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Investigating the Interplay between Morphosyntax and Event Comprehension from the Perspective of Intersecting Object Histories

Yanina Prystauka[a,b1], Emma Wing[a], Gerry T. M. Altmann[a]

[a]University of Connecticut, 406 Babbidge Road, Storrs, CT 06269-1020 United States

[b] UiT The Arctic University of Norway, Hansine Hansens veg 18, Tromsø 9019 Norway

Highlights

- Representations of both the initial and end states are accessible after state change verbs.
- Relative to the accessibility of the end state, participles reduce the accessibility of the initial state of the object entailed by the state change verbs they are derived from.
- Intensifier adverbs increase the contrast between the intended end state and the entailed initial state, leading to reduced accessibility of that initial state relative to the end state.

Abstract

In a series of sentence-picture verification studies we contrasted e.g. "… *choose the balloon*" with "… *inflate the balloon*" and "… *the inflated balloon*" to examine the degree to which different representational components of event representation (specifically, the different object states entailed by the inflating event; minimally, the balloon in its uninflated and inflated states) are jointly activated after state-change verbs and past participles derived from them. Experiments 1 and 2 showed that the initial and end states are both activated after state-change verbs, but that

[1] Correspondence concerning this article should be addressed to Yanina Prystauka, who is currently at UiT The Arctic University of Norway, e-mail: yanina.prystauka@uit.no. The work on this article was done in part at the University of Connecticut and in part at UiT The Arctic University of Norway. Stimuli, data and analysis scripts are available at https://osf.io/fpqx4/?view_only=3de7442eb9db487e98deecc1e58b2c09

the initial state is considerably less accessible after participles. Experiment 3 showed that intensifier adverbs (e.g. *completely*) before both state change verbs and participles further modulate the accessibility of the initial state. And in Experiment 4 we ruled out the possibility that the initial state is accessible only because of the semantic overlap. We conclude that although state-change verbs activate representations of both the initial *and* end states of their event participants, their accessibility is graded, modulated by the morphosyntactic devices used to describe the event.

Keywords: sentence processing, event representation, object state representation, morphosyntax.

CRediT authorship contribution statement

Yanina Prystauka: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft. **Emma Wing:** Conceptualization (experiment 3), Data curation (experiment 3), Investigation (experiment 3), Methodology (experiment 3), Writing – review & editing. **Gerry Altmann:** Conceptualization, Project administration, Resources, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Introduction

Our intent, in day-to-day conversation, is often to communicate specific details about entities, their relationship to other entities, and to the events they participate in. And our intent when communicating *events* is to communicate not simply *who did what, when, where, and to whom*, but to communicate the *consequences* of those events for the *changes* that the who and the whom undergo as they dynamically engage in the event (Altmann & Ekves, 2019). Different linguistic devices (e.g. different parts of speech and their grammatical markers) help us communicate these dynamics (Altmann & Mirkovic, 2009; Carreiras et al., 1997; Ferretti et al., 2007; Magliano & Schleich, 2000; Morrow, 1986). Here, we focus on the representational correlates of these dynamics, and specifically, the claim associated with the *Intersecting Object Histories* account of event representation (Altmann & Ekves, 2019) that sentences that describe changes of state to an object (e.g. "*The clown will inflate the balloon*") require the simultaneous representation of that object in its multiple states (minimally, the balloon in its initial uninflated state and in its final inflated state; Altmann and Ekves, 2019; Hindy, Altmann, Kalenik, and Thompson-Schill, 2012; Solomon, Hindy, Altmann, and Thompson-Schill, 2015). Altmann & Ekves (2019) pointed out that to understand an event in which one or more objects undergoes change requires, *a priori*, a representation of the initial state of the world before the event unfolded *and* a representation of the end state of the world after the event played out: If all we had available was a representation of the end state (much like a "running commentary" of the current state of the world), how could one know that an event had occurred, let alone what the event entailed?

