-binary responses at all, and whether negation increases the rate of *true* responses. A monist view along the lines of Zehr (2014) would predict a general correlation between vagueness and presupposition in both cases: if children make use of non-binary responses, they should do so for both vague and presuppositional descriptions, as these are assumed to be equally represented as non-bivalent; moreover, assuming the process behind adults' increase in *true* responses to negative descriptions applies equally to vagueness and presupposition, we may expect to see this response pattern emerging concurrently for vagueness and presupposition in children. In contrast, a dualist view along the lines of Spector (2015) predicts no such correlation: some children could give non-bivalent responses to one phenomenon while exhibiting an exclusively bivalent behavior for the other, and negation might yield an increase in *true* judgments for one but not the other.

Some defenders of the latter view could also anchor the distinction in a semantic vs. pragmatic opposition. One way to read Spector's (2015) system is to regard presupposition as being treated at the semantic level, and to regard vagueness as an ambiguity in truth value that must be pragmatically resolved. Future developmental work could investigate the implications of such a semantic/pragmatic divide for the relative timecourse of acquisition.

Finally, looking at what bivalent answers, if any, children give for each phenomenon will also be informative, in particular for derivational analyses. For instance, Abusch (2002) and Romoli (2014) propose mechanisms that derive presuppositions from propositions that are semantically *false* in case of presupposition failure. Sudo (2012) and Klinedinst (2010), on the other hand, suggest that some presuppositional sentences are semantically true in situations of presupposition failure. From a derivational perspective, looking at children's judgments may shed light on the semantic representations from which presuppositions are derived.

Further investigation into the development of vagueness also holds great potential. Positivist views according to which any entity is either in the positive or negative extension of a vague predicate (e.g., Williamson 1994) usually draw the borderline as touching upon both the negative and positive extensions. Understanding how children characterize borderline cases and where they themselves draw the line could help to shed light on the underlying representation of vagueness and how it is acquired by child learners.

5. **General discussion**

In this chapter, we have made the argument that child language data provide a very useful perspective with which to assess semantic theories about gappy phenomena. By comparing how children

perform on the different gappy phenomena, we obtain not just a relative timeline of when different phenomena are acquired, but also insight into potential connections among the phenomena. Developmental studies can therefore shed light on how these phenomena should be treated within linguistic theories. We have seen that children differentiate presupposition from scalar implicature, providing support for those theories that posit different underlying mechanisms for the two phenomena. In another case study, we have observed developmental evidence against the view that homogeneity is derived via scalar implicature. Finally, we have suggested that further developmental study may shed light on the relationship between presupposition and vagueness.

The studies we have discussed also suggest that gappy phenomena are not all treated alike by the child learner. This is relevant for the question of how child learners initially navigate different gappy phenomena. The experimental studies we have discussed suggest that already for young children, presupposition and implicature are distinct, as are homogeneity and implicature. If indeed children already posit different analyses for two phenomena from as early as we can test them, an open question is what leads them to do so. Presumably children do not encounter (many) instances of *gappiness* in their input. They should only rarely encounter presupposition failures, borderline instances of vagueness, homogeneity violations, etc. How then do they become sensitive to gappiness, let alone distinguish among different gappy phenomena? What kinds of evidence would be relevant in helping the child to navigate gappy phenomena?

One intriguing direction would be to investigate the role of negation. Consider again Zehr's positive sentences involving borderline instances of vague predicates and presupposition failure. Zehr (2014) reports that these positive propositions receive a non-binary truth value in the critical gappy contexts. Yet negation does something interesting: it has a common effect on the two phenomena, increasing the proportion of *Completely true* judgments in adults. That is, negation actually converts the non-binary value to a clear *True*. If the set of true sentences that children hear in their input includes such negative presuppositional or vague sentences, such cases of *local accommodation* could form part of the dataset that help children to sort out the various gappy phenomena. Along these lines, comparing the potentially distinct patterns (under negation) for the different gappy phenomena may be quite instructive. For example, the child might observe that presuppositions and vagueness can be locally accommodated under negation, whereas implicatures commonly disappear under negation; meanwhile they should only rarely encounter homogeneity violations in the presence of negation. An alternative way to characterize the distinct patterns is to say that children might sometimes observe *bivalent* uses of vague predicates and presuppositional expressions (specifically under negation), whereas they should not encounter bivalent instances of homogeneity under negation. Such contrasts could turn out to be informative evidence for the learner, who is tasked with sorting out the various phenomena.

Returning to our semantic theories, the child data we have described provide but one piece of the puzzle. Such data can be considered hand in hand with experimental work that has been conducted with adult speakers. Both kinds of empirical work provide useful insights into how we should analyze various semantic phenomena. Our main premise is that fundamental similarities and differences will be reflected in the developmental trajectory of the respective phenomena, such that we can use child language as a means to better understand how these phenomena should be dealt with in our linguistic theories. Future work should continue to refine our understanding of how various semantic phenomena are alike and different. Additionally, as we have touched upon in the previous sections, future work should also be devoted to refining the experimental methods at our disposal, which allow us to tap into young children's intuitions about truth values and the

relevant truth value gaps.

Before closing, we would note a further distinction that has been somewhat glossed over in the discussion. We have raised the question of when and how children might acquire *gappiness* (i.e. non-bivalent truth values), and gappy phenomena more generally. How do they come to realize that “win” triggers a presupposition, that “some” triggers an implicature, that plural definite descriptions impose homogeneity, and that “big” is a vague predicate? But this is a distinct question from asking what children actually do with these phenomena once they have discovered their gappiness (thanks to Alexandre Cremers for discussion of this point). For example, as Bill et al.’s (2016) study shows, 4-year-old children appear to be aware of the presuppositional status of “win”, yet they do not locally accommodate the presupposition the way that adults do. As more gappy phenomena are systematically studied and compared in development, we will not only be able to address the question of when children’s sensitivity to each gappy phenomenon emerges, we will also begin to uncover the development of the mechanisms that are involved in the interpretation and treatment of the different gappy phenomena.

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