Language and awareness are inextricably linked. We can only talk about things we are aware of, and it would seem paradoxical to say that we understood a sentence if we were not consciously aware of what it meant. Despite this, the precise role played by conscious awareness in understanding complex language is unclear. While there has been a long history of investigating whether consciousness is critical for extracting the shape, sound or meanings of individual words, that work has only rarely examined whether or how consciousness influences the processes by which the meanings of words are combined [ref Draine greenwald, ref Marcel].

Many of the most prominent theories of consciousness have assumed that, in fact, combinatorial semantics demands awareness. For example, combining the meanings of the words *the cats that Jim likes* would be difficult under so-called global workspace theories because a) sentence comprehension requires working memory (e.g., to determine that *cats* is the grammatical object of *likes*), and b) the processes involved in understanding a sentence are typically assumed to require access to a quite detailed store of global world knowledge (e.g., to determine that precise meaning of *likes* in this case, as compared to *the girl that Jim likes* REF Hobbs). Under global workspace theories, the efficacy of both working memory and global access are greatly diminished without awareness.

Given this, it is both interesting and surprising that a number of recent experiments have reported that combinatorial linguistic operations might in fact operate on words that are presented subliminally. For instance, ERP work by van Gaal et al (2013) and behavioral work by Armstrong and Dienes (2013) has suggested that semantic priming caused by subliminally presented adjectives and nouns is modulated by the presence of a subliminal modifier (e.g., *very good* and *not good* have different priming effects). These results have typically been interpreted quite cautiously. For instance, van Gaal and colleagues suggest that they might reflect a rather basic and reduced form of combinatorics semantics.[[1]](#footnote-1)

Contra to this conservative interpretation, a very prominent set of recent experiments on unconscious sentence processing has been used to argue that there is essentially no limit to the mental operations that can be conducted without conscious awareness, including combinatorial semantics. According to the ‘Yes It Can’ principle, “unconscious processes [are able to] perform the same fundamental, high-level functions that conscious processes can perform.” [ref Hassin, quote in abstract] Evidence for these claims was provided by Sklar et al (2012), through experiments using continuous flash suppression (CFS). CFS is a form of binocular rivalry where a monocularly-presented stimulus can be masked from awareness for multiple seconds by presenting a repeatedly-changing and high-contrast stimulus to the other eye. Previous work has shown that the time taken for a stimulus to emerge from suppression is affected by its lower-level visual properties (e.g., larger, noisier or less familiar stimuli break through suppression faster). Excitingly, Sklar et al found that the time taken for a masked sentence to break through suppression was also affected by its meaning.

In particular, Sklar and colleagues found that masked complex sentences with unusual meanings were faster to break through suppression than control sentences. This result held for nonsensical sentences compared to controls (*I ironed the coffee* vs. *I drank coffee*) and also for phrases that were more versus less emotionally valenced. For instance, phrases like *electric chair* – in which each word is unvalenced but the phrase itself is valenced -- broke through suppression faster than phrases such as *dining table*.

Sklar et al’s results – alongside their additional demonstrations that arithmetic expressions can be processed without awareness – provide an important and interesting challenge to current theories of how conscious awareness and high-level cognition inter-relate. How can this challenge be met? One possibility is that our theories of consciousness need adjustment. For instance, the Yes It Can principle may be correct, and previous work might have over-estimated the degree to which awareness is actually necessary for high-level cognitive abilities such as language. Alternately, it could be that our assumptions about linguistic processing, and in particular the roles of world knowledge and working memory, need to be adjusted. Indeed, many contemporary linguistic theories assume that a word’s lexical entry not only specifies its meaning, but also the procedures by which it should combine with other words. It is therefore plausible that semantic combination could proceed through lexical access alone, without the need for any high-level or top-down guidance.

