Toward a Redefinition of Yes/No Questions

Julia Hirschberg
Department of Computer and Information Science
Moore School/D2
University of Pennsylvania
Philadelphia, PA 19104

ABSTRACT

While both theoretical and empirical studies of question-answering have revealed the inadequacy of traditional definitions of ***yes-no questions*** (YNQs), little progress has been made toward a more satisfactory redefinition. This paper reviews the limitations of several proposed revisions. It proposes a new definition of YNQs based upon research on a type of ***conversational implicature***, termed here ***scalar implicature***, that helps define appropriate responses to YNQs. By representing YNQs as ***scalar queries*** it is possible to support a wider variety of system and user responses in a principled way.

I INTRODUCTION

If natural language interfaces to question-answering systems are to support a broad range of responses to user queries, the way these systems represent queries for response retrieval should be reexamined. Theorists of question-answering commonly define questions in terms of the set of all their possible (true) answers. Traditionally, they have defined ***yes-no questions*** (YNQs) as ***propositional questions*** ($?P$) or as a special type of ***alternative question*** ($?P \vee ?Q$), in which the second alternative is simply the negation of the first ($?P \vee ?\neg P$). So 'Does Mary like skiing?' would be represented as $?like(Mary,skiing)$ or $?like(Mary,skiing) \vee ?\neg like(Mary,skiing)$ and the range of appropriate responses would be *yes*, *no* and, possibly, *unknown*. However, both theoretical work and empirical studies of naturally occurring question-answer exchanges have shown this approach to be inadequate: *Yes*, *no*, and *unknown* form only a small portion of the set of all appropriate responses to a YNQ. Furthermore, for some YNQ's, none of these simple direct responses alone is appropriate.

While it is widely recognized (Hobbs, 1979, Pollack, 1982) that ***indirect*** responses[1] to YNQs represent an important option for respondents in natural discourse, standard theories of question-answering have not been revised accordingly. A practical consequence surfaces when attempts are made to support indirect responses to YNQs computationally. For lack of alternative representations, question-answering systems which would permit indirect responses must still represent YNQs as if the direct responses were the 'norm', and then resort to *ad hoc* manipulations to generate second-class 'indirect' responses, thus perpetuating an asymmetric distinction between 'direct' and 'indirect' responses. However, research under way on how a type of generalized ***conversational implicature***, termed here ***scalar implicature***, can be used to guide the generation and interpretion of indirect responses to YNQs suggests a revised representation for YNQs which accommodates a wide variety of responses in a uniform way.

II CURRENT REPRESENTATIONS OF YNQS

Among standard accounts of YNQs, Hintikka's (Hintikka, 1978) is one of the simplest and most widely accepted, combining the concepts of YNQ as propositional question and as alternative question; as such, it will be used below to represent traditional approaches in general. To define ***answerhood***, the conditions under which a response counts as an answer to a natural-language query, Hintikka divides queries into two parts: an imperative or optative operator (!), roughly expressing 'bring it about that', and a ***desideratum***, a specification of the epistemic state a questioner desires. For Hintikka, a YNQ is a special case of alternative question in which the negative alternative 'or not P' has been suppressed. So the desideratum of a YNQ is of the form *(I know that P)* $\vee$ *(I know that neg+P)*, where *neg+* indicates the negation-forming process. 'Does Mary like skiing?' thus has as its desideratum *I know that Mary likes skiing or I know that Mary does not like skiing*, or, more concisely, $(K_S like(Mary,skiing) \vee K_S \neg like(Mary,skiing))$, where K_S is the epistemic representation of 'S knows that'. The full sense of the query is then 'Bring it about that I know that Mary likes skiing or that I know that Mary does not like skiing', which can be represented by $!\,(K_S P \vee K_S \neg P)$. Possible responses are simply $\{P, \neg P\}$, or {yes,no}.

