Attested connectives are better at answering questions*

Moshe E. Bar-Lev and Roni Katzir

Tel Aviv University

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Abstract

Why are AND and OR the only binary connectives that are lexicalized as simplex? Horn (1972) first observed this striking typological fact and suggested an account that relied on the assumption that 'positive' connectives like AND and OR are inherently simpler than other connectives. Much subsequent work adopted this assumption, along with Horn's insight that the strengthening of utterances through scalar implicature plays a role in explaining the typological pattern. Bar-Lev & Katzir (2022a) aim to derive the typological pattern from strengthening alone, without assuming that 'positive' connectives are inherently simpler. The present remark aims to address several issues for their view, building in part on work by Enguehard (2023) and Bar-Lev & Katzir (2022b), by taking a step back and asking why connectives are lexicalized to begin with. We suggest that the motivation for lexicalizing connectives comes from their ability to help in answering questions. In particular, connectives should help speakers convey their epistemic state with respect to a given question. We show that, once several proposals from the recent literature on questions and strengthening are adopted, AND and OR turn out to be the only connectives whose lexicalization allows speakers to convey their epistemic attitude towards all the possible complete answers to a given question. This provides a simpler and more principled derivation of what sets apart AND and OR from the other connectives than earlier accounts of Horn (1972)'s typological puzzle.

1 Introduction

1.1 Puzzle

Among all possible binary logical connectives in Table 1, only two connectives are ever lexicalized as simplex in natural languages—AND and OR; and only one is ever lexicalized as complex—NOR.

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	Commutative								Non-commutative							
							Trivial		Redundant							
	AND	OR	NOR	NAND	XOR	IFF	TAU	CONT	L	R	NOTL	NOTR	ONLYL	ONLYR	$\rightarrow$	$\leftarrow$
$p \wedge q$	1	1	0	0	0	1	1	0	1	1	0	0	0	0	1	1
$p \wedge \neg q$	0	1	0	1	1	0	1	0	1	0	0	1	1	0	0	1
$q \wedge \neg p$	0	1	0	1	1	0	1	0	0	1	1	0	0	1	1	0
$\neg p \wedge \neg q$	0	0	1	1	0	1	1	0	0	0	1	1	0	0	1	1

Table 1 Truth table for all binary logical connectives taking P and Q as arguments.

Since Horn's (1972) seminal work, two assumptions have been usually taken to be necessary in order to explain this typological pattern: What we call here (following Bar-Lev & Katzir 2022a) Strengthening and Positivity (see Katzir & Singh 2013; Uegaki 2022; Züfle & Katzir 2022).

(1) **Strengthening**: Implicature computation plays a role in the analysis of the typological pattern.

(2) **Positivity**: 'Positive' connectives (e.g., AND and OR) are more basic than 'negative' ones (e.g., NAND and NOR).

Bar-Lev & Katzir (2022a) aim to reduce these two assumptions to one by deriving Positivity effects from Strengthening.[1] They do so by asking how Strengthening might relate to successful communication. Specifically, they show that, on a particular view of Strengthening based on Iterated Rationality Models of communication (IRMs; following Franke 2009, 2011; Frank & Goodman 2012; Bergen et al. 2016), together with assumptions about the alternatives considered in Strengthening (following Katzir 2007), AND and OR are different from all other connectives because they are the only connectives whose interpretation does not depend on the prior probabilities of the conversation participants (in both positive and negative sentences)—a property they call Stability. They then take Stability to be the key property which makes the lexicalization of AND and OR preferable to that of other connectives. On their view, then, Positivity is reduced to a side effect of Strengthening.

There are, however, several issues with their account which make this reduction incomplete and which will motivate the alternative view we will present in this paper. First, it relies on a particular view of Strengthening based on IRMs. Whether IRMs are a good theory of Strengthening to begin with is however under debate, and several arguments against an IRM-based theory of Strengthening have been brought up in recent years (see especially Fox & Katzir 2021; Asherov et al. 2022). One particularly thorny issue for IRMs is a prediction common to many of them that prior probabilities should affect communication in ways that are unattested (Fox & Katzir 2021; Cremers et al. 2022). Potentially problematically, sensitivity to prior probabilities stands at the heart of Bar-Lev & Katzir's (2022a) notion of Stability.

Second, their account relies on the idea that when a sentence containing a connective is

1 Several other recent papers aim to avoid assuming Positivity, for example Enguehard & Spector (2021); Incurvati & Sbardolini (2022). See Bar-Lev & Katzir (2022a) for discussion.

'unstable'—that is, when its interpretation depends on speaker's and hearer's assumptions about prior probabilities—there is room for miscommunication which would make lexicalizing this connective an undesirable choice for communication. But this idea lacks independent evidence; for example, one could imagine that divergences in speaker's and hearer's assumptions about prior probabilities which would lead to miscommunication are sufficiently rare and do not affect desirability of lexicalization. And even if such situations are very common, we are not aware of any evidence that lexicalization is shaped by pressure to avoid situations where divergences between speakers and hearers would lead to different interpretations (in fact, the abundance of context-dependent and vague expressions may suggest that the opposite is true).

Third, their account (like much other work) doesn't quite explain why connectives are lexicalized in the first place. Stability can only explain why certain connectives are never lexicalized, but it doesn't provide motivation for lexicalization of any connective. And yet, languages which don't lexicalize any connective are very rare, and even languages which only lexicalize one connective aren't very easy to find (see Uegaki 2022). So the following question remains unexplained: Why is it that so many languages opt to lexicalize AND and OR?

Fourth, Bar-Lev & Katzir (2022a) stipulate that non-commutative connectives (see Table 1) cannot be lexicalized due to reasons other than Stability. It might be better, however, if we could come up with a single principle which would explain both the non-lexicalizability of commutative and of non-commutative connectives.

While these worries are not fatal arguments against Stability, which might still be relevant to the explanation of the typological pattern, they do provide reasons to keep looking further for explanations which will not share these concerns. There might of course also be ways to address them within the Stability account; we will however pursue a different direction that we think provides a more principled explanation, building on two responses to Bar-Lev & Katzir (2022a) by Enguehard (2023) and by Bar-Lev & Katzir (2022b).

Enguehard (2023) points out that Bar-Lev & Katzir's notion of Stability can be restated in non-probabilistic terms and connects it to question answering (specifically to proposals by Dayal 1996 and Fox 2018). By doing so, he provides a potential way to address worries 1 and 2 above, both of which arise from the probabilistic setting of Stability and its reliance on IRMs and do not transfer to the logical setting of questions and answers. Worries 3 and 4, however, remain unaddressed by Enguehard's translation of Stability. His account does not offer any motivation for lexicalization of connectives, at least no more than Stability does, though one might hope that a view based on question answering could provide such a motivation (and this is what we will aim to do in this paper). And, being a translation of Bar-Lev & Katzir (2022a), Enguehard's proposal only concerns the commutative connectives, leaving the absence of non-commutative connectives in need of a separate stipulation.[2]

2 Another issue for the perspective put forward in Enguehard (2023) concerns the motivation for lexicalizing OR. For Enguehard (2023), what governs lexicalization is whether sets of alternatives derived for sentences with various con-

As to Bar-Lev & Katzir (2022b), they start from observing that the attested AND and OR have a logical property that sets them apart from all other meaningful connectives — including, significantly, the non-commutative ones — and that relates to their behavior under Strengthening. In a nutshell, Strengthening succeeds in negating propositions that are logically-independent of the arguments of a given connective only when that connective is either AND or OR. (We will review this in greater detail in section 6.) Bar-Lev & Katzir (2022b) show how this logical property of AND and OR makes them the only connectives that can satisfy Stability. While this extends the empirical picture so as to cover all of the binary connectives, thus addressing worry 4, it is an explanation that is still grounded in Stability and therefore does nothing to allay worries 1–3.