If the distinct states of an object *are* representationally accessible at the offset of change-of-state event descriptions (and we leave open the question of whether *intermediary* states are also accessible), the comprehender must choose between these alternative state representations if the

object is subsequently referred to. For example, "*The clown will inflate the balloon*" can be followed by either "*and then he will take a pin and pop it*" or by "*but first he will take it from his pocket*" – in each case, the temporal adverb determines which representation is selected to be "carried forward" (i.e. maintained in focal attention). And whereas "*but first*" unambiguously selects the initial state of the balloon before it was inflated, it cannot do so in the morphosyntactically related participial construction "*The inflated balloon was placed on a table, but first it was…"* – in this case, "*it*" refers unambiguously to the balloon in its inflated state (at least in English). It would appear, then, as if the initial and end states of the balloon, reflecting the pre- and post-event states of the world, are both accessible (and hence activated)[2], albeit to different degrees, after the main verb construction, but not (or not to the same extent) after the participial construction. In contrast to these cases, after a sentence such as "*The clown will choose the shiny balloon*", both states of the balloon (the inflated and uninflated) are presumably accessible (albeit in proportion to their typicality – see below), evidenced by the ease of the continuations "*He will pop it*" and "*He will inflate it*", where "*it*" can refer to the balloon in either state. In this case, the alternate states are due to semantic knowledge of balloons, while in the "*inflate*" cases they are due to the entailments of the verb "*inflate*" (i.e. due to semantic knowledge pertaining to the concept of inflation).

Activating alternative state-representations introduces ambiguity: The claim is that after "*The clown will inflate the balloon*" the balloon must be represented both in its uninflated and

[2] For our purposes, the terms "*accessible*" and "*activated*" are interchangeable and will be used as such. We acknowledge that the distinction is elsewhere useful (accessibility could depend, for example, on the strength of a retrieval cue, or on the strength of an association between that cue and the to-be-retrieved item, independently of the activation strength of that target item).

inflated states. Depending on the subsequent context (in the example above, "*and then…*" or "*but first*"), one or other of these state-representations is selected as the intended one. The ambiguity arises because two mutually exclusive representations are each a potential candidate for the referent when a subsequent expression is encountered that refers to the balloon. These *object-state ambiguities* are quickly resolved in favor of the intended interpretation. In some respects, they appear similar to how the different meanings of a lexically ambiguous word (e.g. "*bug*") are transiently activated in a bottom-up manner until the comprehension system settles on the intended representation (e.g. an insect; Swinney, 1979). The difference is that in the change-of-state case, that activation of the prior state of the object (for example, the representation of the balloon in its uninflated state when comprehending that the balloon is now in an inflated state) is a *necessary* component of the comprehension of the event, but in the case of the interpretation of, for example, *bug* as an insect, the transient activation of the alternative interpretation (a spying device) is *not* constitutive of the insect concept. And, as discussed above, in the case of change-of-state verbs, since both states comprise the episodic history of the object being acted upon and can be referred to in the subsequent discourse, they need to remain activated (more than just transiently). In the case of lexical ambiguity, there is no need for the transiently activated contextually irrelevant meaning to remain activated. Thus, the mechanisms for resolving object-state ambiguities, and for resolving lexical ambiguities, must be different.

The simultaneous activation of multiple representations of the same object in different states presents challenges to the cognitive system: Unlike the distinct constitutive parts of, for example, a human being – head, eyes, mouth, limbs, and so on, the distinct states of an object, as changed by unfolding events, are mutually exclusive; they cannot co-exist. But their representations can, and indeed must, co-exist (hence that difference between object-state

ambiguity and lexical ambiguity). That is, while the balloon cannot simultaneously exist in both its uninflated and inflated states, our mental representations of those distinct states must co-exist in order for us to comprehend inflating events. Nonetheless, only one such representation enters into focal attention, and yet which state that corresponds to is fluid; it is not simply the "later" state (later relative to the unfolding of the event – the inflated balloon when "*The clown will inflate the balloon*"). For events set in the future ("*she will open the umbrella for you – pass it to her*") the later state (the umbrella in its open state) is not the state that will be acted upon in the first instance, and is not the state referenced by "it". But for events set in the past ("*she opened the umbrella for you – take it from her*"), those later states are most likely the only ones that *can* be acted upon. There are, clearly, complex interactions between the form of the language used to describe an event and its participants, and the representations of those participants' states, that determine which of the necessarily simultaneously active states of an object are propagated forward through the discourse. But given that at least one representation of state *is* carried forward through the discourse (perhaps only momentarily), what about the representations of the other states? Do they just decay until they are no longer available? Would that not entail losing the information that the object in question had been a participant in an event that caused it to be in the current state it finds itself in?