A. Hypothesis Confirmation

Bolinger (Bolinger, 1978) has called such interpretations into question by showing that YNQs may have very different meanings from their alternative-question counterparts; they also have more restricted paraphrase and intonation patterns. In Bolinger's view the term ***yes-no query*** has hypnotized scholars into assuming that, simply because a class of question **can** be answered by a *yes* or *no*, these alternatives are criterial, and every YNQ is intended to elicit one or the other. He proposes instead that YNQs be viewed as hypotheses put forward for confirmation, amendment, or disconfirmation -- in any degree. Thus, in Bolinger's example (1), the

(1) Q: Do you like Honolulu?
R: Just a little.

questioner (Q)'s hypothesis 'you like Honolulu' is amended by the respondent (R) in a response which is neither *yes* nor *no* but somewhere in between. In his example (2), Q's hypothesis 'it is

(2) Q: Is it difficult?
R: It's impossible.

difficult' is confirmed by R's assertion of a more positive response than a simple *yes*.

While Bolinger makes a good case for the inadequacy of standard views of YNQs, the revision he proposes is itself too limited. 'It's impossible', in (2), does more than simply present a strong affirmation of the hypothesis 'it is difficult' -- it provides new and unrequested though pertinent information. In fact, 'strong affirmation' might better be provided by a response such as 'I am absolutely sure it's difficult' than by the response he suggests. And there are equally appropriate responses to the queries in (1) and (2) that are not easily explained in terms of degree of hypothesis confirmation, as shown in (3) and (4).

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[1] Indirect responses to YNQs are defined here as responses other than *yes*, *no*, or some expression of ignorance.

(3) Q: Do you like Honolulu?
a. R: I don't like Hawaii.
b. R: I like Hilo.

(4) Q: Is it difficult?
a. R: It could be.
b. R: Mike says so.

Finally, Bolinger does not propose a representation to accommodate his hypothesis-confirmation model.

B. Focussed YNQs

Similarly, Kiefer (Kiefer, 1980) points out evidence for the inadequacy of the standard view of YNQs, but proposes no unified solution. In a study of the indirect speech acts that may be performed by YNQs, he notes that certain YNQs, which he terms ***focussed YNQs***, actually function as wh-questions. Focussed YNQs for Kiefer are YNQs that are marked in some way (apparently by stress) to indicate a ***background assumption*** which Q and R typically share. For example, (5a) is **not** a focussed YNQ while (5b)-(5d) **are**. While any of the four may be answered with *yes* or

(5)
a. Is John leaving for Stockholm tomorrow?
b. Is John leaving for Stockholm TOMORROW?
c. Is John leaving for STOCKHOLM tomorrow?
d. Is JOHN leaving for Stockholm tomorrow?

no, it is also possible that, if Q asks (5b), she wants R to answer the question 'When is John leaving for Stockholm?'; if she asks (5c) she may want to know 'Where is John going tomorrow?'; and if she asks (5d) she may want to know 'Who is leaving for Stockholm tomorrow?' Thus a focussed YNQ resembles the wh-question that might be formed by replacing the focussed element in the desideratum with a corresponding Pro-element. In Kiefer's analysis, only one element can be focussed, so responses such as 'He's leaving for Paris Thursday' will not be accommodated.

Although Kiefer does not propose a representation for focussed YNQs, a disjunct resembling the desideratum of a wh-question might be added to the traditional representation to accommodate his third alternative: for (5d) this might take the form 'Is John leaving for Stockholm tomorrow, or, if not, who is?' or, in Hintikka's notation,

$$
\begin{aligned}
&!\, K_Q \text{leaving(John,Stockholm,tomorrow)} \vee \\
&K_Q \neg \text{leaving(John,Stockholm,tomorrow)} \vee \\
&\exists x\, K_Q \text{leaving(x,Stockholm,tomorrow)}.
\end{aligned}
$$

This representation reflects another problem posed by Kiefer's analysis: the third disjunct is appropriate only when the second also is and not when the direct response *yes* is true. For example, a response of 'Bill is' to (5d) seems to convey that *John* is **not** leaving for Stockholm tomorrow. Thus viewing some YNQs as wh-questions requires a rather more complex representation than simply adding a wh-question as a third disjunct.[2] In addition, defining different representations for various YNQ subtypes seems a less than satisfactory solution to the limitations presented by current representations of YNQs. A more unified solution to the problems identified by Bolinger and Kiefer would clearly be desirable. Such a solution is suggested by current research on the role conversational implicature plays in accounting for indirect responses to YNQs.