1.2 Our proposal in a nutshell

Our proposal combines what to us are the key insights of Enguehard (2023) and Bar-Lev & Katzir (2022b). From Enguehard (2023) we take the idea of switching from a probabilistic setting to a logical framework of question answering. However, rather than seeking a translation of a given system into question answering we propose to take a step back and ask what makes answers good in general, and in particular how connectives can help or hurt an attempt to answer a question. And from Bar-Lev & Katzir (2022b) we take the significance of the logical property of AND and OR that sets them apart from the other connectives. But instead of connecting this property to probabilistic models of communication we consider its implications for question answering. In particular, we show that AND and OR are the only meaningful connectives that support good answers, if one assumes recent proposals about: (a) question answering (in particular, that the epistemic state of a speaker is generally relevant, in a formal sense, as argued by Fox 2016 and discussed further by Buccola & Haida 2019); and (b) Strengthening (in particular, that it involves exhaustification that interacts with a belief operator, as argued by Meyer 2013, building on Fox 2007; henceforth F/M). On these assumptions, AND and OR are successful since, as we discuss below, they allow speakers to convey their epistemic state with respect to the distinctions that a question makes relevant. Other

nectives satisfy conditions on the denotation of questions. But while the set of alternatives of a sentence like P OR Q satisfies Dayal's strongest answer condition, it does not satisfy the requirement of partition by exhaustification argued for by Fox (2018) as a replacement to the strongest answer condition. Enguehard acknowledges this issue but argues that it is solved once we ignore what he refers to as 'dominated alternatives' (alternatives which are not maximally strong within the set of alternatives). But since P OR Q is itself a dominated alternative (it is weaker than both P and Q), the question of why OR should be lexicalized becomes even more pronounced.

One may wonder whether this issue could be solved once we take into account the fact that sentences with OR are used when the speaker is not fully knowledgeable (a fact we will make crucial use of later); specifically, a natural way to try and solve the problem is to consider the set of alternatives resulting from pointwise application of a universal epistemic operator (such as Meyer 2013's K operator) to the set of alternatives, because this set satisfies partition by exhaustification even when dominated alternatives are not ignored. Opting for this would however obliterate the ability to distinguish between AND and OR on the one hand and other connectives on the other hand, since it can be shown that all sets of alternatives can satisfy partition by exhaustification with pointwise application of a universal epistemic operator. The view we will propose, which does not assume that partition by exhaustification is what governs lexicalization, will be able to employ a universal epistemic operator and still distinguish between AND and OR and all the other connectives (see section 5).

meaningful connectives fail to do so and in fact even hurt the ability of AND and OR to convey an epistemic state.

The goal of the present remark is then to argue that Positivity can be derived from Strengthening once we consider the question why connectives are lexicalized in light of the simple idea that sentences should be able to provide good answers to questions. In particular:[3]

(3) a. Why are AND and OR often lexicalized?
Because, when combined with Strengthening, they always allow speakers to convey their epistemic state relative to a question.
b. Why is no other connective lexicalized (as simplex)?
Because, even with Strengthening, they often don't allow speakers to convey their epistemic state relative to a question (and moreover they harm the ability of speakers to convey their epistemic state using AND and OR).

The rest of the paper is structured as follows. Section 2 provides a bit more background on answering questions and focuses on the idea that good answers are ones where the speaker conveys their epistemic attitude towards the question. In section 3 we ask what might motivate lexicalizing a given logical connective. Starting from a consideration of how questions can be answered in the absence of connectives, we put forward the hypothesis that lexicalization of connectives is driven by their ability to enable identification of various epistemic states. This will suggest a central role for Strengthening, though it will not yet commit us to any strong views on how Strengthening is implemented. AND, which we consider in section 4, will be a straightforward connective: it dramatically extends the ability of answers to identify states of complete knowledge, and it does so without requiring any further assumptions about Strengthening beyond those already made in section 3. In section 5 we turn to cases of incomplete knowledge, which will motivate the lexicalization of OR. The use of OR in answers will force us to be more careful about how Strengthening is implemented and about how it interacts with the expression of belief. Then, in section 6, we consider the broader range of connectives and their effect on the identification of epistemic states. As we will show, connectives other than AND and OR do not merit lexicalization: they fail to identify an epistemic state on their own, and in fact their very inclusion in the lexicon harms the ability of AND and OR to identify an epistemic state.

2 Answering questions and complete answers

A very common view holds that sentences are answers to explicit or implicit questions (Questions Under Discussion, Roberts 1996). This view raises the following question: What does it mean for a

3 Since our focus will be on deriving Positivity from Strengthening, we will set aside the question of why NOR is the only complex connective lexicalized. Bar-Lev & Katzir (2022a) propose an account of the complexity of NOR, albeit one which relies on non-trivial assumptions (as they point out; see Bar-Lev & Katzir 2022a: fn. 21).

sentence to be a 'good answer' to a particular question (see Groenendijk & Stokhof 1984; Roberts 1996; Katzir & Singh 2015; Fox 2018; Katzir 2023; Bar-Lev & Fox to appear, among others)? One kind of answer which is clearly good is a *complete answer*: one that determines the truth value of each of the propositions in the question denotation (assuming the Hamblin-Karttunen denotation of questions). Simplifying somewhat, we can assume the following (which we will revise later):[4]

(4) **Cell identifiability** (CI): Given a topic of conversation (a question), a speaker's utterance (an answer) should be able to convey a complete answer to the question.

For instance, suppose the question under discussion is *who smiled?*, and that the individuals in context are Penny, Quentin, Rachel and Sue. The propositions in the question denotation are the following:

(5) a. Penny smiled. (= P)
b. Quentin smiled. (= Q)
c. Rachel smiled. (= R)
d. Sue smiled. (= S)

There are of course many possible complete answers to this question; these form the partition of logical space into cells induced by the question.[5] In our example, this partition is as in Figure 1.

Before we proceed, we would like to briefly discuss the conceptual reason behind CI (and why it is a simplifcation). We take the motivation for CI to be an expectation which is often operative in conversation to deliver all the information that the speaker's epistemic state entails concerning the question (see Fox 2016; Buccola & Haida 2019). If we are fully knowledgeable about the question, then it follows that we should provide a complete answer. Note however that, on this view, providing a complete answer is only required when the speaker is fully knowledgeable. But we are not always fully knowledgeable, and sometimes our epistemic state is compatible with more than one complete answer to the question (more than one cell). In section 5 we will indeed argue on this basis that CI is too strong, and propose a weaker (albeit slightly more complex) version in (9) which takes into account the possibility of speakers who are not fully knowledgeable about the question (speakers whose epistemic state is compatible with more than one cell in the partition). Until then, though, we will keep things simple and only consider speakers who are fully knowledgeable

4 We do not aim to argue that CI (or its revised version which we will introduce in (9)) is an inviolable requirement on answers; this position would be at odds with the availability of mention-some readings of questions and the possibility of using special prosody for providing partial answers. Instead, our view is that CI is operative in the (presumably very common) case where the full beliefs of the speaker relative to a question matter, which is the case we will focus on.

5 The partition of the context set C that is induced by a question Q is the set of all the consistent ways to assign truth values to the elements of Q. The elements of the partition are referred to as the *cells* in the partition. The partition can be characterized by defining an equivalence relation $\sim_Q$ over the context set C such that for any $w, w' \in C$, $w \sim_Q w'$ if and only if for every $p \in Q$, $p(w) = p(w')$. The partition of the context set is then the quotient set of the context set by $\sim_Q$, $\Pi_C(Q) = C/\sim_Q$. When the elements of Q are contextually independent of one another (which is the case we focus on in this paper), the number of cells in $\Pi_C(Q)$ is $2^{|Q|}$.