However, before accepting the need for large changes to theories of consciousness or language, it is important to know that Sklar et al’s results are fully robust. In fact, there are reasons to be concerned that they might not be. First, lower-level visual differences across conditions in Sklar’s et al’s stimuli may have been confounded with their semantic combination manipulation. For instance, their Experiments 1 and 2 compared semantic violations (*I ironed the coffee*) to control sentences matched by verb and object (*I ironed* *the* *clothes* and *I made coffee*). This approach controls for lexical identity across the sentences, but it does not control for participants’ experience with the co-occurrences of each word (e.g., *coffee* and *ironed* are rarely found in the same sentence). Low-level co-occurrence statistics are stored and tracked by readers, and variation in these statistics would make the low-probability sentences visually “surprising”, potentially causing them to break suppression faster.

In addition to concerns about Sklar et al’s experimental controls, their results also run counter to other findings about the effect of CFS on semantic access for single words. For instance, Kang et al REF found no evidence that the meanings of individual words were accessed under continuous flash suppression (although see REF for a valid critique of their EEG method). Perhaps more surprisingly, Yang and Yeh REF did find evidence that the meanings of individual words were accessed under suppression. However in their study, which used a similar “breaking suppression” method, emotionally negative words such as *angry* were in fact slower to break suppression than neutral words, which is the opposite direction to the effect found by Sklar.[[2]](#footnote-2)

Given the potential theoretical importance of Sklar et al’s results, but also the concerns about their robustness, we decided to conduct a series of partial replications and extensions of their experiments. We label these replications as “partial” because Sklar et al’s experiments were conducted in Hebrew, while ours (with the exception of Experiment 2c) were all conducted in English. In Experiment 1 we conduct a replication of the finding that anomalous phrases (*I ironed the coffee*) break suppression faster than neutral phrases (*I ironed the clothes*), using English translations of Sklar’s et al’s original sentences as well as novel sentences that better control for low-level visual properties. In Experiment 2a, we conduct a replication of the finding that emotionally valenced phrases (*electric chair*) break suppression faster, again using both original stimuli and novel stimuli designed to control for low-level factors.

To preview, across our experiments we never find evidence that participants process the combinatorial semantics of suppressed sentences. We do find that the time taken for a sentence to break suppression is influenced by certain lower-level visual factors, such as the participant’s familiarity with the writing system (English/Hebrew, see Jiang et al 07 REF) or the luminance contrast between the sentence and its background. But we do not find evidence to support the hypothesis that combinatorial semantic processing can occur without awareness. Indeed, a Bayesian analysis suggests that our data is most consistent with the hypothesis that consciousness is a requirement for semantic combination.

**Experiment 1**

Experiment 1a details a replication of Sklar et al’s Experiment 1, using English versions of their stimuli. That experiment tested whether anomalous sentences (*John ironed the coffee*) break suppression faster than neutral sentences. Experiment 1b describes an extension of that experiment, which attempted to better-control for lexical co-occurrence statistics by contrasting neutral sentences (*John read the book*) that, when reversed, were anomalous (*the book read John*).

Although we report Experiments 1a and 1b separately, the data were collected in the same testing session. Since the parameters of the experiments were identical, participants completed them in one single task.

**Experiment 1a**

**Method**

**Participants**

Fifty-three students (39 female, mean age 21.8 years) from the University of Edinburgh community. Each received payment for their time. All identified English as their native language from birth and had normal or corrected vision with no colour blindness.

**Apparatus**

Stimuli were presented on a 19" CRT monitor, connected to a computer running PsychoPy2 software. A chin rest and mirror stereoscope were positioned :distance: from the monitor, with a vertical divider splitting the display in half so that subjects saw only the left hand side of the screen with their left eye and only the right hand side with their right. Participant responses were given via the cursor keys on a standard keyboard.