III CONVERSATIONAL IMPLICATURE AND YNQS

In a large class of indirect responses to YNQs, query and response each refer to an entity, attribute, state, activity, or event that can be viewed as appearing on some ***scale***; such references will be termed ***scalars*** and responses in such exchanges will be termed ***scalar responses***.[3] In such scalar exchanges, questioners can infer both a direct response and additional implicit information from the unrequested information provided by the respondent. In (6) for example, Q is entitled to infer the direct response *no* or *I don't know*

(6) Q: Are mushrooms poisonous?
R: Some are.

and the additional information that R believes that there may be mushrooms that are not poisonous, even though $\exists x(mushroom(x) \wedge poisonous(x))$ does not logically imply any of this information. Clearly 'Some are' is an appropriate response to the query – more appropriate in fact than a simple *no*, which might convey that no mushrooms are poisonous – but what makes it appropriate?

Grice's (Grice, 1975) Cooperative Principle claims that, without contrary evidence, participants in conversation assume their partners are trying to be cooperative. In consequence, they recognize certain conversational maxims, such as Grice's ***Maxim of Quantity***

a) Make your contribution as informative as is required (for the current purposes of the exchange).
b) Do not make your contribution more informative than is required.

and his ***Maxim of Quality***

Try to make your contribution one that is true.
a) Do not say what you believe to be false.
b) Do not say that for which you lack adequate evidence.

Speaker and hearer's mutual recognition of these maxims may give rise to ***conversational implicatures***: An utterance ***conversationally implicates*** a proposition **P** when it conveys **P** by virtue of the hearer's assumption of the speaker's cooperativeness. While a speaker may not always obey these maxims, the hearer's expectations are based on her belief that such conventions represent the norm.

A. Scalar Predication

Following Grice, Horn (Horn, 1972) observed that, when a speaker refers to a value on some scale defined by ***semantic entailment***[4], that value represents the highest value on its scale the speaker can truthfully affirm. The speaker is saying as much (Quantity) as she truthfully (Quality) can. Higher values on that scale are thus implicitly marked by the speaker as not **known** to be the case or known **not** to be the case.[5] Values lower on the scale will of course be marked as true, since they are entailed. Horn called this phenomenon ***scalar predication***, and Gazdar (Gazdar, 1979) later used a variation as the basis for a phenomenon he termed ***scalar quantity implicature***. Here a much revised and extended version will be termed ***scalar implicature***.

Horn's simple notion of scalar predication **does** provide a principled basis for interpreting (6) and similar indirect responses to YNQs where scales are defined by entailment. *Some* is the highest value on a quantifier scale that R can truthfully affirm. Truth-values of higher scalars such as *all* are either unknown to R or believed by him to be false. Thus, if Q recognizes R's implicature, roughly, 'As far as I know, not all mushrooms are poisonous', she will derive the direct response to her query as *no* or *I don't know*. R must believe either that some mushrooms are **not** poisonous or that some mushrooms **may not** be poisonous.

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[2] In fact, the third disjunct would have to be something like $\exists x\, K_Q \neg leaving(John,Stockholm,tomorrow) \wedge leaving(x,Stockholm,tomorrow)$.

[3] The ideas outlined in the following section are discussed in more detail in (Hirschberg, 1984).

[4] W semantically entails T iff T is true whenever W is.