A further issue concerns the mechanisms by which distinct object-state representations for the same object token might be managed in episodic memory. In a series of neuroimaging studies reviewed briefly below, Hindy et al. (2012) and Solomon et al. (2015) found evidence for competition between the alternative object states of a single object token; this competition was graded – the greater the *dissimilarity* between the object states (i.e. the more something was changed by the event it took part in) the greater the competition. Solomon et al. (2015) argued that

this reflected the greater difficulty of binding into a single token representation the object properties corresponding to each distinct state – the more dissimilar two objects (or object states) are, the harder it is to generalize properties of one (such as its identity) to properties of the other. How does such binding occur? Is it similar to how, for example, the redness of an apple is bound to a specific token apple? Presumably not, because whereas the properties corresponding to redness and appleness co-exist, the distinct states of an object cannot co-exist (except in memory) – rather, they exist at different times in an object's temporal existence. The mechanisms of binding must therefore be somewhat different. Nor is this binding similar to reference in language; the different linguistic antecedents or real-world referents to which a referring expression might refer, just one of which should be bound to that referring expression, can all co-exist and are independent of each other. Not so for the distinct states of an object, all of which should be bound to that object (albeit associated with different moments in that object's trajectory through space and time), and are dependent on one another.

At stake in the present paper is whether there are measurable behavioral consequences of having to maintain multiple distinct object-state representations, and whether such multiple representations are indeed activated in response to event descriptions of the kind discussed thus far. In the absence of such evidence, their existence and associated challenges remain largely theoretical. The experiments below provide the first behavioral evidence for the *parallel* activation of object-state representations. In addition, they consider the relationship between verbs that entail an object changing from one state to another (e.g. "*inflate*") and their corresponding participles ("*inflated*"). We shall consider whether these participles also entail change (they do), whether like verbs their processing entails activation of some representation of change (they may not), and what the processing mechanisms are that control which representations are activated (or not). Indeed,

we take advantage of the assumption (discussed further below) that the *function* of the adjectival participle morphology in "*the inflated balloon*" is to preferentially activate (i.e. focus attention on) the end state of the balloon (as inflated) at the expense of (i.e. with less activation of) the initial state of that balloon (as uninflated); we use this case as a baseline against which to compare the verbal form "*inflate the balloon*" – evidence of greater accessibility or availability of the initial state at the ends of sentences containing the verbal form, relative to those containing the participial form, would provide evidence that both the initial and end states are simultaneously activated by descriptions of change-of-state events.

The verb/participle alternation, "*inflate the balloon*" versus "*the inflated balloon*", allows us to explore how changes in morphosyntax change the dynamics of event representation when other factors are held constant; in neither case is an uninflated balloon mentioned, in both cases whatever will happen next will happen with the balloon in its inflated state, and both cases entail that the balloon is or was previously in an uninflated state. The fact that a sentence affords a certain inference (e.g. that the balloon was in a different state) doesn't necessarily mean that this inferred information is automatically activated when processing this sentence. For example, does one encode a spoon when hearing *he had soup for lunch,* where the spoon is not explicitly mentioned but can be inferred as an instrument for eating soup? McKoon & Ratcliff (1992) suggested a minimalist hypothesis of inference processing, whereby only those inferences which are based on easily available information and are necessary to make statements locally coherent, are encoded. In contrast to the minimalist hypothesis, the theories of mental models (Johnson-Laird, 1983; van Dijk & Kintsch, 1983) or situation models (summarized in Zwaan & Radvansky, 1998 and Zwaan & Pecher, 2012) suggest that during language comprehension we build a model of the situation described by language which involves inferences beyond those minimally required. One of our

goals here is thus to examine and highlight whether and how such entailed object state information is activated during sentence comprehension as a function of morphosyntax.