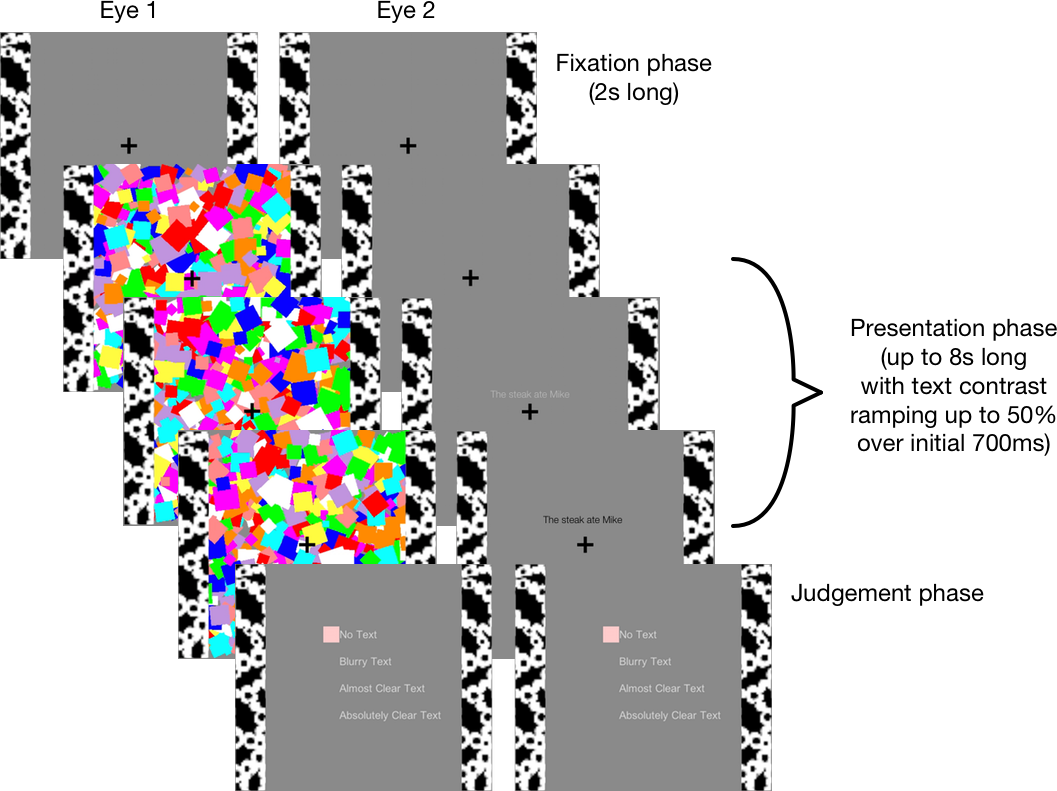
**Procedure**

Each trial consisted of three phases. In the fixation phase, a cross was binocularly presented at the center of each eye's visual field. After 2 seconds, the presentation phase showed one eye a lexical stimulus and the other eye a visual mask (with a fixation cross super-imposed on both). Presentation side was determined randomly for each trial. The lexical stimulus consisted of a sentence either above or below the fixation cross, ramping up from 0% to 50% contrast over 700ms. The position of the text relative to the cross was determined randomly for each trial. The visual mask consisted of a field of squares which randomly changed in size, colour, contrast, rotation and position at a rate of 60Hz. Stimuli were presented in randomised order.

Participants were instructed to focus on the fixation cross with both eyes open, without blinking or looking around, and quickly press the “up” cursor key if they detected text above the cross, or the “down” cursor key if they detected text below the cross. If the participant did not respond within 8s, the trial timed out. This time-out was not included in Sklar et al.’s original method, but we did not think it was likely to greatly affect our results, as average by-condition reaction times in their experiments were typically less than one second. As such, reaction times as long as 8s would be considered outliers.

After participants made their judgements, they also reported their subjective experience of the trial. Using a modified version of the perceptual rating scale (REF), they rated the clarity with which they had experienced the lexical stimulus, choosing from the levels 'No Text', 'Blurry Text', 'Almost Clear Text' and 'Absolutely Clear Text'. Upon making a choice, the next trial would begin.

Before beginning the experiment, participants completed five training trials to ensure that the stereoscope was properly calibrated and that they understood the task. To counteract fatigue, participants were given the opportunity to pause after every 75 trials.



**Figure 1.** Schematic of the experimental procedure.

**Materials**

Lexical stimuli were English translations of the Hebrew expressions used in Sklar et al’s Experiments 1 and 3 . These consisted of 34 critical Violation sentences, in which an animate actor performed an implausible action on an object (e.g. I ironed the coffee); 68 Control sentences, in which the action or object from the Violation condition was used in a sensible way (e.g. I made the coffee, I ironed the clothes); and 34 semantically felicitous Filler sentences (e.g. I washed the cup). A full list of stimuli is presented in the appendix.