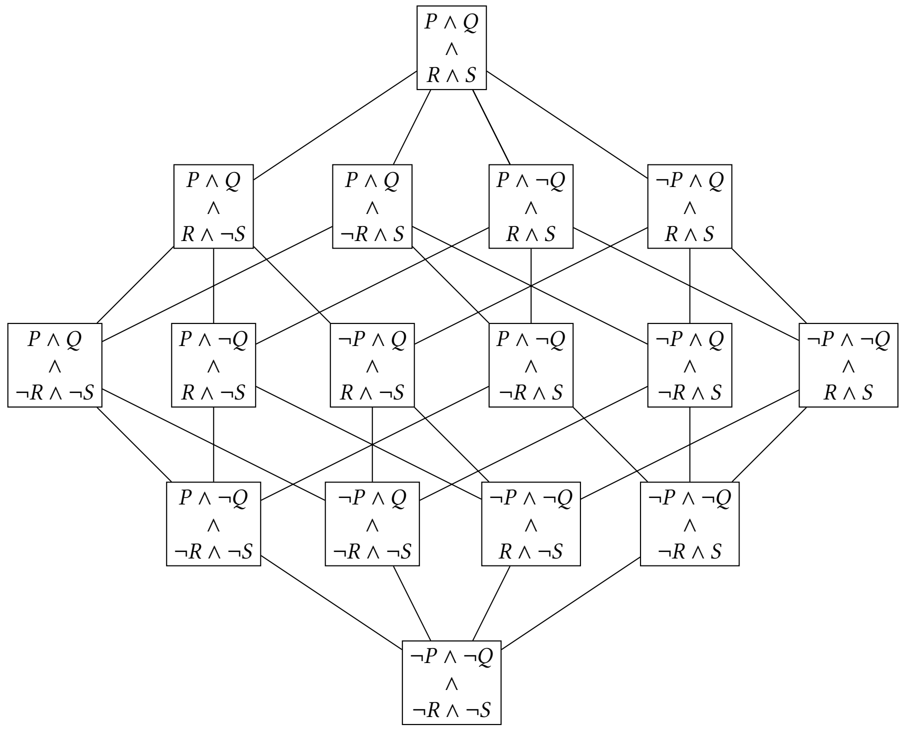

Figure 1 Partition induced by the question $\{P, Q, R, S\}$.

about the question, in which case the choice between the two versions doesn't make a difference. For the same reason, before section 5 we will use the terms cell identification and epistemic state identification interchangeably.

The connection between Strengthening and questions has been extensively discussed (from Groenendijk & Stokhof 1984 to Fox 2018, among many others). Specifically, Strengthening is a crucial ingredient in making answers complete (as we will see in detail later). Our main contribution in this paper is to show that, while the F/M theory of Strengthening can make sure that sentences with connectives identify the speaker's epistemic state when the connectives are AND and OR, it doesn't do so with other connectives, at least not in any useful way. Hence, if identification of epistemic states is required, the F/M theory predicts only AND and OR to be useful, and can then derive Positivity from Strengthening.

3 Connectives: What are they good for?

3.1 Answering questions without connectives

Why do languages lexicalize connectives to begin with? Suppose we didn't have any connective. What utterances could we use that would identify cells (i.e., satisfy CI)? Without Strengthening, the answer is none, at least as long as the propositions in the question denotation are not mutually exclusive (as in the example we used above in (5)). This is because any proposition in the question

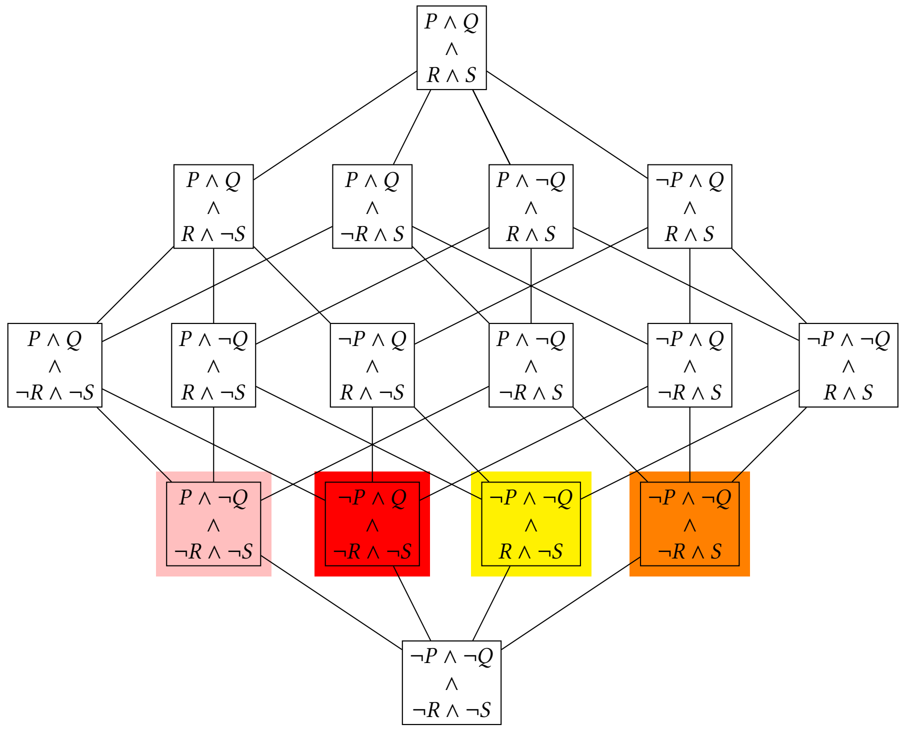

Figure 2 Partition induced by the question $\{P, Q, R, S\}$, with color-coding of the cells identified by the sentences with no connectives in (6).

denotation is compatible with various different complete answers: P is compatible with $P \wedge Q \wedge R \wedge S$, but also with $P \wedge \neg Q \wedge \neg R \wedge \neg S$ and several other cells. And since we don't have connectives, we can't combine propositions in the question denotation in a way that would identify cells (there might be other propositions which accidentally denote cells, but nothing we can construct compositionally and systematically).

Once Strengthening applies, however, the propositions in the question denotation will end up identifying cells. Relying on the intuition that Strengthening (for which we use the shorthand $\mathcal{E}xh$) does something similar to *only* (Chierchia, Fox & Spector 2012), and that *only Penny smiled* entails the exhaustive inference that no one else did, we expect the results in (6), with Figure 2 showing the color-coded cells identified by the sentences in (6).

(6) a. $\mathcal{E}xh(P)$ identifies the cell $P \wedge \neg Q \wedge \neg R \wedge \neg S$

b. $\mathcal{E}xh(Q)$ identifies the cell $\neg P \wedge Q \wedge \neg R \wedge \neg S$

c. $\mathcal{E}xh(R)$ identifies the cell $\neg P \wedge \neg Q \wedge R \wedge \neg S$

d. $\mathcal{E}xh(S)$ identifies the cell $\neg P \wedge \neg Q \wedge \neg R \wedge S$

At this point we do not commit to any particular theory of Strengthening, and we use $\mathcal{E}xh$ for now as a shorthand for some Strengthening procedure and not as a commitment to a grammatical theory (Chierchia et al. 2012) rather than a pragmatic one in the spirit of Grice (1975). Our commitment to the grammatical theory (specifically the F/M theory) will be made explicit in section 5, and

	TAU	CONT	L	R
$p \wedge q$	1	0	1	1
$p \wedge \neg q$	1	0	1	0
$q \wedge \neg p$	1	0	0	1
$\neg p \wedge \neg q$	1	0	0	0

Table 2 Trivial and redundant connectives

this theoretical choice will become crucial when we talk in section 6 about why sentences with unattested connectives are not predicted to have exhaustive inferences like the ones in (6).