In respect of this last point we note that studies have already shown that the activation of object state information is modulated by morphosyntax. For example, Misersky et al. (2021) combined a sentence-picture verification task (see below) with EEG to show that grammatical aspect – the distinction between, for example, "*inflated the balloon*" and "*was inflating the balloon*" – can cue different phases of an event (e.g. its completion, its progress, and so on), with the progressive "*was inflating*" defocusing the end state. Here, we take as given that such influences are a part of what morphosyntax *is for*. But while both the Misersky et al. study and the present study extend existing research by Hindy et al. (2012) and Kang et al. (2019), our focus here is on demonstrating that sentences that describe change-of-state events engender the *simultaneous* activation of representations of the same object in its different states as experienced through the event described by the sentence. In other words, we ask not whether morphosyntax can differentially focus on one phase or another, but whether, when focusing on those phases, the before-and-after states of the affected object are simultaneously represented, even during the reading of (in our study) simple future tense sentences.

Activating Object-State Representations

Evidence for the simultaneous representation of the initial and end states of affected objects during event comprehension is scant. Hindy et al. (2012) and Solomon et al. (2015) obtained evidence for such dual activation in a series of neuroimaging studies. They found that an established neural marker for semantic competition (activation in the left inferior frontal gyrus; e.g. Thompson-Schill, Bedny, & Goldberg, 2005) indicated more competition following "*The clown will inflate a balloon. Then he will point at the balloon*" than following "*The clown will*

choose a balloon. Then he will point at the balloon" or "*The clown will inflate a balloon. Then he will point at another balloon*"; the authors interpreted this as reflecting competition between the inflated and deflated states of the (same) balloon which were reactivated upon its repeated mention in the second clause after *"inflate*" but not after "*choose*" (without such dual activation there could be no such competition). This reactivation occurred despite the unambiguously intended interpretation of the balloon as inflated (in the "*inflate*" condition), and reflected, they claimed, the selection of one object-state representation (and corresponding feature set) over another.

The Hindy et al. (2012) and Solomon et al., (2015) findings were, however, an indirect indication of representational availability – relying on competition as an index of dual activation rather than on some more direct measure. In principle, however, the graded relationship between the degree to which an object undergoes change and the BOLD response to descriptions of such change need not reflect competition between distinct episodic representations of object state (compelling as the account may seem) – if greater change entails greater featural distance from the set of features associated with the object in its initial state, one could argue that greater distance requires greater (cognitive) control to inhibit the initial feature set and select/activate the new set (in much the same way as, in a color Stroop task, it takes cognitive control to inhibit the meaning associated with the form of the word in service of selecting the color in which that word is printed). In this respect, these earlier findings do not *necessarily* indicate the simultaneous activation of multiple episodic object-state representations; selecting the appropriate feature set may come at a cost (c.f. the cost associated with Stroop mismatch), and that cost could conceivably scale with the distance in semantic space between the feature sets. Such an account is agnostic as to whether the distinct feature sets are associated with distinct episodic representations of the same object at

different moments in time (they certainly are not associated with distinct episodic representations in respect of Stroop conflict).