[5] Whether a speaker implicates ignorance or falsity of a value is a subject of some disagreement among Horn and those (Gazdar, 1979, Soames, 1982) who have taken up his basic notion. In (Hirschberg, 1984) I contend that such implicatures should be viewed as disjunctions, $K(\neg T) \vee \neg K(T)$, which may be disambiguated by the nature of the ordering relation or by the context.

It is also important to note that, in (6), were R simply to deny Q's query or to assert ignorance with a simple *I don't know*, Q would be entitled, by virtue of the Cooperative Principle, to assume that there is no scalar value whose truth R can in fact affirm. That is, Q can assume that, as far as R knows, there are no mushrooms that are poisonous, for otherwise R could commit himself to the proposition that 'some mushrooms are poisonous'. More generally then, R is obliged by the Cooperative Principle, and more especially by Joshi's (Joshi, 1982) modification of Grice's ***Maxim of Quality***: 'Do not say anything which may imply for the hearer something which you the speaker believe to be false.', to provide an indirect response in (6), lest a simple direct response entitle Q to conclude some ***false implicatures***. Thus indirect responses **must** be included among the set of all appropriate responses to a given YNQ, since in some cases they may be the **most** appropriate response R can make.

B. Scalar Implicature

While scalar predication provides a principled explanation for (6), a revised and extended notion of ***scalar implicature*** can account for a much larger class of indirect responses to YNQs. It can also suggest a revised representation of YNQs in general based upon this enlarged class of appropriate responses.

Orderings not defined by entailment and orderings other than linear orderings, including but not limited to set/set-member, whole/part, process stages, spatial relationship, prerequisite orderings, entity/attribute, ***isa*** hierarchy, or temporal ordering, permit the conveyance of scalar implicatures in much the same way that the entailed quantifer scale does in (6). In (7) the set/member

(7) Q: Did you invite the Reagans?
R: I invited Nancy.

(8) Q: Have you finished the manuscript?
R: I've started a rough draft.

relationship orders *the Reagans* and *Nancy*; R implicates that he has not invited *Ronald*, for instance. In (8), *starting a rough draft* precedes *finishing a manuscript* in the process of preparing a paper. So Q is entitled to conclude that R has not finished the manuscript or completed any later stage in this process, such as *finishing the rough draft*.

More formally, any set of referents $\{b_1,...,b_n\}$ that can be ***partially ordered*** by a relation $\mathbf{O}$[6] can support scalar implicature. Any scale **S** that permits scalar implicature can be represented as a ***partially-ordered set***. For any referents b_1, b_2 on S, b_2 is ***higher*** on S than b_1 iff b_1Ob_2; similarly, b_1 is ***lower*** on S than b_2 iff b_1Ob_2. Any pair b_1, b_2 of ***incomparable elements*** (elements not ordered with respect to one another by O) will be termed ***alternate*** values with respect to S. This redefinition of scale accommodates orderings such as those mentioned above, while excluding orderings such as cycles, that do not permit scalar implicature. It also helps define the inferences licensed when R affirms a higher or an alternate value, or when he denies or asserts ignorance of lower, higher, or alternate values.

For example, R affirms a higher scalar value than the value queried in Bolinger's example reproduced in (2). If *difficult* and *impossible* are viewed on a scale defined in degrees of feasibility, then Q can conclude that by affirming the higher value R has affirmed the lower. Similarly, R may affirm an alternate value, as he does in (3b). If R sees Honolulu and Hilo as both members of a set of Hawaiian cities, he can affirm an unqueried set member (Hilo) to deny a queried member (Hawaii). The affirmation of an unqueried alternate value generally conveys the falsity or R's ignorance of the queried value.

Speakers may also license scalar implicatures by denying scalars. The dual to Horn's notion of affirming the highest affirmable value would be negating the lowest deniable scalar. In such a denial a speaker may implicate his affirmation or ignorance of lower scalars. So, in exchanges like (9a), a value higher than a queried value (here,

(9) Q: Did you write a check for the rent?
a. R: I haven't mailed it yet.
b. R: I haven't signed it.
c. R: I didn't pay cash.

a stage in the process of mortgage payment) may be denied to convey the truth of the queried value. R may also deny lower values (9b) or alternate values (9c).