Note however that Strengthening alone only goes so far: Without connectives, we are not able to identify any complete answer where there are two true propositions (any cell in the mid row and upwards in Figure 2). More generally, without connectives we cannot identify any epistemic state other than ones where the speaker believes about a single proposition that it is the only true one. We hypothesize that this is precisely the reason why connectives are lexicalized:

(7) **Hypothesis on pressure for lexicaliztion of connectives**:
Lexicalizing connectives is helpful for identifying epistemic states which are otherwise unidentifiable.

In what follows we will focus on the following question: Assuming this hypothesis, which connectives will help us achieve the goal of identifying epistemic states? In other words, which connectives will it be useful to lexicalize?

3.2 The unhelpfulness of trivial and redundant connectives for answering questions

Let us begin from the case of connectives which are easy to dismiss as unhelpful, and ask the following, somewhat silly question: Why don't languages ever lexicalize connectives that are not 'meaningful'? We call connectives meaningful when they are neither trivial (namely return the same truth value regardless of the truth value of their arguments, like TAU and CONT) nor redundant (namely return the truth value of one of their arguments, like L and R); see Table 2.

In light of our hypothesis about the pressure for lexicalization of connectives, we should consider what states they would help us identify. First, consider the redundant connectives L and R. These connectives are redundant because they give rise to sentences that are equivalent to a proper subconstituent: P L Q is equivalent to P, and P R Q is equivalent to Q. As a result, $\mathscr{E}xh$(P L Q) and $\mathscr{E}xh$(P R Q) would identify the same state $\mathscr{E}xh$(P) and $\mathscr{E}xh$(Q) identify, respectively, so lexicalizing them would not achieve anything: they are completely unhelpful.

Second, consider the trivial connectives CONT and TAU. $\mathscr{E}xh$(P CONT Q) would not identify any state, so it is unhelpful. The situation with TAU is a little more complicated: One can imagine that Strengthening in the case of P TAU Q will exclude all the propositions in the question denotation, namely it will identify the state $\neg P \wedge \neg Q \wedge \neg R \wedge \neg S$ (this is indeed the prediction of the theory of

Strengthening we will adopt later in the paper). Note however that the same would hold no matter what TAU's arguments are; in other words, TAU is not very helpful either: it only helps identify one epistemic state. Arguably, lexicalizing a connective which will only help identify one state is not worth it.[6]

To conclude, we can explain why trivial and redundant connectives are not lexicalized if we assume that unhelpful connectives are not lexicalized. Now that we have seen extreme examples where lexicalizing connectives isn't helpful, we can move on to showing why lexicalizing AND and OR is helpful.

4 Answering questions with AND

In contrast with redundant and trivial connectives, lexicalizing AND allows speakers to convey various epistemic states once Strengthening is taken into account. Assuming that Strengthening derives exhaustive inferences for sentences of the form ϕ AND ψ, namely that it excludes all the propositions in the question denotation which are logically independent from the connective's arguments (similarly to what we assumed in section 3.1 about the derivation of exhaustive inferences), we expect that any sentence of the form ϕ AND ψ will identify the cell where ϕ and ψ are true and all other propositions in the question denotation are false. Moreover, once we take into account the possibility of recursive application of AND (or alternatively a definition of AND where it takes an arbitrary number of arguments), it turns out that all the epistemic states involving complete knowledge concerning the question (except the one where all propositions are false, i.e., the bottom cell in figure 2) can be conveyed.

In (8) there are several examples of cells identified by sentences with AND after strengthening, and Figure 3 shows the corresponding color-coded cells that are identified by these sentences.

(8) a. $\mathscr{E}xh(P \text{ AND } Q)$ identifies the cell $P \wedge Q \wedge \neg R \wedge \neg S$ ■
b. $\mathscr{E}xh(P \text{ AND } R)$ identifies the cell $P \wedge \neg Q \wedge R \wedge \neg S$ ■
c. $\mathscr{E}xh(Q \text{ AND } R)$ identifies the cell $\neg P \wedge Q \wedge R \wedge \neg S$ ■
d. $\mathscr{E}xh(P \text{ AND } Q \text{ AND } R)$ identifies the cell $P \wedge Q \wedge R \wedge \neg S$ ■
e. $\mathscr{E}xh(P \text{ AND } Q \text{ AND } R \text{ AND } S)$ identifies the cell $P \wedge Q \wedge R \wedge S$ ■

AND is then helpful for identifying epistemic states where the speaker is completely knowledgable, because a language which has AND and strengthening can identify all the cells in the partition induced by the question (except the bottom cell).

Clearly, however, we don't always know everything. If a speaker's epistemic state does not entail

6 Note furthermore that it is not clear whether the bottom cell (identified here by sentences with TAU) should be identified at all, given that questions often have the presupposition that at least one of the propositions in the question denotation is true. See Dayal (1996); Fox (2018) for proposals as to why this presupposition arises. We thank Itai Bassi for pointing this out.

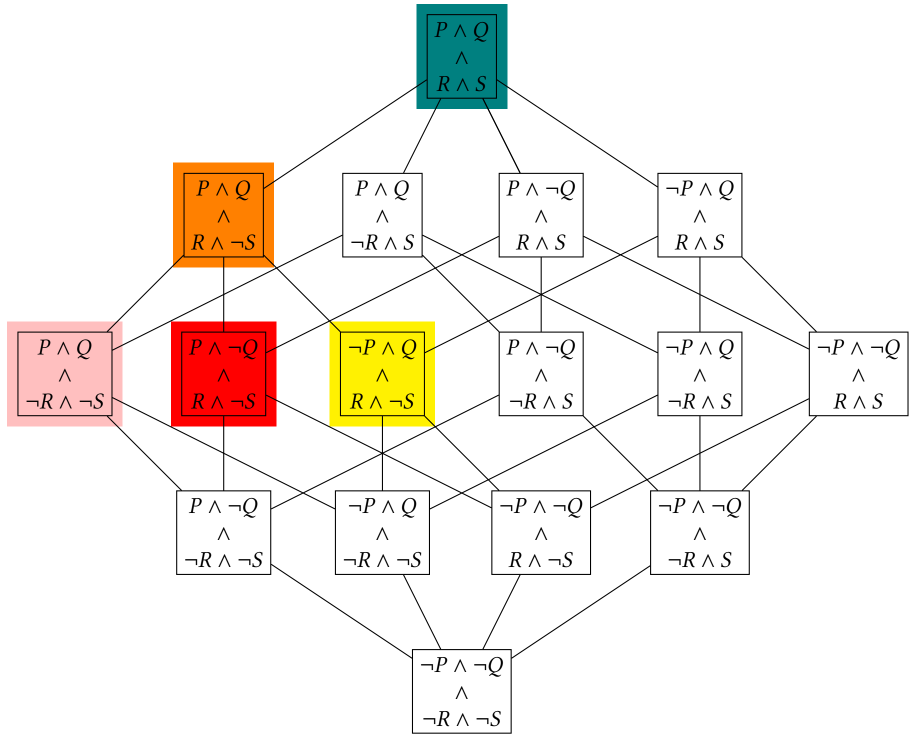

Figure 3 Partition induced by the question $\{P, Q, R, S\}$, with color-coding of the cells identified by the sentences with AND in (8).

a specific cell, but is rather compatible with two cells or more, they will not be able to convey their epistemic state using a language which only has AND and strengthening. This, we will suggest in the following section, is why it is useful for languages to lexicalize OR.

5 Answering questions with OR

As mentioned in section 1, if the reason behind CI is that speakers should be able to convey their epistemic attitude towards the question, then it poses too strong a requirement: If sentences always identify a particular cell, speakers with partial knowledge about the question would not be able to convey their epistemic state since it is compatible with more than one cell. In other words, if good answers are ones where a speaker delivers all the relevant information that their epistemic state entails concerning the question (see Fox 2016; Buccola & Haida 2019), requiring good answers to always be complete answers is too strong. We therefore suggest the following weakening of CI, which takes into account the possibility of partial knowledge but still requires providing all the information that the speaker's epistemic state entails concerning the question:

(9) **Epistemic state identifiability** (ESI): Given a topic of conversation (a question), a speaker's utterance (an answer) should be able to convey their epistemic attitude towards each possible complete answer to the question (each cell in the partition induced by the question).

