Phrase Superiority in RSVP and RPVP

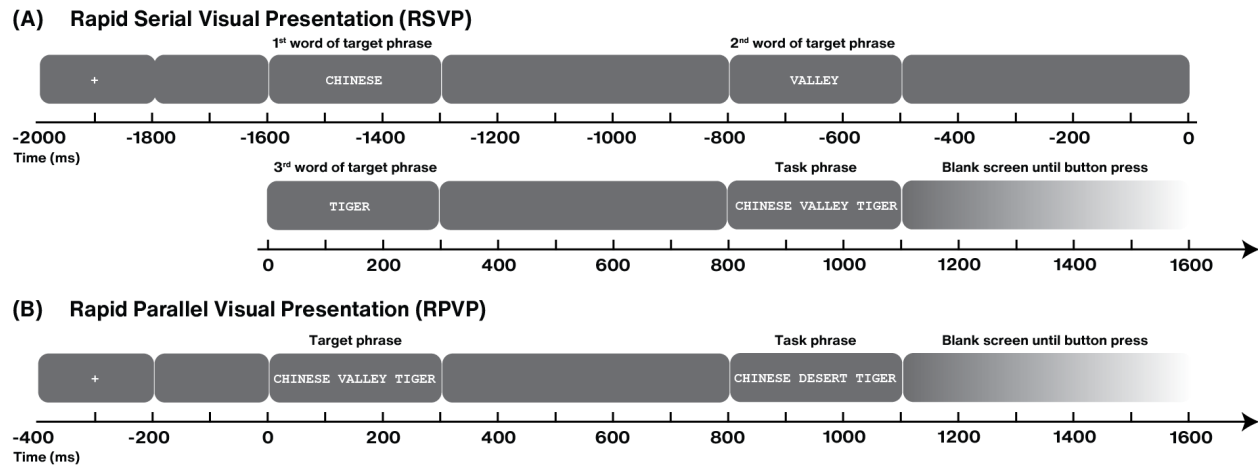*Simone M. Krogh & Liina Pylkkänen, New York University*

Letters are more easily recognized within words, just like words are more easily recognized within sentences (Cattell, 1886). There has been a recent surge in efforts to map out *why* structured stimuli exhibit a processing advantage compared to unstructured stimuli, focusing especially on the Sentence Superiority Effect (SSE) obtained using Rapid Parallel Visual Presentation (RPVP), in which an entire stimulus is flashed all-at-once (Snell & Grainger, 2017). Here, we report results from an online behavioral study (n = 25) examining whether three-word phrases (CHINESE VALLEY TIGER) exhibit facilitated processing—a Phrase Superiority Effect (PSE)—compared to phrases with ungrammatical modifier ordering (VALLEY CHINESE TIGER). This is a precursor to a larger study using magnetoencephalography to track animacy in low-probability phrases.

The SSE might be driven by many things: Sentences have well-formed syntax and semantics, often a recognizable visual envelope, and express events and states as full propositions, typically using existing conceptual combinations. Of these factors, our all caps, low-probability phrasal stimuli only have well-formed syntax and semantics, thus allowing us to test if pure structural coherence is sufficient to elicit a processing advantage. In contrast, the relatively subtle structural violations of our ungrammatical stimuli could also go unnoticed by the between-words semantic compatibility present in both of our conditions. Relatedly, we asked whether facilitated processing of structured stimuli is contingent on presentation mode by comparing RPVP with Rapid Serial Visual Presentation (RSVP) which delivers stimuli word-by-word. Each trial stimulus was followed by a briefly flashed task stimulus that either matched or differed from the target stimulus by one word (Figure 1). Notably, grammatical and ungrammatical phrases were randomly followed by either a matching or a mismatching task stimulus, making the task identical across experimental conditions. The task has been used in RPVP to elicit instances of the Sentence Superiority Effect (e.g., Pegado et al., 2021) but not previously in RSVP. Since the visual contours of trial and task stimuli are identical in RPVP, processing benefitting from perceptual matching should reveal faster and more accurate performance in RPVP than in RSVP. In contrast, it is possible that the prolonged stimulus delivery in RSVP allows for enhanced consolidation of the trial stimulus, potentially manifesting as faster and more accurate performance than in RPVP.