Kang et al. (2019; see also Horchak and Garrido, 2020) used a sentence picture verification task that could, *in principle*, provide a more direct demonstration of the dual activation of initial and end states. In this task, the informational content of a sentence is matched against the depicted representation of an object that may have been referred to in that sentence, with faster reaction times and more "yes"-responses when the two are congruent than when they are incongruent. Although there has been some controversy about the locus of these congruency effects (e.g. whether low-level sensorimotoric representations or higher level, perhaps amodal representations mediate such effects; Ostarek et al., 2019), the reduction in reaction time to the picture is interpreted as reflecting, during the processing of the sentence, pre-activation of information or features contained within the subsequent picture (see e.g. Ostarek et al., 2019). After the sentence "*The clown will inflate the balloon*", faster reaction times to a picture of a deflated balloon than after the sentence "*The clown will choose the balloon*" would suggest greater accessibility (i.e. activation) of the feature set associated with deflated balloons after "*inflate*" than after "*choose*" – we take as given that the feature set associated with *inflated* balloons is also accessible after "*inflate"* (and also after "*choose*", given that inflated balloons are more typical exemplars of the concept balloon than are deflated balloons – see below). However, the majority (but not all) of the items used by Kang et al. (2019) and by Horchak and Garrido (2020) employed state-change verbs in which a change was entailed from a more typical state (e.g. inflated, for balloons) to a less typical state (e.g. uninflated). Using events that entail change from typical to atypical states, rather than from atypical to typical states, renders the paradigm insensitive to parallel activation of initial and end states (and, in fact, neither of these two studies intended to address parallel activation).

After "*The clown will deflate the shiny balloon*", the representation of an inflated balloon (putatively reflecting the initial state of the balloon) might be activated, not as a part of the representation of the deflating event, but rather as a default representation activated by the lexical item "*balloon*" *independently* of the sentential context: Kukona et al. (2014) found that when hearing a sentence like "*The boy will eat the white…*" while viewing an array of objects including a white cake, a white car and distractors, participants looked at the car when they heard "*white*" more than they looked at the distractor objects (while still fixating on the contextually appropriate white cake the most – c.f. Altmann & Kamide, 1999). Thus, the word "*white*" attracted participants' looks to the two white objects in the display regardless of the fact that one of them did not fit the context of the sentence (a car is not a plausible argument for the verb "*eat*"). This finding illustrates that sentence comprehension involves both top-down anticipatory processes guided by sentential constraints and local bottom-up processes elicited by individual lexical items independently of their context.

This interplay between top-down and bottom-up processing can be reinterpreted as the interplay between semantic and episodic memory. Bottom-up processing implicates semantic memory, whereby a mapping is established between a lexical item and a corresponding concept in our long-term memory (Yee et al., 2013; Yee & Thompson-Schill, 2016). Thus, the lexical item "*balloon*", in isolation, will activate a representation of a typical balloon more than of an atypical balloon (which in the sentence picture verification task, or a word picture verification task, would manifest as more Yes-responses and faster reaction times to an image of an inflated balloon than to an image of a deflated balloon – see Kang et al., 2019). Crucially, even in a context which constrains interpretation to a non-inflated balloon (e.g. "*although it was in pieces scattered across the room, the balloon*…"), the word "*balloon*" may still activate to some degree a representation

of a typical, inflated balloon. Such a semantic representation would be distinct from the *episodic* representation of the *token* balloon – the specific instantiation of a balloon that is introduced by the language (reflecting an *instance* drawn from the class of balloons) and to which subsequent words, such as "*it*" might refer (see Altmann & Ekves, 2019, for a theoretical account of the distinction between types and tokens). Consequently, in response to sentences such as "*The clown will deflate the balloon*", participants might activate a representation of a generic inflated balloon at the sentence-final item "*balloon*" irrespective of the context (c.f. Kukona et al., 2014) and irrespective, therefore, of the event representation encoding the deflation of a balloon. In Experiment 1, below, we address this issue by using change-of-state verbs that entail a change not from the typical state to an atypical state ("*The clown will deflate the balloon*"), but from an atypical state to a typical one (e.g. "*The clown will inflate the balloon*"). We shall contrast this case with the participial form (e.g. "*The clown will choose the inflated balloon*"); on the assumption that only the end (inflated) state is accessible following such constructions (although nothing actually hinges on this assumption – see the logic below), notwithstanding the entailed initial state (see discussion below), we can use this construction as a baseline against which to compare the accessibility of representations following "*... inflate the balloon.*" Our logic is as follows: If there is greater accessibility of the initial (atypical) state of the balloon after "…*inflate the balloon*" than after "*... the inflated balloon*", as evidenced by faster reaction times (and "yes" responses; see below) to a visual depiction of an uninflated balloon, we can conclude that the (semantic) feature set associated with the uninflated state of a balloon has been activated to a greater extent in the "*inflate*" case. That is, there has been activation of the initial state, as well as of the end state, in this case. Similarly for the comparison against "*... choose the balloon*" – faster reaction times to an uninflated balloon following "*inflate*" than following "*choose*" would provide

additional evidence for the activation of the initial, atypical (uninflated) state of the balloon after "…*inflate the balloon*".