Instead of requiring that an answer provide a complete answer (identifying a cell) as in CI, ESI requires that an answer tell us which complete answers are compatible with the speaker's epistemic state and which ones are not. Put differently, ESI says that S is a good answer to a question Q only if S provides a complete answer to the following question: Which complete answers to Q are compatible with the speaker's epistemic state?

Before we proceed to talk about how we can convey epistemic states with partial knowledge, we should briefly talk about how we think of epistemic states and about the space of possible epistemic states, something which will facilitate the discussion going forward. Since we are only interested in what epistemic states entail concerning a question, what matters for us is what cells in the partition are compatible with the speaker's epistemic state (the speaker's epistemic attitude towards the question). We can then identify an epistemic state with the set of all the cells in the partition induced by the question which are compatible with it. In other words, we take the space of epistemic states to be the powerset of the partition induced by the question, with the bottom element removed (see Franke 2009).[7,8] What we mean by talking of epistemic states as sets of cells is made explicit in (10).

(10) When we say that $C = \{c_1, \ldots, c_n\}$, a subset of a partition I of logical space, is an epistemic state, what we mean is that every cell in C is compatible with the speaker's epistemic state and no other cell is. In other words, C stands for the epistemic state $\bigwedge\{\Diamond c : c \in C\} \wedge \bigwedge\{\neg\Diamond c : c \in I \setminus C\}$.

Given the question $\{P, Q, R, S\}$ from (5), there are 16 cells in the partition I (as in Figure 1), and as a result there are 65,535 possible epistemic states.[9] Among these states, there are 16 singleton states which are states where the speaker is fully knowledgable about the question, for example the state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S\}$ where the only cell compatible with the speaker's beliefs is $P \wedge \neg Q \wedge \neg R \wedge \neg S$; stated explicitly, this is the epistemic state $\Diamond(P \wedge \neg Q \wedge \neg R \wedge \neg S) \wedge \bigwedge\{\neg\Diamond c : c \in I \setminus \{P \wedge \neg Q \wedge \neg R \wedge \neg S\}\}$, which in this particular case is equivalent to $\Box(P \wedge \neg Q \wedge \neg R \wedge \neg S)$. Note that when we move from CI to ESI, everything we said in the previous sections remains intact because when speakers are fully knowledgeable about the question (which is the case we focused on), identifying a cell and identifying an epistemic state amount to the same thing. For example, $\mathscr{E}xh(\text{P})$ identifies the epistemic state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S\}$, which is a different way of saying that it identifies the cell $P \wedge \neg Q \wedge \neg R \wedge \neg S$. The move from CI to ESI then only makes a difference with epistemic states with partial knowledge, which are the topic of this section.

7 Note that the bottom element corresponds to an epistemic state where the speaker's beliefs are incompatible with any complete answer to the question, which is an impossible epistemic state.

8 The connection between Strengthening and the speaker's epistemic state has been discussed extensively since at least Gazdar (1979); for instance, Franke (2009) uses what he calls 'epistemic lifting' (parallel to our move from cells to epistemic states here) specifically to deal with disjunctive sentences.

9 More generally, given that the number of cells in the partition induced by a question with n (logically independent) propositions is 2^n (see fn. 5), the number of epistemic states given such a question is $2^{2^n} - 1$.

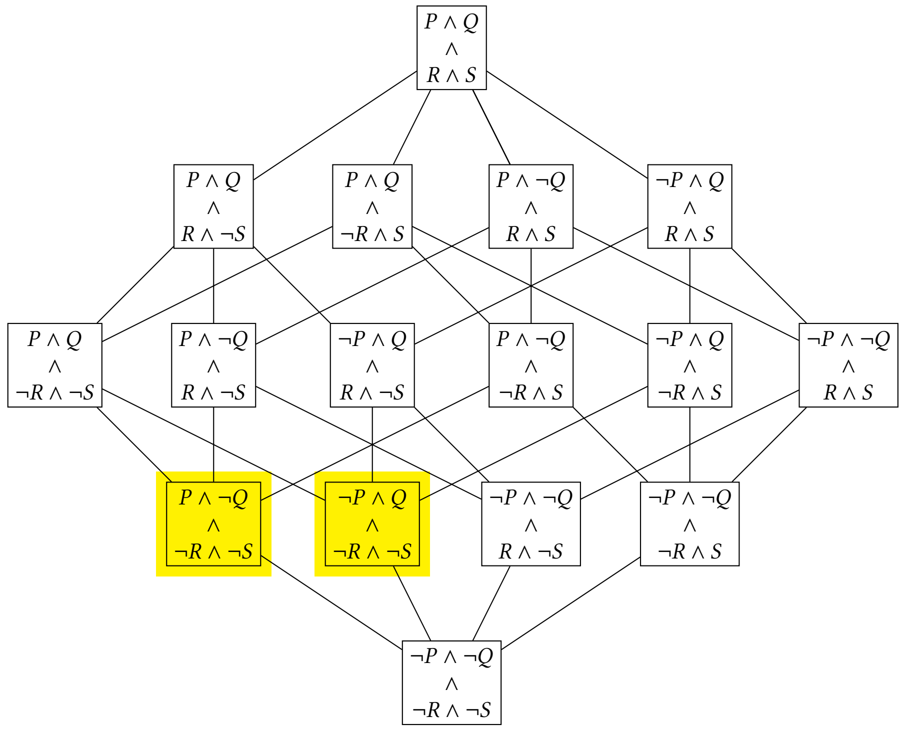

Figure 4 A visual representation of the epistemic state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge Q \wedge \neg R \wedge \neg S\}$.

Among the 65,535 epistemic states, one can also find the state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge Q \wedge \neg R \wedge \neg S\}$ which is an epistemic state where the speaker is not certain whether only P is true or whether only Q is true, but is certain that one of them is true. This state is visually represented in Figure 4. How can a speaker convey this epistemic state? In many languages, sentences with OR are used to convey precisely this kind of epistemic states with partial knowledge. Consider for instance the following sentence:

(11) Penny OR Quentin smiled

a. **Literal meaning** (Quality): The speaker is certain that Penny or Quentin smiled
b. **Exclusive inference**: The speaker is certain that not both Penny and Quentin smiled
c. **Exhaustive inferences**:
 (i) The speaker is certain that Rachel didn't smile
 (ii) The speaker is certain that Sue didn't smile
d. **Ignorance inferences**:
 (i) The speaker is not certain that Penny smiled
 (ii) The speaker is not certain that Quentin smiled

When we take into account all the inferences in (11) (as before, in a context where the QUD is $\{P, Q, R, S\}$), the result is compatible with the epistemic state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge Q \wedge \neg R \wedge \neg S\}$ (for discussion of these inferences see Gazdar 1979; Sauerland 2004; Fox 2007, among many others).

Importantly, the inferences don't only tell us that the speaker's epistemic state *might* be the set containing these two cells (and perhaps also might be a set containing just one of them or containing other cells as well), but rather that the only possible epistemic state of a speaker who commits to these inferences is the set of these two cells; that is, the speaker's epistemic state must be compatible with both of these cells and only with those cells. In other words, the sentence with its inferences *identifies* the epistemic state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge Q \wedge \neg R \wedge \neg S\}$, and is incompatible with any of the other 65,534 epistemic states. This will be crucial in the next section, where we will show that other connectives do not share this property of identifying only one epistemic state with Strengthening (under the F/M view of Strengthening we will immediately lay out).