Our stimuli (Table 1) were in English and crossed composition (grammatical, ungrammatical), concept type (animal, location, representation of animal), and presentation mode (RSVP, RPVP). We will not engage with the concept type-manipulation here. Phrases consisted of three words: A geographical (e.g., CHINESE) or constitutive material (e.g., MARBLE) modifier followed by an animal (e.g., TIGER) and a location (e.g., VALLEY) in either order (animal-location, location-animal). All phrases obeyed real world constraints, excluding improbable combinations like SWEDISH VALLEY TIGER. Word string conditions with less opportunity for composition were created by reversing the order of the two modifiers (grammatical: CHINESE VALLEY TIGER → ungrammatical: VALLEY CHINESE TIGER). Log-transformed reaction times were analyzed using a linear mixed-effects regression model (fixed effects: presentation mode, composition, concept type, task trial-type; random effects: by-participant and by-item intercepts). Accuracies were analyzed using a generalized linear mixed-effects regression model with the same structure of fixed effects but with just a by-participant intercept. All *p* values were generated via likelihood ratio tests and pairwise comparisons corrected using a Tukey adjustment.

Our results revealed clear instances of a PSE as a main effect of composition, with grammatical phrases eliciting shorter reaction times and higher accuracies than ungrammatical phrases (Figure 2). Since our stimuli differed solely in modifier order, this finding underscores the language system's sensitivity to structural configurations, even for non-frequent meanings. Interestingly, we observed asymmetrical effects of presentation modes, with faster reaction times for RPVP trials but higher accuracies for RSVP trials. The discrepancies in visual contours between trial and task stimuli in RSVP may require participants to "realign" the individually presented trial stimuli, resulting in slower reaction times but higher accuracies due to deeper processing than in RPVP. Crucially, however, the lack of an interaction effect between composition and presentation mode supports the viability of the matching task across RSVP and RPVP.

Figure 1. Trial structures for (**A**) RSVP with a match trial and (**B**) RPVP trials with a mismatch trial.

(A)   Rapid Serial Visual Presentation (RSVP)

	1st word of target phrase		2nd word of target phrase
+	CHINESE		VALLEY

-2000   -1800   -1600   -1400   -1200   -1000   -800   -600   -400   -200   0
Time (ms)

3rd word of target phrase		Task phrase	Blank screen until button press
TIGER		CHINESE VALLEY TIGER	

0   200   400   600   800   1000   1200   1400   1600

(B)   Rapid Parallel Visual Presentation (RPVP)

	Target phrase		Task phrase	Blank screen until button press
+	CHINESE VALLEY TIGER		CHINESE DESERT TIGER	

-400   -200   0   200   400   600   800   1000   1200   1400   1600
Time (ms)

Table 1. Experimental design. All trials were presented once in RSVP and once in RPVP.

Composition	Concept type	Example	No. of trials
GRAMMATICAL	ANIMAL	CHINESE VALLEY TIGER	50
GRAMMATICAL	LOCATION	CHINESE TIGER VALLEY	50
GRAMMATICAL	REPRESENTATION	MARBLE VALLEY TIGER	50
UNGRAMMATICAL	ANIMAL	VALLEY CHINESE TIGER	50
UNGRAMMATICAL	LOCATION	TIGER CHINESE VALLEY	50
UNGRAMMATICAL	REPRESENTATION	VALLEY MARBLE TIGER	50

Figure 2. Plots showing the main effects of composition (grammatical, ungrammatical), presentation mode (RSVP, RPVP), and task trial-type (match, mismatch) on reaction times and accuracies. Pairwise comparisons reveal PSEs for match trials only (solid lines). Across both match and mismatch trials, RPVP trials have faster reaction times and RSVP trials higher accuracies (dashed lines). Match trials are always faster and more accurate than mismatch trials (all $p < 0.001$, not depicted). * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.