Experiment 1

Using a sentence-picture verification task, the present study investigates whether the initial object state is accessible after a sentence describing a state-change event, and whether it is more accessible after a state-change verb than after either participial constructions or verbs that do not entail changes in state (e.g. "*choose*"). The sentence-picture verification paradigm has been successfully used to probe episodic representations elicited by language stimuli (Connell, 2007; Kang et al., 2019; Stanfield & Zwaan, 2001; Zwaan et al., 2002; Zwaan & Pecher, 2012). In this paradigm, participants are presented on each trial with a sentence followed by a picture, and are asked to verify whether the object in the picture was mentioned in the sentence. The proportion of Yes-responses and reaction times in response to images are interpreted as indices of the degree of accessibility, and hence activation, of that particular object as a consequence of reading that particular sentence. Studies reported in Zwaan and Pecher (2012) were on-line replications of in-lab experiments reported earlier in Connell (2007), Stanfield and Zwaan (2001) and Zwaan et al., (2002). Kang et al., (2019) was also conducted on-line, as are the studies reported below.

Experiment 1 includes the two conditions replicating Kang et al.'s (2019) Experiment 3, but using state-change verbs that entailed a change to an object from a less typical state to a more typical state:

6. *The clown will choose the shiny balloon*[3].

7. *The clown will inflate the shiny balloon.*

It also includes an additional condition containing a participle:

8. *The clown will choose the inflated balloon.*

The sentence in (8) contains both a minimal-change verb (*choose*) as in (6), and a participle (*inflated*) derived from a state-change verb as in (7). We assume that increased accessibility, as reflected in a higher proportion of Yes-responses and faster reaction times, reflects the degree of activation of the corresponding object-state representations (we return to this assumption in the discussion of Experiment 3, when we consider alternative interpretations of yes-responses and associated reaction times). However, an important difference between (7) and (8) is that in (7), the uninflated state participated in the focal event described by the state-change verb whereas in (8), the uninflated state did *not* take part in the focal (choosing) event described by the sentence. So, while the initial state is entailed in both (7) and (8), it should not be activated in (8) as a part of its corresponding *event representation*. Hence our assertion that past participles will activate only the linguistically denoted end state and not the entailed initial state. We return to this assertion after Experiment 3, where we show that this is not quite the case, and that there is *some* residual activation of the initial state in the past participle case. This in fact speaks to an ongoing debate about adjectival participles as *resultatives* (focusing on the result of an event) or eventives (focusing on the process of change); e.g. Embick (2004) and Sleeman (2011). We return to this distinction in our General Discussion.

[3] We used the grammatical future tense for compatibility with our prior studies (Kang et al., 2019; Experiment 3; Hindy et al., 2012; Solomon et al., 2015). Kang et al. (2019) also included a past tense version (their Experiment 2) which yielded the same key pattern (equal accessibility of the initial and end states after the state-change verbs).

In Experiment 1 we will first compare state-change and minimal-change verbs (e.g. (6) & (7) above). Sentences with minimal-change verbs (such as "*choose the shiny balloon*") provide one baseline against which to compare sentences with state-change verbs (such as "*inflate the shiny balloon*" or "*fill the deep pool*"); this comparison is critical with respect to demonstrating activation of both object states in the absence of bottom-up, context-independent, activation of typical states (c.f. Kukona et al., 2014). We expect no difference in Yes-responses and RTs to the end state (an inflated balloon) because this state matches the most typical state and would thus be activated bottom-up after the minimal-change verb ("*choose the shiny balloon*") and as the end state as part of the event structure for the substantial-change verb ("*inflate the shiny balloon*"). However, for the initial, less typical, state (e.g. an uninflated balloon), we expect increased accessibility after the state-change verb (*inflate the shiny balloon*) than after the minimal-change verb (*choose the shiny balloon*). This is because in the *choose-shiny* condition we expect the typical, and not atypical, state to be more activated, but in the *inflate-shiny* condition we expect the atypical uninflated state to be activated as a part of the event structure – i.e. reflecting the initial state of the balloon taking part in the inflating event.