**Analyses**

Sklar et al used a fairly complex set of criteria for excluding participants and trials from analysis. We followed these criteria in the following order. First, subjects were excluded if their accuracy was below 90%. Second, subjects were excluded if their mean RT was greater than 3 standard deviations away from the grand mean of all subjects. Third, trials were excluded if they were answered incorrectly or timed out. Fourth, trials were excluded for each participant if their RT was greater than 3 standard deviations away from the participant’s grand mean. Fifth, trials were excluded for each condition if their RT was greater than 3 standard deviations from the condition’s grand mean. Finally, trials were excluded if their RT was less than 200ms.

We then analyzed the resulting data in two ways. First, we followed Sklar in using paired *t*-tests to compare participants RT on Violation and Control sentences. Second, we used linear mixed effects models to test a similar comparison. In lme format (ref) our model had the structure RT ~ Condition + (1+Condition|Subject) + (1|Item); mixed effects models have the advantage of accounting well for unbalanced data, which was true here as there were twice as many Control sentences as Violation sentences. To generate *p* values for these mixed effects models, we approximated the *t* distribution with the *z* distribution.

Visual inspection of the RTs suggested that they had considerable positive skew. We therefore analyzed both raw RTs (following Sklar et al) and log-transformed RTs (which reduced the skew).

**Results**

When the raw RT data was analysed using a paired *t*-test, we found a marginal effect of sentence type (STAT). However, as can be seen in Figure 2, this effect was in the opposite direction to that found by Sklar et al. In the original study, Violation sentences were faster to break suppression than Controls, but we found that Violation sentences were marginally *slower* to break suppression. We thus failed to replicate the first key finding of Sklar et al. (ref). Our subsequent analyses confirmed this failure to replicate. When log-transformed reaction times were analyzed in the same way, we no longer found even a marginal effect of sentence type (STAT). When reaction times were analyzed using mixed effects models, we found no reliable effect of sentence type; this held for both raw reaction times (STAT) and log-transformed reaction times (STAT).



**Figure 2.** Mean reaction times in Experiments 1a and 1b.

**Discussion**

Experiment 1a failed to replicate, in English, Sklar et al’s finding that semantically anomalous Hebrew sentences break suppression faster than neutral sentences. This could be due to many reasons. One potential low-level explanation is differences in visual co-occurrence statistics between English and Hebrew. For instance, English lexical co-occurrence statistics may have worked against any semantic effect. Experiment 1b contrasted sentences that were better matched.

**Experiment 1b**

Experiment 1b used the same participants, procedure, and analysis. The sole difference was in the materials, which consisted of 150 plausible sentences (where an animate actor performed a plausible action, e.g. John read the book), and 150 implausible sentences (which reversed the order of actor and patient, e.g. The book read John).

**Results**

Just as in Experiment 1a, we found no evidence for unconscious semantic combination in Experiment 1b. Mean reaction time is plotted in Figure 2. When the raw RT data was analysed using a paired *t*-test, we found no effect of sentence type: the sentence’s meaning did not influence reaction times (STAT). Our subsequent analyses confirmed this. There was no effect of sentence type for log-transformed reaction times analyzed using a *t-*test (STAT), nor for analyses conducted using mixed effects models (raw reaction times:STAT; log-transformed reaction times STAT).

**Experiment 1 Discussion**

In Experiments 1a and 1b, we failed to replicate the previous demonstration that semantic combination can occur without awareness. This held for both English translations of the original stimuli used by Sklar et al REF, and a new, larger set of stimuli that were designed to more-precisely control for low-level perceptual features that, we worried, might have driven the original demonstration.

One reasonable concern about these findings is that our continuous flash suppression manipulation might have been too strong: Perhaps no aspect of the suppressed stimuli could have influenced participants’ responses. We therefore conducted a post-hoc test of this, examining whether longer sentences broke suppression faster. In particular, we used a mixed effects model to regress reaction time against the length of each stimulus in characters (centered and standardized), collapsing across the two experiments. Counter our concern, we did indeed find that longer sentences were faster to break suppression (STAT), suggesting that suppression time can be influenced by visual, but not semantic, aspects of the stimulus.