So far, we were agnostic about the proper theory of Strengthening, that is, what $\mathcal{E}xh$ stands for. We however need to assume a specific theory of strengthening as our goal is to consider what Strengthening predicts for connectives other than the attested connectives AND and OR, where we cannot rely on speaker judgments of what inferences sentences in imaginary languages have. Let us then briefly lay out the F/M view of how all the inferences in (11) are brought about due to Fox (2007) and Meyer (2013) (see also Fox 2016; Buccola & Haida 2019). Fox assumes a grammatical theory of Strengthening where implicatures are derived by a covert exhaustivity operator $\mathcal{E}xh$, akin to overt *only* (Chierchia et al. 2012). What's important for our purposes is that Fox's $\mathcal{E}xh$ operator only excludes 'innocently excludable' (IE) alternatives, because the notion of Innocent Exclusion (which has roots in Groenendijk & Stokhof 1984) will play a crucial role in our discussion of unattested connectives in section 6. Informally, an alternative is IE given an assertion if negating it consistently with the assertion does not affirm a disjunction of other alternatives. As long as there are just two alternatives, the following simple definition suffices:[10]

(12) When a sentence S has two alternatives, A_1 and A_2, neither A_1 nor A_2 are IE if both of the following conditions hold (in which case we say that these alternatives are 'symmetric'):

a. Negating each of them is consistent with S ($S \wedge \neg A_1 \not\Leftrightarrow \bot$ and $S \wedge \neg A_2 \not\Leftrightarrow \bot$)

b. Negating both of them together is inconsistent with S ($S \wedge \neg A_1 \wedge \neg A_2 \Leftrightarrow \bot$)

The idea behind Innocent Exclusion is that Strengthening aims to exclude as many alternatives as possible without making arbitrary choices between them and without reaching a contradiction. If negating A_1 makes it so that it's no longer possible to negate A_2 without reaching a contradiction given S (namely if A_1 and A_2 are symmetric relative to S), then negating A_1 would be an arbitrary choice to make and so would be negating A_2, so neither is negated by $\mathcal{E}xh$.

10 For the general case, Fox (2007) defines $\mathcal{E}xh$ and IE alternatives as follows:

(i) Definition of $\mathcal{E}xh$:

a. $[\![\mathcal{E}xh]\!](C)(p)(w) = 1$ *iff* $p(w) = 1 \wedge \forall q \in IE(C,p)[q(w) = 0]$

b. $IE(C,p) = \bigcap\{C' : C' \text{ is a maximal subset of } C, \text{ s.t. } p \wedge \bigwedge\{\neg q : q \in C'\} \not\Leftrightarrow \bot\}$

Innocent Exclusion is crucial in the case of (11), since if $\mathscr{E}xh$ were to exclude all stronger (or non-weaker) alternatives, it would have excluded both the alternative P and the alternative Q, both of which are stronger than P OR Q, resulting in a contradiction. Excluding only IE alternatives instead avoids this problem, since P and Q are symmetric given P OR Q: P OR $Q \wedge \neg P$ is non-contradictory, and P OR $Q \wedge \neg Q$ is non-contradictory, but P OR $Q \wedge \neg P \wedge \neg Q$ is contradictory.

Assuming that the alternatives of a sentence like ϕ OR ψ are derived as in Katzir (2007), namely that they are derived by replacing constituents with their sub-constituents, replacing constituents with lexical items, and replacing constituents with constituents that are salient in context, we expect the set of alternatives in (13) for ϕ OR ψ when uttered as a response to the question $\{P, Q, R, S\}$ (that is, when all four propositions are salient).[11] (This set of alternatives is what's predicted by Katzir in a language which lexicalizes both OR and AND, such as English; things look different if that's not the case, see Fox 2007; Bowler 2014. We discuss this possibility in Appendix A.)

(13) $Alt(\phi \text{ OR } \psi) = \{\{\phi' \text{ OR } \psi' : \phi', \psi' \in \{P, Q, R, S\}\} \cup \{\phi' \text{ AND } \psi' : \phi', \psi' \in \{P, Q, R, S\}\} \cup \{P, Q, R, S\}\}$

When we apply $\mathscr{E}xh$ to a sentence of the form P OR Q given the set of alternatives in (13), the result is as follows:

(14) $\mathscr{E}xh$(P OR Q)

a. $\Rightarrow (P \text{ OR } Q)$

b. $\Rightarrow \neg(P \text{ AND } Q)$

c. $\Rightarrow \neg R$

d. $\Rightarrow \neg S$

Exhaustification then gives us both the exclusive inference ((14b)) and the exhaustive inferences ((14c)) and ((14d)) in (11). What's still missing are the ignorance inferences. While in Fox (2007) ignorance inferences are genuine pragmatic inferences, Meyer (2013) argues for a theory where even these inferences are derived grammatically (for conceptual reasons behind this and further discussion see Fox 2016; Buccola & Haida 2019). This is done by applying $\mathscr{E}xh$ above a universal K(nowledge) operator: a universal modal paraphrasable as 'the speaker is certain that. . . '. Assuming the structure in (15), this theory derives all the inferences in (11): As we have seen in (14), exclusive and exhaustive inferences are derived by $\mathscr{E}xh$ below K; applying another $\mathscr{E}xh$ above K further derives the ignorance inferences.[12]

11 The careful reader might notice that (13) contains alternatives like P OR P. The results we report on later do not assume that these alternatives are derived, but deriving them would not affect our discussion (some of the numbers in Table 3 would have to change if these alternatives are derived, but the overall picture would remain the same).

12 We assume here with Meyer (2013) that the alternatives the higher $\mathscr{E}xh$ operator operates on are the result of pointwise application of K to the alternatives in (13).

(15) $\mathscr{E}xh\ K\ \mathscr{E}xh$(P OR Q)

a. $\Rightarrow K(P \text{ OR } Q)$

b. $\Rightarrow K(\neg(P \text{ AND } Q))$

c. $\Rightarrow K(\neg R)$

d. $\Rightarrow K(\neg S)$

e. $\Rightarrow \neg K(P)$

f. $\Rightarrow \neg K(Q)$

(15) then identifies the following epistemic state, since, as we pointed out above, that's the only epistemic state compatible with the inferences in (11) which are entailed by (15).

(16) $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge Q \wedge \neg R \wedge \neg S\}$

Having OR in a language with AND is then useful because it helps identify various epistemic states of partial knowledge. Here are some identifications we get in such a language for sentences with OR, when $\mathscr{E}xh$ applies both above and below K:

(17) a. $\mathscr{E}xh$ K $\mathscr{E}xh(P \text{ OR } Q)$ identifies the state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge Q \wedge \neg R \wedge \neg S\}$ (see Figure 4)

b. $\mathscr{E}xh$ K $\mathscr{E}xh(P \text{ OR } R)$ identifies the state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge \neg Q \wedge R \wedge \neg S\}$

c. $\mathscr{E}xh$ K $\mathscr{E}xh(Q \text{ OR } R)$ identifies the state $\{\neg P \wedge Q \wedge \neg R \wedge \neg S, \neg P \wedge \neg Q \wedge R \wedge \neg S\}$

d. $\mathscr{E}xh$ K $\mathscr{E}xh(P \text{ OR } Q \text{ OR } R)$ identifies the state $\{P \wedge \neg Q \wedge \neg R \wedge \neg S, \neg P \wedge Q \wedge \neg R \wedge \neg S, \neg P \wedge \neg Q \wedge R \wedge \neg S\}$

Let us take stock. We have seen that AND and OR (in a language which lexicalizes both) always enable the identification of epistemic states, i.e., satisfying ESI. Moreover, one can show that this does not depend on the number of propositions in the question denotation, nor does it depend on the number of arguments AND or OR take. Stated more explicitly:

(18) For each subset $C = \{P_1, \ldots, P_n\}$ of a question Q whose alternatives are logically independent:

a. $\mathscr{E}xh$ K $\mathscr{E}xh(\text{P}_1 \text{ AND } \ldots \text{ AND } \text{P}_n)$ identifies the state $\{\bigwedge\{P : P \in C\} \wedge \bigwedge\{\neg P : P \in Q \setminus C\}\}$.

b. $\mathscr{E}xh$ K $\mathscr{E}xh(\text{P}_1 \text{ OR } \ldots \text{ OR } \text{P}_n)$ identifies the state $\{P_1 \wedge \bigwedge\{\neg P : P \in Q \setminus \{P_1\}\}, \ldots, P_n \wedge \bigwedge\{\neg P : P \in Q \setminus \{P_n\}\}\}$.

