Approaching scalar diversity through RSA with Lexical Uncertainty

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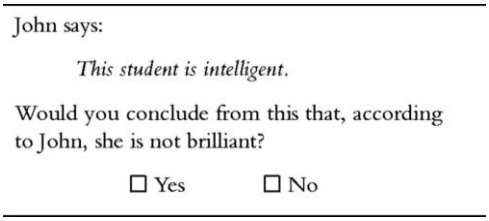
Previous research [1-2] suggests that different scalar expressions give rise to scalar inferences (SIs) at different rates. This phenomenon has become known as scalar diversity (SD). For instance, [2] used an inference paradigm to study the variability of inference rates across a wide range of scalar expressions. Fig.1 is an item from [2], of which a 'Yes' response indicates that an SI has been drawn (where the use of *intelligent* implies *not brilliant*). The study showed that while quantifiers and modal expressions consistently gave rise to SIs, there was much greater variability within adjectives and verbs. As for the source of SD, [2] found that a modest amount of the variation in SI rates might be explained by factors that bear on the relation between scalar term and its Alternative (Alt). Here we approach SD by exploring how enrichments not involving Alts, e.g. w/- a maximality operator, can explain the effect. We implement this using RSA-LU [3-4], a Rational Speech Act approach that allow for multiple semantic interpretations. For scalar term 'some', the literal meaning could be characterised in terms of a set of possibilities where *some and not all* is the case or where *all* is the case: {$\exists\&\neg\forall$, $\forall$}. Possible strengthened meanings of 'some' are {$\exists\&\neg\forall$} and {$\forall$}. In general, for scalar term W with literal meaning {$\omega\&\neg\sigma$, σ}, possible strengthened meanings are {$\omega\&\neg\sigma$} and {σ}. RSA-LU approaches multiple interpretations by assigning a prior probability to each possible lexical interpretation and marginalising at the level of the pragmatic listener, L1. Thus, the likelihood of a scalar implication even for sentences containing an unembedded scalar term is impacted by the prior likelihood of each strengthening for that term, as well as relations between Alts. It therefore predicts scalar diversity is possible if the priors for strengthenings vary across different scalar terms. We test this prediction by measuring the liability for each of the {$\omega\&\neg\sigma$} and {σ} strengthenings for each scalar term, W, found in [2] and also in [5]. This is achieved by our 'so' and 'i.e.' tasks respectively. We find the predicted correlations with results on an inference task based on [2]. We also demonstrate that RSA-LU models based on our results outperform vanilla RSA models.

Exp. 1a,b We used 43 scalar expressions found in [2] and then 70 adjectives used in [5] to construct sentences of the form *S so not W*, where S is stronger than *W* (see Table 1 for examples). For each set, 40 Participants were asked to indicate how natural these constructions are on a Likert scale. Fig.2 is an example trial. *S so not W* sentences should be more coherent to the extent that *W* can be strengthened to mean {$\omega\&\neg\sigma$}. **Exp. 2a,b** We used these scalar expressions to construct sentences of the form *W, i.e. S*, where *S* is stronger than *W* (see Table 1 for examples). Two more sets of 40 participants rated the naturalness of these constructions. Fig.3 is an example trial. *W, i.e. S* sentences should be more coherent to the extent that *W* can be strengthened to mean {σ}. In all experiments, each participant judged either 43 or 70 experimental sentences and 7 fillers. We also conducted separate replications of the inference task for scales in [2] and in [5].

Results: As predicted by RSA-LU, we found the rating of '*S so not W*' was positively correlated with the rate of SIs from our inference tasks (Exp.1a: r=0.35, p=.02; Exp 1b: r=0.80, p<.001), while the rating of '*W, i.e. S* ' was negatively correlated with the SI rate (1a: r=-0.79, p<.001; 1b: r=-0.76, p<.001). The ratings from two naturalness tasks do not correlate. As in [2] and [5], a

multiple regression analysis was conducted to predict the rate of SIs determined in separate inference tasks from ratings obtained from Exp.1a-2a;1b-2b and other factors explored in [2]. For van Tiel et al.'s scales, the model accounted for 68% of the variance (R^2=.75, F(9,32)= 10.51, p<.001). This is significantly more than a model with the factors in [2] alone (42%). But we note that semantic distance (between scalar term and its Alt) as well as *so* and *ie* ratings are sig. factors in this model. For Gotzner et al.'s scales, we account for 75% of the variance, with *so* and *ie* task ratings being the only significant predictors. **Models**: We used results of experiments 1,2 to estimate priors on each kind of interpretation of W (literal, {ω&¬σ}-strengthening , {σ}- strengthening). For each set of scales, both van Tiel et al.'s and Gotzner et al.'s, we implemented these priors in a RSA-LU model. We employed Kendal Rank Correlations to assess how closely model-predicted scalar ranks and actual ranks obtained from the inference paradigm are aligned. In both cases, our model predictions significantly correlate with the ranking observed in the inference task (van Tiel: tau=0.63, p<.001; Gotzner: tau=0.68, p<.001). Moreover, for the Gotzner et al.'s items, we not only correlate our model prediction with participants' responses in the inference task, we also compared our model's performance to a baseline RSA model (i.e. vanilla RSA) that only considers the priors of possible words. Our model was significantly better than the baseline model (χ^2 (1) = 67.17, p <.01) in predicting participants' interpretation of the scalar terms.

Discussion: When a speaker says, 'The student is intelligent', two kinds of enrichment are possible: the speaker is ruling out that the student is brilliant, or she is encouraging the hearer to enrich the meaning of the adjective to mean something stronger, like *brilliant*. The latter is easier to imagine for 'intelligent' than for 'some'. RSA-LU takes into account that both kinds of enrichment are possible, but vary across scalar terms. The approach predicts that these possibilities influence judgements in van Tiel et al.'s inference task. Our results show that the SD effect is not only due to factors that bear on standard scalar inference (Distinctness of Alternatives), but also to factors relating to local enrichment. We note that Distinctness remains a separate factor. We also have analyses to show that Distinctness is not a significant factor in *so* and *ie* ratings themselves. Based on these results, we argue that not all scalar enrichments (whether global or local) are derived with respect to Alternatives.


John says:

This student is intelligent.

Would you conclude from this that, according to John, she is not brilliant?

☐ Yes ☐ No

Fig. 1 Sample item used in van Tiel et al.

Sentence	unnatural---------- natural
The student is brilliant so not intelligent.	◦ 1 ◦ 2 ◦ 3 ◦ 4 ◦ 5 ◦ 6 ◦ 7

Fig. 2 Sample item of Exp. 1

Y so not X	The student is *brilliant* so not *intelligent*.
	The water is *hot* so not *warm*.
X, i.e. Y	The student is *intelligent*, i.e. *brilliant*.
	The water is *warm*, i.e. *hot*.

Table 1 Example sentences in Exp. 1-2

Sentence	unnatural---------- natural
The student is intelligent, i.e. brilliant.	◦ 1 ◦ 2 ◦ 3 ◦ 4 ◦ 5 ◦ 6 ◦ 7

Fig. 3 Sample item of Exp. 2

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