Another reasonable concern is that this experimental paradigm – semantically unusual versus neutral sentences – might not be the strongest test of the Yes It Can principle. In their Experiments 4 and 5 [check numbering], Sklar et al found that phrases with negatively-valenced meanings (EXAMPLE) broke suppression faster than neutral phrases (EXAMPLE), a finding that echoes demonstrations that fearful faces break suppression faster than neutral faces (Yang zald blake). Given the potential support of this finding from the face processing literature, we attempted to replicate it in Experiment 2.

**Experiment 2**

Experiment 2a details a replication of Sklar et al’s Experiment X, using English versions of their stimuli. Experiment 2b describes an extension that again used reversible sentences to properly control for low-level perceptual factors (*EXAMPLE)*.

Experiment 2c is somewhat different: we wondered whether Sklar et al’s previous results might have been due to low-level visual differences in their Hebrew stimuli, and so conducted a replication in which English speakers read phrases in Hebrew script. In addition, we varied whether these stimuli were presented at a maximum of 50% contrast (replicating Sklar et al) or at a maximum of 80% contrast, in order to confirm our participants’ sensitivity to the visual properties of the suppressed image.

**Experiment 2a**

**Methods**

**Participants**

61 students (47 female, mean age 21.6 years) from the University of Edinburgh community. Each received payment for their time. All identified English as their native language from birth and had normal or corrected vision with no colour blindness.

**Procedure**

The procedure was the same as Experiment 1, except for a modification of the perceptual rating scale (REF), with participants’ experiences being rated as 'No Text', 'Blurry Text', 'Almost Clear Text' and 'Absolutely Clear Text'.

**Materials**

A total of 50 English phrases, 24 with neutral emotional affectivity and 26 positive. 34 of these were taken from the English translations of Sklar et al's 45 Hebrew stimuli used in their experiments 4a, 4b and 5. Those stimuli judged to be too specific to Israeli culture or composed of more than two words in translation (e.g. "a stake in the eye") were replaced with suitable alternatives.

Emotional affectivity ratings were generated using Amazon Mechanical Turk (AMT). A total of 649 English-speaking workers (504 USA, 89 India, 33 UK, 15 Canada, 8 other) were paid to rate up to 15 stimuli, using an affective scale ranging from -5 to 5. They were instructed to give negative scores to negative stimuli, positive scores to positive stimuli and a score of zero to neutral stimuli. On average, each stimulus received 50 ratings. A paired sample t-test performed on the mean ratings of the stimuli confirmed a significant difference (t = 14.583, df = 25, p-value = 9.906e-14) between those we had labeled negative before, and those we had labeled as neutral. In common with Sklar et al, the mean ratings for the constituent words of the negative and neutral phrases ranged were neutral, with an overall mean rating of 0.27.

**Analyses**

We again followed Sklar et al’s exclusion criteria. First, subjects were excluded if their accuracy was below 90%. Second, subjects were excluded if their mean RT was greater than 3 standard deviations away from the grand mean of all subjects. Third, trials were excluded if they were answered incorrectly or timed out. Fourth, trials were excluded for each participant if their RT was greater than 3 standard deviations away from the participant’s grand mean. Finally, trials were excluded if their RT was less than 200ms.

We then analyzed the resulting data in two ways. First, we followed Sklar by conducting a by-items regression of reaction time against valence score. Second, we used linear mixed effects models to test a similar comparison. In lme format (ref) our model had the structure RT ~ ValenceScore + (1+ValenceScore|Subject) + (1|Item). To generate *p* values for these mixed effects models, we approximated the *t* distribution with the *z* distribution.

As before, we analyzed both raw RTs and log-transformed RTs (to reduce skew).

**Results**

Our results were surprisingly similar to Experiment 1a. Again, we found a (very) marginal effect of affective valence on reaction time (see Figure X), but in the opposite direction to that found by Sklar et al. More neutral phrases (marginally) broke suppression faster than negative phrases (STAT). This also held for the log transformed data (STAT). When analyzed using mixed effects models, the results were similar (raw reaction times: STAT, log-transformed reaction times: STAT).