Two assumptions have been crucial for the identification of cells by AND and OR in the system we assumed: (i) Strengthening is done grammatically by an $\mathscr{E}xh$ operator which only negates IE alternatives (Fox 2007), and (ii) ignorance inferences are derived by applying $\mathscr{E}xh$ above K (Meyer 2013). In the next section we will show how this system predicts a striking difference between AND

and OR on the one hand and all the other connectives on the other hand in terms of the ability to satisfy ESI.

6 Answering questions with other connectives

6.1 The problem with exhaustive inferences

What about other connectives? As pointed out in Bar-Lev & Katzir (2022b), the system of Strengthening we assume here—specifically the assumption of Innocent Exclusion—makes a sharp distinction between AND and OR on the one hand and all other connectives on the other hand in terms of whether exhaustive inferences can be derived. As we will show, this has ramifications for the ability of sentences with such connectives to satisfy ESI.

Bar-Lev & Katzir (2022b) observe that when a sentence of the form ϕ CON ψ has logically independent alternatives (LIAs)— that is, alternatives that stand in no entailment relations to either ϕ or ψ— these alternatives are IE if CON is AND or OR, but non-IE if CON is one of the other 10 meaningful connectives in table 1.

In other words, exhaustive inferences are only predicted to be entailed by $\mathcal{E}xh(\phi \text{ CON } \psi)$ if CON is AND or OR. This holds under the assumption we made before (see (13)), namely that alternatives are derived as in the theory of structural alternatives by Katzir (2007). On this theory, when P, Q, R, and S are salient, ϕ CON ψ has the set of alternatives in (19) (LANG here is the set of connectives lexicalized in the language in which ϕ CON ψ is uttered).

(19) $Alt(\phi \text{ CON } \psi) = \bigcup\{\{\phi' \text{ CON' } \psi' : \phi', \psi' \in \{P, Q, R, S\}\} : \text{CON'} \in \text{LANG}\} \cup \{P, Q, R, S\}$

For instance, R is non-IE given P NAND Q, because it's symmetric to P NAND R: (P NAND Q)∧¬(P NAND R) is consistent, and (P NAND Q)∧¬(R) is consistent, but (P NAND Q)∧¬(P NAND R) ∧¬(R) is inconsistent. So R is non-IE, and for the same reasons neither is S. Similar considerations make R non-IE given any sentence of the form P CON Q for any meaningful CON other than AND or OR.[13]

Note that no addition of alternatives to $Alt(\phi \text{ CON } \psi)$ can make R IE if it is not already so, so exclusion of LIAs is only guaranteed in languages without any connective other than AND and OR. In other words, among all 4095 (= $2^{12} - 1$) possible inventories of meaningful connectives, there are only 3 where LIAs are IE for every sentence of the form ϕ CON ψ: {AND}, {OR}, and {AND, OR} (see Uegaki 2022 for evidence that all of them are attested). Excludability of LIAs (i.e., the ability to derive exhaustive inferences) then distinguishes AND and OR from all other meaningful connectives:

13 In some cases exhaustive inferences are not blocked due to symmetry between an LIA and just one other alternative, but due to symmetry with more than one alternative. For instance, given a sentence like P XOR Q, R is symmetric to {Q, P XOR R}: (P XOR Q) ∧¬ R is non-contradictory, and so is (P XOR Q) ∧¬ Q ∧¬ (P XOR R), but (P XOR Q) ∧¬ Q ∧¬ (P XOR R) ∧¬ R is contradictory. While our partial characterization of Innocent Exclusion in (12) does not make R non-IE in this case, the full characterization in fn. 10 does.

(20) **Excludability of LIAs**: AND and OR are the only meaningful connectives which enable the innocent exclusion of LIAs.

6.2 Non-excludability of LIAs affects the ability to answer questions

Of course, when exhaustive inferences are impossible to derive, a sentence can no longer identify epistemic states with complete knowledge. One may wonder though whether, with the aid of $\mathcal{E}xh$ above K, sentences like P NAND Q can still identify epistemic states with partial knowledge. This expectation may seem reasonable, given that whenever there is symmetry between alternatives, embedding under a universal quantifier (one which has no dual alternative, cf. Bar-Lev & Fox 2020) breaks the symmetry and allows all non-weaker alternatives to be negated by $\mathcal{E}xh$ (see Fox & Katzir 2011). In this section we show that this expectation, though reasonable, is not borne out; that is, the inability of meaningful connectives other than AND and OR to derive exhaustive inferences makes them unable to identify epistemic states.

Let us illustrate this point with NOR. Negation of all the non-weaker alternatives by the higher $\mathcal{E}xh$ in (21) yields the inference that the speaker is neither certain that R is true nor that R is false, and likewise for S:

(21) $\mathcal{E}xh$ K $\mathcal{E}xh$(P NOR Q)
$= K(P \text{ NOR } Q) \wedge \neg K(P \text{ NOR } R) \wedge \neg K(P \text{ NOR } S) \wedge \ldots \wedge \neg K(R) \wedge \neg K(S)$
$= K(P \text{ NOR } Q) \wedge \neg K(R) \wedge \neg K(S) \wedge \neg K(\neg R) \wedge \neg K(\neg S)$

While it may look like a relatively strong inference, it does not in fact identify a state; (21) doesn't determine whether the speaker's epistemic state is compatible with any of the following cells:

(22) a. $\neg P \wedge \neg Q \wedge R \wedge S$
b. $\neg P \wedge \neg Q \wedge R \wedge \neg S$
c. $\neg P \wedge \neg Q \wedge \neg R \wedge S$
d. $\neg P \wedge \neg Q \wedge \neg R \wedge \neg S$

Specifically, a speaker who commits to (21) still does not provide enough information for the hearer to determine what their epistemic state is, since all of the following epistemic states are compatible with (21):

(23) a. {(22a), (22d)}
b. {(22b), (22c)}
c. {(22a), (22b), (22c)}
d. {(22a), (22b), (22d)}
e. {(22a), (22c), (22d)}
f. {(22b), (22c), (22d)}

	AND	OR	NAND	NOR	XOR	IFF	ONLYL	→	NOTL
AND	1	1	5	4	6	4	7	2	7
OR	1	5	1190	1566	1472	1552	1568	692	1538
NAND	1538	1190	1538	1538	1449	1524	1538	692	1538
NOR	7	5	5	7	6	6	7	4	7
XOR	175	96	89	174	175	169	175	41	164
IFF	192	124	112	186	174	192	192	72	174
ONLYL	7	5	5	7	6	6	7	4	7
→	1288	916	916	1288	1265	1288	1288	1288	1288
NOTL	193	125	125	193	175	174	193	72	193

Table 3 Summary of results: Each cell CON_i, CON_j in this table represents the number of epistemic states (given a question like $\{P, Q, R, S\}$) compatible with $\mathcal{E}xh$ K $\mathcal{E}xh$ P CON_i Q, in a language where CON_j is the only connective (potentially) different from CON_i (the diagonal represents the results in languages with only one connective). The highlighted cells are those where $\mathcal{E}xh$ K $\mathcal{E}xh$ P CON_i Q identifies exactly one epistemic state.

g. {(22a), (22b), (22c), (22d)}

Parallel results are obtained for all meaningful connectives other than AND and OR, which, as we have seen in the previous sections, enable identification of states when embedded under $\mathcal{E}xh$ K $\mathcal{E}xh$. Table 3 summarizes our results for inventories of meaningful connectives of size 1 and 2.[14] As this table shows, the only languages which lexicalize one or two connectives and enable identification of epistemic states are {AND} and {AND, OR} (note that {OR} doesn't, despite enabling the exclusion of LIAs; we discuss the case of {OR} in Appendix A).

