Rational ERPs: The comprehension of over-specification in visually-situated contexts

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According to Grice's maxim of Quantity [1,2], referential redundancy may engage addressees in unintended pragmatic inferencing [3], as they expect speakers' utterances to convey the minimal amount of information that is necessary for conversational purposes. Yet, speakers frequently use redundant information to specify a referent in a visual domain [4-7]. For example, while 'blue' is required to identify the target (ball) in panels A and B of Figure 1, it is unnecessary but likely to be mentioned in panels C and D. It is, however, unclear whether such over-specifications (OS) hinder comprehension [8,9] or not [10,11]. In previous ERP studies, OS were associated both with an increased [8] and with an attenuated [11] N400 compared to minimally-specified expressions (MS). Both findings are subject to alternative explanations, however. In [8], visual displays were highly simplified, which may have emphasised the redundancy in the expression, while in [11] redundancy was confounded with the reduction of uncertainty about the target referent (referential entropy): in OS (but not in MS), the redundant adjective identified exactly one object, thereby immediately reducing referential entropy to zero [12,13]. In the current study, we manipulated *Specificity* and *Entropy reduction* as orthogonal factors, to examine their independent influence on the comprehension of over-specifications, and whether they interact.

In an ERP experiment, we presented participants (N=32) with either of four versions of a visual display (cf. Fig.1) paired with a single audio instruction like 'Find the blue ball' in German. In a 2x2 experimental design, we fully crossed Specificity (MS vs. OS) and Entropy reduction rate (high reduction, HR vs. low reduction, LR). That is, when a shape competitor was present (cf. the green ball in Fig.1 A and B) the expression was MS, while it was OS when the target was singleton (Fig. 1 C and D). Moreover, the adjective ('blue') reduced entropy at a higher (1.58 bits in Fig.1 A and C) or lower (0.58 bits in Fig.1 B and D) rate, leaving a smaller (1 bit) or larger (2

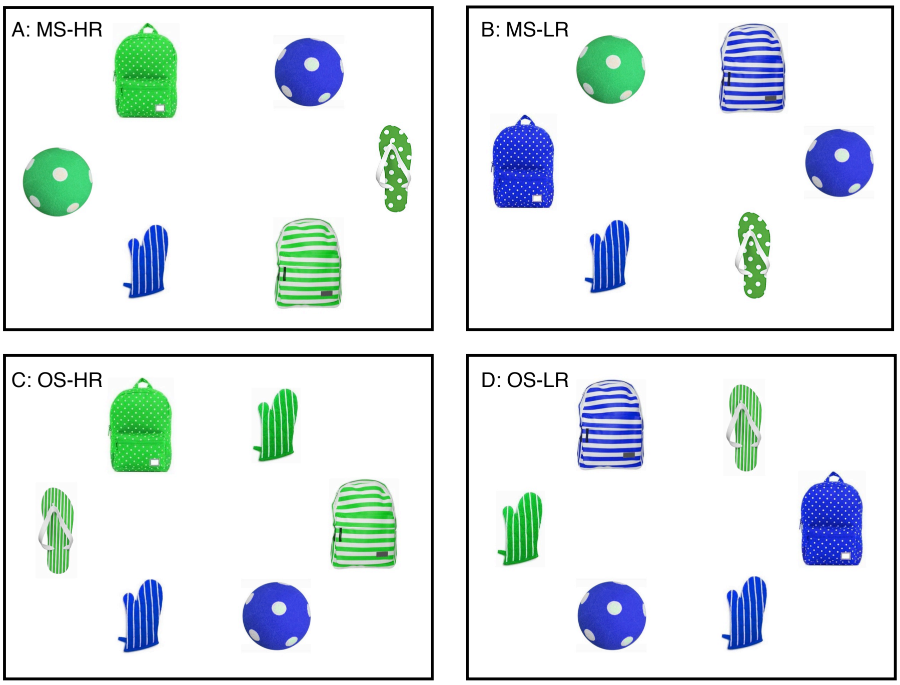

Figure 1. Sample visual stimuli for the four conditions paired with the audio instruction "*Find the blue ball*". In panels A and B the adjective was necessary to identify the target referent, and the expression was therefore minimally-specified (MS). In panels C and D the adjective was redundant rendering the expression over-specified (OS). Additionally, the adjective reduced the amount of referential entropy (ambiguity) at a higher rate (high reduction, HR) in panels A and C, and at a lower rate (low reduction, LR) in panels B and D.

bits) amount of entropy, respectively, to be eliminated at the noun. Participants were allowed to freely scan the scene for 2.5 sec, after which a cross appeared in the centre of the screen that they had to fixate for the duration of the instruction. After 500 ms of wrap-up time, participants were prompted to indicate on which side of the screen (left or right) the target object appeared by making a button press. Based on previous findings, we expected Specificity to modulate the N400, with OS amplitude being higher if redundancy hindered comprehension [8], or lower if it facilitated it [11]. The rate of Entropy reduction was also expected to influence comprehension (possibly resulting in an additive effect), with higher reduction being more beneficial.