So, indirect scalar responses may be defined upon a number of metrics and may involve the affirmation or negation of higher, lower, or alternate values. They may also involve the affirmation or denial of more than one scalar for a single query, as shown in (10). Assume that Mary and Joe are brother and sister and both are known to Q and R. Also, Mary and Tim are fellow-workers with Q and R. Then to Q's question in (10), R may felicitously respond with any of the

(10) Q: Does Mary like skiing?
a. R: She loves ice-skating.
b. R: Joe loves cross-country.
c. R: Tim likes cross-country.

answers given — as well as a variety of others, such as 'She used to' or even 'Joe used to love ice-skating.' That is, R may base his response upon any one or more scalars he perceives as invoked by Q's query. In addition, a single lexical item (here *Mary*) may invoke more than one scale: R may view Mary as a member of a family or of a set of fellow-workers, for example, to generate responses (10b) and (10c), respectively.

C. A Scalar Representation of YNQs

Given this characterization of appropriate indirect responses, it is possible to model the exchanges presented above in the following way:

1. For some query uttered by Q, let $\mathbf{P} \vee \neg\mathbf{P}$ represent the query's desideratum;
2. Let $\mathbf{P}_{x_1/b_1,x_2/b_2,...,x_n/b_n} \vee \neg\mathbf{P}_{x_1/b_1,x_2/b_2,...,x_n/b_n}$ represent the open proposition formed by substituting variables $\mathbf{x}_i$ for each $\mathbf{b}_i$ invoked by **P** that R perceives as lying on some scale $\mathbf{S}_i$;
3. Then $\mathbf{P}_{a_1/x_1,a_2/x_2,...,a_n/x_n} \vee \neg\mathbf{P}_{a_1/x_1,a_2/x_2,...,a_n/x_n}$ defines the set of possible responses to Q's query, where each $\mathbf{a}_i$ represents some scalar cooccurring with its corresponding $\mathbf{b}_i$ on S_i.
4. A subset of these possible responses, the set of possible **true** responses, will be determined by R from his knowledge base, and an actual response selected.[7]

In (6), for example, the desideratum ($P \vee \neg P$) of Q's query is the generic '(all) mushrooms are poisonous' $\vee$ 'not (all) mushrooms are poisonous'. Here R might perceive a single scalar *all* lying on a quantifier scale, *none/some/all*. So, 'x_1 mushrooms are poisonous' $\vee$ 'not x_1 mushrooms are poisonous' represents the open proposition formed by substituting a variable for *all* in P, where x_1 ranges over the values on $\mathbf{S}_1$, *none/some/all*. Then the set of possible responses to Q's query, given R's choice of scalar, is defined by the affirmation or negation of each of the possible instantiations of 'a_i/x_1 mushrooms are poisonous', or the set {no mushrooms are poisonous,some mushrooms are poisonous,all mushrooms are poisonous,¬no mushrooms are poisonous, ¬some

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[6] A *partial ordering* may be defined as an irreflexive, asymmetric, and transitive relation.

[7] See (Hirschberg, 1984) for further discussion of this selection process.

mushrooms are poisonous, ¬all mushrooms are poisonous}. The set of possible **true** responses will be a subset of this set, determined by R from his knowledge base. Note that $\mathbf{a}_1$ and $\mathbf{b}_1$ may in fact be identical. Thus, the simple direct responses, equivalent to 'All mushrooms are poisonous' and 'Not all mushrooms are poisonous', are accommodated in this schema.