Note that our results show something more significant than just that AND and OR are the only connectives which can satisfy ESI (while also helping to identify various epistemic states). They also show that the ability of AND and OR to satisfy ESI is lost once other connectives are also lexicalized. In other words, other connectives are not simply unsuccessful extra baggage; they do actual harm. This can explain why languages don't only tend to prefer to lexicalize AND and OR over other connectives, but in fact never lexicalize any other connectives (as simplex): If the pressure for lexicalization of connectives comes from the need to identify states, as we hypothesized in (7), then lexicalizing other connectives will not only be unhelpful for achieving this goal but actually damaging.[15]

14 The code we used in order to obtain these results can be found in the following address: `https://osf.io/rafw4/?view_only=ab1ea8a6e5b642d0ada98401e2ea3800`.

15 When we move to languages with 3 connectives the picture remains the same. With 4 connectives, however, all 'strong' connectives (those which determine the truth value of both of their arguments, i.e., AND, NOR, ONLYL and ONLYR) identify states if they have OR, NAND, and → (or ←) as alternatives (and in some cases not all of them are needed; AND satisfies ESI also when it has OR, NOR, and → as alternatives). We suspect that this is an accidental result which will disappear once we consider cases with more LIAs (that is, questions with more than 4 propositions), something we weren't able to test so far due to computational limitations. Even if we are wrong, we do not think this threatens our

7 Summary

In this paper we argued that given the F/M theory of Strengthening (due to Fox 2007; Meyer 2013), we can explain why AND and OR are the only connectives that are lexicalized as simplex. We have shown that AND and OR stand out when this theory is combined with the rather simple idea that sentences should be good answers to questions, and particularly that being a good answer to a question entails identifying the speaker's epistemic attitude towards the question (ESI, repeated in (24)), together with the hypothesis that connectives are lexicalized in order to help speakers convey their epistemic states (repeated in (25)).

(24) **Epistemic state identifiability** (ESI): Given a topic of conversation (a question), a speaker's utterance (an answer) should be able to convey their epistemic attitude towards each possible complete answer to the question (each cell in the partition induced by the question).

(25) **Hypothesis on pressure for lexicaliztion of connectives**:
Lexicalizing connectives is helpful for identifying epistemic states which are otherwise unidentifiable.

Our analysis rests on the observation that on the F/M theory of Strengthening, AND and OR are the only connectives which enable the identification of epistemic states (in a helpful way). Our account then derives the appearance of Positivity from Strengthening, as was the goal in Bar-Lev & Katzir (2022a), but instead of relying on IRMs as a theory of Strengthening together with the notion of Stability, it relies on the F/M theory of Strengthening together with the idea that delivering epistemic states is important in answering questions, both of which are arguably better motivated.

Appendix

A The case of $\{OR\}$

In section 5 we showed that the only languages which enable the satisfaction of ESI are {AND, OR} and {AND}. On our assumptions in the main text, {OR} does not satisfy ESI (as can be seen in Table 3). But it has been argued that such languages exist; specifically, Bowler (2014) argues that Warlpiri is {OR}. Crucially, however, Bowler (2014) argues that OR in Warlpiri (lexicalized as *manu*) behaves

account for two reasons. First, In all of these languages there are connectives which cannot identify epistemic states; lexicalizing an otherwise unhelpful connective just for another connective to be able to identify a state might not be a good enough reason for lexicalization. Second, even if this was a good enough reason for lexicalization, languages might not get the chance to do it: If connectives are lexicalized one at a time, then for a language to develop into a stage where it has 4 connectives, of which just one satisfies ESI, it would have to first be at a stage where it has 3 connectives, none of which satisfies ESI. But it would have no incentive whatsoever to get to this latter stage to begin with, so the question of whether it is worth it to lexicalize one (otherwise unhelpful) connective in order to save another will not even arise.

	AND	OR	NAND	NOR	XOR	IFF	ONLYL	$\rightarrow$	NOTL
AND	1	1	5	4	6	5	7	5	7
OR	1	1	1190	1566	1472	1	1568	1	1538
NAND	1538	1190	1538	1538	1449	1524	1538	692	1538
NOR	7	5	5	7	6	6	7	4	7
XOR	175	96	89	174	175	169	175	41	164
IFF	1	1	112	186	174	1	192	1	174
ONLYL	7	5	5	7	6	6	7	4	7
$\rightarrow$	1	1	916	1288	1265	1	1288	1	1288
NOTL	193	125	125	193	175	174	193	72	193

Table 4 Summary of results (see Table 3) assuming $\mathcal{E}xh$ with Innocent Inclusion.

like AND in positive sentences. She proposes that $\mathcal{E}xh$ strengthens OR in Warlpiri into AND. And if that is indeed the case, then OR in warlpiri will also be able to satisfy ESI. This can be done in various ways; for concreteness, let us assume that $\mathcal{E}xh$ does not only negate all the innocently excludable (IE) alternatives, but also affirms all the 'innocently includable' alternatives, as argued by Bar-Lev & Fox (2017, 2020).[16] Innocent Inclusion has the desired property that it turns disjunctions into conjunctions in the absence of a conjunctive alternative, as argued by Bowler (2014) to be the case in Warlpiri (see also Singh et al. 2016). Once $\mathcal{E}xh$ both excludes innocently excludable alternatives and affirms innocently includable alternatives, the results we get slightly change but the overall picture remains the same. The results with Innocent Inclusion appear in Table 4. As desired, now $\mathcal{E}xh$ K $\mathcal{E}xh$ P OR Q in a language which only lexicalizes OR identifies a state. An immediate concern is however that there are several cases in this table where an unattested connective (IFF, $\rightarrow$) identifies epistemic states (highlighted in orange). Closer inspection however reveals that these are cases where the state being identified is the same no matter what the connective's arguments are. That is:

(26) $\mathcal{E}xh$ K $\mathcal{E}xh$ (P CON Q) = $\mathcal{E}xh$ K $\mathcal{E}xh$ (P CON R) = $\mathcal{E}xh$ K $\mathcal{E}xh$ (P CON S) = ...

Recall that when we discussed the trivial connective TAU in section 3.2, we suggested that it isn't lexicalized because it would only help identifying one epistemic state. The same would apply here: IFF and $\rightarrow$ will not be lexicalized because they only help identify one epistemic state, no matter what their arguments are.

16 Here is the definition of $\mathcal{E}xh$ based on both Innocent Exclusion and Innocent Inclusion from Bar-Lev & Fox (2020):

(i) a. $[\![\mathcal{E}xh]\!](C)(p)(w) = 1$ *iff* $p(w) = 1 \wedge \forall q \in IE(C,p)[q(w) = 0] \wedge \forall r \in II(C,p)[r(w) = 1]$
b. $IE(C,p) = \bigcap\{C' : C'$ is a maximal subset of C, s.t. $p \wedge \bigwedge\{\neg q : q \in C'\} \not\Leftrightarrow \bot\}$
c. $II(C,p) = \bigcap\{C'' \subseteq C : C''$ is a maximal subset of C, s.t. $p \wedge \bigwedge\{\neg q : q \in IE(C,p)\} \wedge \bigwedge C'' \not\Leftrightarrow \bot\}$

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