

## The enduring effects of default focus in *let alone* ellipsis: Evidence from pupillometry

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**Introduction.** In contrastive clausal ellipsis, the remnant is placed in focal contrast with its correlate (Winkler 2018 for review). A particularly intriguing case is focus-sensitive coordination (FSC), like *John can't run a mile, let alone a marathon* (Fillmore et al., 1988). Harris (2016) analyzed the material following the coordinator (*let alone*) as a focus-marked remnant to clausal ellipsis (e.g., *let alone* [<sub>FOC</sub> *a marathon*]<sub>1</sub> ~~*John run t<sub>1</sub>*~~); see also Toosarvandani (2010). To interpret the remnant (*a marathon*), the processor locates the contrasting correlate phrase (*a mile*) in the prior clause from among other same-category competitors using multiple, possibly competing, preferences. Experimental and corpus research finds that the nearest possible correlate is vastly preferred (*Locality Bias*; Harris & Carlson, 2015). Similar biases have been observed for other clausal ellipsis structures, like sluicing (Frazier & Clifton, 1998), and replacives (Carlson, 2013). However, semantic and prosodic parallelism have also been shown to interact with Locality (Harris & Carlson 2015), suggesting a general, but violable, preference for pairing a remnant with a correlate that is maximally similar along multiple dimensions.

The tradeoff between Locality and prosodic marking in *let alone ellipsis* was explored by Harris & Carlson (2018). In an auditory corpus of radio interviews, every correlate and remnant in an FSC bore pitch accent, usually an L+H\* contrastive accent (79% on correlates and 73% on remnants). The corpus revealed a strong Locality bias: 88% of remnants contrasted with the most local correlate. In auditory naturalness ratings studies, they observed a penalty for non-local (subject) correlates over local (object) correlates. Although pitch accent on subject correlates reduced the penalty for violating Locality, it did not eliminate it.

To explain why the preferred correlate did not simply match the location of pitch accent, they proposed that correlate selection was subject to *Enduring Focus*: “Locations that typically bear default focus continue to provide potential locations for focus, regardless of overt markers of focus”, a constraint that might be particularly strong in ellipsis processing. An unaccented Local object noun would therefore continue to provide a tempting correlate, despite lacking overt pitch accent. However, it is unclear whether the impact of default focus is limited to post-sentence interpretation or is active in real time, as well. This study employs pupillometry, an implicit measure of cognitive load or effort, to assess whether default focus locations tempt the processor during online auditory sentence processing.

**Method and design.** Pupillometry measures minute changes in pupil diameter associated with a stimulus, typically peaking between 700 and 1200ms after stimulus offset (Laeng, et al., 2012). Increased pupil dilation is associated with greater cognitive load, and crucially, does not appear to be under strategic control. Pupil size has recently been explored as a dynamic measure of language comprehension (Schmidtke, 2017 for review), finding increased pupil size for syntactically complex sentences (Engelhardt et al., 2010), metrical violations (Scheepers et al., 2013), and inadequate or misleading pitch accent (Zellin et al., 2011; Breiss et al., 2021).

20 quartets crossed Pitch Accent location (Object/Subject PA) and Remnant contrast (Subject/Object Remnant), operationalized as animate and inanimate nouns, respectively; Table 1. Sentence stimuli were produced with contrastive L+H\* accent on the correlate and the remnant, an L-H% boundary tone before *let alone* and after the remnant, as is typically found in corpora. Two seconds of acoustically identical material was spliced into the recording after the remnant following 100ms of computer-generated silence that served as the baseline for measuring pupil change. In half of the items, the Subject Remnant was locally plausible as an object to the verb (*Jonah sent Daniel*); the other half were not (*#The patient ate her family*). Although Harris & Carlson (2018) found no effects of local plausibility in ratings, implausible nouns have been shown to produce N400 online penalties in gapping constructions (Kaan et al., 2004).

**Results.** 48 native English speakers with self-reported normal hearing listened to sentences over high-quality headphones. Pupil size was recorded with a high-speed eye-tracker for 2 seconds after the offset of the remnant on acoustically identical material within a quartet. Data cleaning followed the recommendations of Mathôt et al. (2018). After removing blinks and other artefacts, and interpolating missing points with spline-smoothing, the data was down-sampled to 10Hz to reduce autocorrelation. The data were then normalized by trial to reflect *change in pupil size over time* by subtracting the mean pupil size obtained from the 100ms baseline, rather than absolute pupil size. Time-series analyses were conducted to capture changes in pupillary excursion. The best-fitting model was a generalized additive mixed effects model (van Rij et al., 2019) with subject-as-object plausibility as a 3-way interactive factor.

As expected, the baseline condition with both default object accent and a local correlate (Object PA-Object Rem) elicited the lowest pupil response overall; see the leftmost condition in Fig 1A for illustration. Pupil response was greater for subject (vs. object) accent,  $t = 7.74, p < .001$ , as well as for subject (vs. object) remnants,  $t = 7.78, p < .001$ . The predicted interaction was observed for which pitch accent had little to no effect on pupil size for subject remnants in comparison to the large effect of pitch accent on object remnants,  $t = -7.21, p < .001$ . This interaction was further moderated by local plausibility,  $t = 1.97, p < .05$ , shown in Fig 1B. In emmeans, a penalty for subject remnants was observed when the subject was plausible as an object,  $t = 2.52, p < .05$ , but not when it was implausible as an object,  $t = 1.09$ . In both cases, subject remnants appeared to be more taxing than the baseline.

**Conclusion.** The findings largely support Harris & Carlson’s interaction between Locality and Enduring Focus in online auditory comprehension. In *let alone* ellipsis, subject remnants elicited a processing cost and failed to show a mismatch penalty when the object correlate bore contrastive accent. The study also presents a novel use of pupillometry to explore the real-time influence of prosodic information to resolve ellipsis structures in sentence comprehension.

**Table 1. Sample materials.** Accent (Object/Subject) x Remnant contrast (Object/Subject).

	Subject Plausible as Object		Subject Implausible as Object	
Pitch Accent	<i>Object Accent</i>	<i>Subject Accent</i>	<i>Subject Accent</i>	<i>Subject Accent</i>
Host clause	Jonah wouldn't send a POSTCARD, let alone	JONAH wouldn't send a postcard, let alone	The patient didn't eat DINNER, let alone	The PATIENT didn't eat dinner, let alone
Object Remnant	a LETTER	a LETTER	DESSERT	DESSERT,
Subject Remnant	DANIEL	DANIEL	her FAMILY	her FAMILY
Critical region	[100ms silent baseline] during visiting hours at the local hospital.		[100ms silent baseline] and the parents started to get a little worried.	

**Figure 1. Let alone ellipsis.** (A) Mean pupil response. (B) Pupillary response for 2000ms.

