Is language logical? A study of disjunction scope parameters

The meaning of the English (1) can be paraphrased as the speaker disliking both apples and pears. This is because negation and disjunction in English follow negation and inclusive OR in formal logic where, when OR appears in the scope of negation a conjunctive entailment applies, the so-called De Morgan's Law, see (2).

(1) I don't like apples or pears. = I dislike both apples and pears.

(2) ¬ (P ∨ Q) ⇔ (¬P) ∧ (¬Q)

French works the same way as English, as exemplified in (3). (3) means the speaker dislikes both apples and pears.

(3) Je n'aime pas les pommes ou les poires.

I not like.1sg double-neg the-plural apples or the-plural pears.

I don't like apples or pears

This provides good evidence in support of the idea that natural language follows the rules of formal logic and that the meaning of natural language coordinating conjunctions corresponds to the meaning of logical connectives. The prevailing conjecture is that this is true universally. Languages like Mandarin and Japanese present a challenge to this view, as they appear to assign a disjunctive meaning to negative sentences involving a disjunction, rather than the conjunctive entailment, see (4) (Goro and Akiba 2004).

(4) Butasan-wa ninjin ka piiman-wo tabe-nakat-ta

pig-TOP carrot or pepper-ACC eat-neg-Past

The pig did not eat the carrot or the pepper. = The pig did not eat the carrot or the pig did not eat the pepper.

One plausible way to analyse this, while preserving the universality of the correspondence between natural language semantics and formal logic is to argue that the disjunctor in languages like Japanese is a positive polarity item, which must take wider scope than the sentential negation. So, the meaning of (4) would have the logical representation in (5).

(5) (¬ P) ∨ (¬Q)

Crain (2012) and Goro et al (2004) provided evidence for this view from language acquisition. They demonstrated that even in languages where adults assign a disjunctive reading to the disjunctor in negative sentences (i.e. Japanese) children under the age of 6 fail to do so, and instead apply the natural language default, i.e. De Morgan's Law, thus demonstrating a logical meaning of the connector. Crain (2012) argued that it takes time for children to realize that the disjunctor is a positive polarity item in such languages and until they do so they assign the logical default interpretation (i.e. the conjunctive entailment).

It is also known that the disjunctive interpretation of the disjunctor in negative sentences is often associated with prosodic focus (Szabolcsi 2002). Also, Szendroi et al (2018) demonstrated that French children are sensitive to prosodic focal manipulations from a very early age, Age 3. I formulated the following research hypothesis: If French children are sensitive to prosodic focal manipulation of the disjunctor, they could be coerced to assign a disjunctive reading to sentences involving focus on the disjunctor, even in a language like French, where the conjunctive entailment is assigned unless prosodic focus is placed on the disjunctor.

Adapting the methodology of Goro et al (2004), I carried out a Truth-Value Judgment Task with 55 French native speaker monolingual learners (Average age 5,26, Age range 4,3-6,2). The children were randomly assigned to the test group or the control group. In both conditions the children saw two types of stories acted out by props: one type TRUE under the conjunctive entailment reading and FALSE under the disjunctive reading and the other type of stories vice versa, FALSE under the conjunctive entailment reading and TRUE under the disjunctive reading. Following the story (6), a different test sentence was uttered by a puppet, see (7), involving neutral intonation in the control condition and prosodic focus on the disjunctor in the test condition. Tested on an adapted version of the same task, adults adopted a conjunctive reading of negated disjunctions in over 90% of cases.

(6) *A toy is presented with a chocolate, an apple and an orange to eat. The experimenter plays out the toy eating the chocolate only and leaving the fruits. Then a puppet prop is used to introduce the test sentences, the participant is told that the puppet is making guesses on what the toy ate and are asked to judge those guesses. In this case, the test sentence is expected TRUE.*

(7) a. Le dinosaure a mangé le chocolat, mais n'a pas mangé la pomme ou /ou' l'orange.

The-masculine dinosaur has eaten-masculine.sing the-masculine chocolate, but not has double-neg eaten the-feminine apple or/or' the orange.

The dinosaur ate the candy, but he did not eat the apple or/or' the orange

The results showed that children in the control group assigned an adultlike conjunctive entailment reading 97% of the time. In the test group, results diverged between the two story types, with 29,2% giving a FALSE response that corresponded to the disjunctive reading while a higher proportion, 45,7% giving a TRUE response in the stories that associated TRUE with the disjunctive reading. This difference can be accounted for by the Principle of Charity. Moreover, an intragroup age effect was observed, it suggested that the older children were more likely to adopt a disjunctive reading when focus was introduced, this culminated with 70% of the 6 years old and older giving a TRUE response in context where it corresponded to a disjunctive reading.

To sum up, my results support my hypothesis that focus allows for a disambiguation of negative sentences containing disjunctions and explains why formal logic rules can be violated in language. Moreover, teachings on the acquisition of such violations can be derived from the fact that the participants were able to give a reading violating the rules of logic presumably the first time they had ever been given the option to and very likely while they had never heard such a reading from adult-language.

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