For this experiment, we were also able to calculate bayes factor… = 0.02, which is fairly strong evidence for the null hypothesis. In sum, we failed to find any strong evidence that combinatorial semantics occurs without awareness here.

**Experiment 2b**

Short intro explaining that we control for visual differences by pairing stimuli (so not a regression analysis)

**Method**

**Participants**

**Materials**

28 pairs of negatively and positively affective English sentences, as rated by AMT users. These were created by reversing the agent and patient of sentences, thus polarising their emotional valence (e.g. "The baby hit the brick" and "The brick hit the baby").

A paired sample t-test performed on the mean ratings of the stimuli confirmed a significant difference (t = 9.9493, df = 27, p-value = 1.583e-10) between those in the negative condition and those in the neutral.

**Procedure**

The procedure was the same as Experiment 2a.

**Results**

In this case, our results followed Experiment 1a. Again, we found no effect of affective valence on reaction time once low-level factors were controlled for (see Figure X). This was true for raw data (STAT) and log-transformed data (STAT), and also held under a mixed effects model analyses (raw reaction times: STAT, log-transformed reaction times: STAT).

**Experiment 2c**

**Method**

**Participants**

**Materials**

All 45 of the stimuli from Sklar et al's experiments 4a, 4b and 5 were used, in the original Hebrew.

**Procedure**

The procedure was the same as Experiments 2a and 2b.

**Results**

Finally, our results suggested that low-level visual features of the Hebrew stimuli could not explain Sklar et al’s findings. Hebrew stimuli with lower affective valence scores were no faster to break suppression. This was true for raw data (STAT) and log-transformed data (STAT), and also held under a mixed effects model analysis (raw reaction times: STAT, log-transformed reaction times: STAT).

However, as evidence for the effectiveness of our CFS set-up, we did find that stimuli that were presented in higher-contrast were also able to break suppression faster (STAT).

**Discussion**

Just as in Experiment 1, we found no evidence that combinatorial semantic information is processed without awareness. This was the case for phrases that were highly similar to those used by Sklar et al (Experiment 2a), and for sentences that were better-controlled for differences in visual properties (Experiment 2b). Meanwhile, Experiment 2c provided evidence that Sklar’s initial findings were not due to visual differences between items.

Interestingly, this experiment offered us the opportunity to replicate another controversial continuous flash suppression result, that words in familiar scripts break suppression faster than words in unfamiliar scripts Jiang et al (ref). Indeed, Hebrew phrases (in the 50% contrast condition) broke suppression more slowly than English phrases (Hebrew: NUM, English, NUM, STAT). This result, like participants’ sensitivity to stimulus length in Experiment 1 [FN: A result we replicate here], demonstrates that participants in our continuous flash suppression procedure were sensitive to important low-level differences between stimuli, but were insensitive to higher-level semantic properties.

**General Discussion**

The Yes It Can principle argues that there are essentially no limitations on the mental representations or computations that can occur without awareness, an important contrast to previous theories of unconscious information processing. A key piece of evidence for this idea is the finding that, for Hebrew speakers, semantically unusual or emotionally negative sentences “break through” continuous flash suppression before neutral sentences. Our findings cast doubt on the generalizability of that finding. Across four high-powered studies, we found no good evidence that the semantic content of an English sentence affects the speed with which it breaks through suppression. This held for experiments using translations of Sklar et al’s original Hebrew stimuli, as well as for experiments using larger numbers of better-controlled stimuli.

Why did we fail to find evidence for unconscious semantic processing, given that previous work found evidence for it across four different experiments? One possibility is that our continuous flash suppression apparatus – our stereoscope and visual display parameters – were such as to render subjects insensitive to properties of the suppressed image. We see no reason to give this explanation much credence. The participants in our experiment were sensitive to important lower-level stimulus factors such as a sentence’s length and its script. If participants were also engaging in unconscious semantic processing, our apparatus should have been able to detect it.