We found that OS led to faster response times (p<.01) and higher accuracy (p<.01), while HR also resulted in faster responses (p<.01). Regarding the ERPs, in the adjective region none of the comparisons reached significance (p>.05). In the noun region, we observed two main effects: a biphasic N400-P600 effect for OS vs. MS (Fig.2), and an N400 effect for LR vs. HR (Fig.2). In line with previous research [3,8], these results indicate that when the context supports both a contrastive and a non-contrastive reading, listeners are able to draw pragmatic inferences online in order to interpret the pre-nominal adjective, and based on this interpretation predict the upcoming noun. When their prediction fails (OS), noun retrieval is hindered (larger N400), and listeners need to revise their representation of what is being communicated (larger P600) [14]. Nonetheless, both response speed and accuracy showed an advantage for OS vs. MS, replicating [10] and revealing a dissociation between behavioural and neurophysiological measures. That is, while OS misled participants' expectations regarding the linguistic input, visual search for the target referent and therefore performance in the task were facilitated by the redundancy of the encoding. Lastly, while the contribution of the adjective to the reduction of referential entropy was not related to Specificity, it influenced processing of the following word: As indicated by the attenuated N400 for HR vs. LR, lexical retrieval of the noun was easier when the preceding adjective (be it necessary or redundant) restricted the set of possible referents to a higher degree.

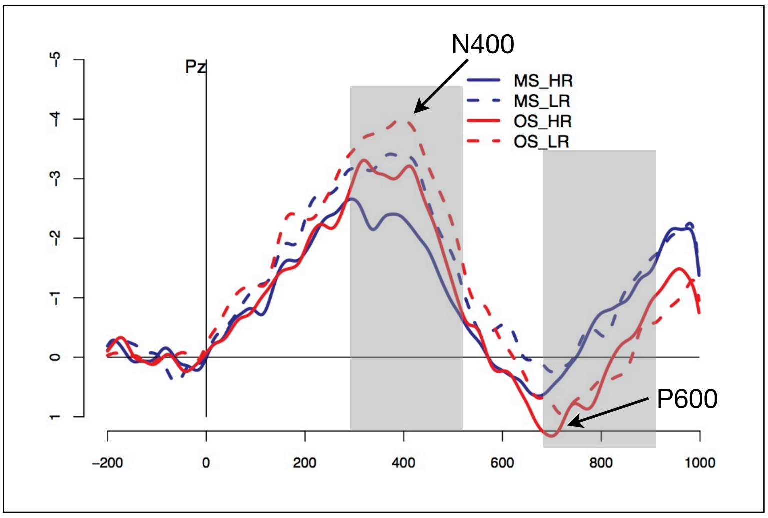

Figure 2. ERP waveforms at electrode Pz time-locked to the onset of the noun ("*ball*"). Negative amplitude is plotted upward. The OS conditions (red lines) a more negative amplitude compared to the MS conditions (blue lines) in the N400 time window (grey-shaded area), and more positive in the P600 time window (green-shaded area). LR (dashed lines) also resulted in a higher N400 compared to HR (solid lines) in the N400 time window.

References. [1] Grice. 1975. In Cole & Morgan, *Syntax & Semantics 3*. [2] Grice. 1989. *Studies in the Way of Words.* [3] Sedivy et al. 1999. *Cognition* [4] Deutsch & Pechmann. 1982. *Cognition* [5] Koolen et al. 2011. *J Pragmat.* [6] Tarenskeen et al. 2015. *Front Psychol.* [7] Rubio-Fernandez. 2016. *Front Psychol.* [8] Engelhard et al. 2011. *Brain Cogn.* [9] Davies & Katsos (2013) *J Pragmat* [10] Arts et al. 2011. *J Pragmat.* [11] Tourtouri et al. 2015. *Proc Annu Conf Cogn Sci Soc* [12] Hale. 2003. *J Psycholinguist Res.* [13] Hale. 2006. *Cognitive Sci.* [14] Brouwer et al. 2012. *Brain Res*