This characterization of potential responses suggests a new representation for YNQs. Following Hintikka, one might paraphrase the query in (6) as "Bring it about that I know that $\mathbf{x}_1$ mushrooms are poisonous or that I know that not $\mathbf{x}_1$ mushrooms are poisonous", where $\mathbf{x}_1$ ranges over the values on some scale $\mathbf{S}_1$ upon which the queried value *some* appears (assuming a many-sorted epistemic logic). Thus the query might be represented as

$$! \exists S_1 \exists x_1 \{some, x_1 \in S_1 \wedge \{K_Q(x_1 \text{ mushrooms are poisonous}) \vee K_Q \neg(x_1 \text{ mushrooms are poisonous})\}\}.$$

For a query like that in (10), an appropriate representation might be:

$$! \exists S_1 \exists x_1 \exists S_2 \exists x_2 \exists S_3 \exists x_3 \{Mary, x_1 \in S_1 \wedge love, x_2 \in S_2 \wedge skiing, x_3 \in S_3 \wedge \{K_Q(x_1\ x_2\ x_3) \vee K_Q \neg(x_1\ x_2\ x_3)\}\}.$$

R may then instantiate each variable with any value from its domain in his response.

In the general case, then, YNQs might be represented as

$$! \exists S_1, \ldots, \exists S_n \exists x_1, \ldots, \exists x_n \{b_1, x_1 \in S_1 \wedge \ldots \wedge b_n, x_n \in S_n \wedge \{K_Q(P_{x_1, \ldots, x_n}) \vee K_Q \neg(P_{x_1, \ldots, x_n})\}.$$

This representation shares some features of standard representations of wh-questions, suggesting that it simply extends Kiefer's view of focussed YNQs to all YNQs. However, there are several significant distinctions between this representation and standard representations of wh-questions, and, thus, between it and Kiefer's suggestion. First, it restricts the domains of variables to scales invoked by corresponding scalars in the original queries desideratum and it includes a negative disjunct. 'Do you like Honolulu?' for example might have as its desideratum

$$\exists S_1 \exists x_1 \exists S_2 \exists x_2 \exists S_3 \exists x_3 \{you, x_1 \in S_1 \wedge like, x_2 \in S_2 \wedge Honolulu, x_3 \in S_3 \wedge \{K_Q(x_1\ x_2\ x_3) \vee K_Q \neg(x_1\ x_2\ x_3)\}\},$$

while the corresponding wh-question 'What do you like?' would have as its desideratum $\exists x\ K_Q(you\ like\ x)$. Second, the representation proposed here allows for reference in a query to multiple scalars, or, multiple focii, which Kiefer does not consider. Third, it avoids both the division of YNQs into focussed and non-focussed queries and the dependency between wh-responses and negative responses noted above; hence, the representation is simpler and more unified. So, YNQs are not represented as wh-questions, although Kiefer's focussed YNQs can be accommodated in this more general representation, which I will term a ***scalar representation***.

IV DISCUSSION

A scalar representation of YNQs can accommodate a wide range of direct and indirect responses which are common in natural discourse but which current representations of YNQs cannot support. Of course, such a redefinition is no panacea for the limitations of current representations: In its current form, for instance, there are some appropriate responses to indirect speech acts, such as (11), which it

(11) Q: Can you tell me the time?
R: It's 5:30.

will not support. In other exchanges, such as (12), the notion of scale may seem less than natural, where a scale like *attributes of a potential date: {pretty, unmarried,...}* must be postulated to accommodate this query in the the representation proposed here.

(12) Q: Is she pretty?
R: She's married.

Too, the actual representation of a particular query may vary according to participants' differing perception of scalars invoked by it, as shown in (10). Because scales are not defined in absolute terms, it is difficult to determine even an abstract specification of the set of all possible responses to a given query; should temporal and modal variables always be understood as implicitly evoked by any query, for example, as in (13)? However, if broad categories of such 'understood' scales can be identified, much of this difficulty might be alleviated. The representation proposed here does accommodate a far larger class of appropriate responses than representations previously suggested, and accommodates them in a unified way. With further refinement it promises to provide a useful tool for theoretical and computational treatments of YNQs.

(13) Q: Is Gloria a blonde?
a. R: She used to be.
b. R: She could be.

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