Alternately, it could be that certain characteristics of the Hebrew language or script make it easier to process unconsciously. For example, printed Hebrew words are typically shorter than English words. Additionally, Hebrew typically marks a word’s case (subject versus object) using particles rather than linear order (subject before verb). Perhaps the spatial processing necessary to recover linear order is impaired under unconscious conditions? However, both of these explanations imply considerable and arbitrary limitations to unconscious processing (e.g., only short words can be semantically processed, or syntactic case can only be determined through particles rather than position), which would not be expected under the Yes It Can hypothesis.

A final possibility is that the previous results may have resulted from certain statistical properties of that data. For example, effects of semantic priming are typically quite small [FN: at least when conscious strategies are eliminated], and those previous studies used smaller sample sizes (approximately 30 participants per experiment) and smaller numbers of items (e.g., only X items in the violation condition of Experiment 1) than our experiments; this may have reduced their power. In addition, the data gathered here were extremely non-normal, raising the possibility of similar non-normality and high numbers of outliers in previous work. In sum, the relative lack of power, the skewness, and also the studies’ idiosyncratic exclusion criteria (see Analysis section of Experiment 1a), all might have contributed to the significant differences found in Sklar et al (ref).

How can our data be reconciled with other demonstrations that semantic combination occurs without awareness, such as the results of REF, Ref, REF? We note that in most of these studies, the critical dependent variable was a measure of neural activity, and so it is possible that some semantic processing does occur, but does not influence behavior. However, there are also reasons to doubt those conclusions. First, DEHAENE paper – not sure how to say this. Second, REFS fMRI study compared full sentences with strings of non-words, meaning that the stimuli differed in much more than semantic combination. Additionally, JNEURO REF’s demonstration of an early ERP response to syntactic anomalies can be explained as a low-level effect, in particular, early ERP responses like this may actually reflect a mismatch between syntactically-driven predictions about the visual form of upcoming words and unexpected input, rather than reflecting a full syntactic analysis. Finally, the one behavioral demonstration of semantic combination comes from DIENES REF. Their experiment, however, was different from Sklar’s demonstration in that participants were consciously familiarized with all stimuli before starting, so that participants did not have to perform novel semantic combinations. We therefore respectfully suggest that there is currently no strong evidence for unconscious semantic combination.

Our findings, that participants do not seem to process sentences without awareness, are therefore most consistent with more “classical” theories of consciousness, in which complex tasks such as semantic interpretation do require consciousness due to their requirements for global processing and access to working memory.

**Procedure Experiment 3**

**Experiment 3 (syntax)**

The procedure was similar to that of Experiments 1 and 2, with the following changes. The presentation phase lasted for 5.8 seconds and required no participant input. Each stimulus was shown twice - once with the characters jumbled at random and once without. Stimuli were presented in randomised order.

After 5.8 seconds had elapsed, there were two judgement phases where participants first stated whether they had seen English or nonsense text then how clear (if seen at all) that text was using the same perceptual rating scale as in Experiments 1 and 2.

Proceeding to the description phase, a black and white line drawing was presented, along with a bare infinitive verb. Participants were asked to describe the scene in the drawing, using the verb. Responses were recorded using a microphone. After having done so, the next trial would begin.

**\*\* Experiment 3 (syntax)**

Lexical stimuli used in the presentation phase were 30 English sentences and 30 randomly shuffled versions of these, making for 60 trials in total. Ten used a prepositional object (e.g. 'John gave the book to Mary') and ten used a direct object (e.g. 'John gave Mary the book'). A further ten fillers (e.g. 'Bob ran a race') were added. Participants were presented with one of two counterbalanced versions of these, which swapped the PO/DO status of the sentences whilst preserving the same agents, patients and objects.

Participants were randomly assigned to one of two conditions. In the 'Same' condition, the verb seen in the description phase was identical to that used in the preceding presentation phase. In the 'Different' condition, some other verb was displayed.

1. There is also this study by Vadim Axelrod that says it finds MRI evidence for lexical combination, but their analysis is to compare sentences under suppression to nonwords under suppression. So that’s exactly a minimal pair. [↑](#footnote-ref-1)
2. Other studies also indicate that breaking suppression times are not sensitive to linguistic factors, such as word frequency REF and… [↑](#footnote-ref-2)