To further address the dual activation of initial and end state representations, we will then compare the participial construction to the state-change verbs. Yes-responses to initial states should be more numerous and faster in the verb condition than in the participial condition (assuming that the verb activates both the initial and end states associated with the corresponding event, and that the function of adjectival participles such as "… the *inflated balloon*" is to focus attention on, and hence more strongly activate, the explicitly referenced result of the corresponding event; again, see below).

Participants

Three hundred native speakers of English were recruited via Prolific (165 female, mean age 35, range 18-73). Kang et al. (2019) had a sample size of approximately 50 participants per condition of their 2 x 2 design (i.e. around 200 participants in all). Because of the similarities between our and their experiments, we also based our sample sizes on 50 participants per condition, with Experiments 1 and 2 each having six conditions (hence approximately 300 participants in total per experiment), and Experiments 3 and 4 four conditions (and hence approximately 200 participants in total per experiment). The experiment lasted approximately 15 minutes and participants received $1.70 for their participation.

Materials & Design

The sentences in this study consisted of 48 sentence triples describing 48 objects. We used 96 clipart images depicting the same 48 objects in two alternative states.

There were three sentence conditions: (1) *Minimal Change, Adjective* (henceforth "*choose-shiny*"); (2) *Substantial Change, Adjective* (henceforth "*inflate-shiny*"); and (3) *Minimal Change, Participle* (henceforth "*choose-inflated"*) (see Table 1 for examples and the full list of experimental stimuli in Appendix A). The *choose-inflated* condition contained a minimal-change verb and a participle derived from the state-change verb used in the *inflate-shiny* condition. Verbs, adjectives, and participles, were matched on length and frequency across the conditions.

All sentences were normed for the degree of change that the verb entailed in a separate off-line norming task. Fifty-nine participants were asked to read sentences and indicate, on a scale from 1 to 7, the extent to which the object in each sentence changes as a result of the action described. Sentences in the *choose-shiny* condition received an average object-state change rating of 3.07 (SD = 0.35); sentences in the *inflate-shiny* condition received an average rating of 4.67 (SD =

0.39), while sentences in the *choose-inflated* condition received an average rating of 3.07 (SD = 0.33). Pairwise comparisons showed that state change ratings for the *choose-shiny* and *inflate-shiny* conditions were significantly different ($t(47) = 19.97$, $p < .01$). There was no significant difference in the state change ratings for the *choose-shiny* and *choose-inflated* conditions ($t(47) = 0.01$, $p = .99$).

Objects in their original and modified states were normed for how typical they are. Participants (N = 100) were asked to indicate, on a scale of 1 to 7, how well the image corresponds to how they would typically think of that specific object. Forty-eight images which depicted experimental objects in their initial (less typical) state received an average rating of 4.29 (SD = 0.79), while forty-eight images depicting the same objects in their end (more typical) states received an average rating of 5.88 (SD = 0.54; $t(47) = 12.7$; $p < .01$).

All participants saw each sentence in just one of the three conditions paired with an image depicting an object in one of the two possible states. The stimuli were divided into six lists using a Latin square design. Across these lists, the same set of 48 fillers and four practice items was used. Thus, each person saw a total of 100 trials, including practice trials.

The stimuli, data, and analysis scripts for this experiment, as well as other experiments described in the following sections, can be accessed at https://osf.io/fpqx4/?view_only=3de7442eb9db487e98deecc1e58b2c09 (Prystauka et al., 2022).

Table 1

Examples of Experimental Stimuli Used in Experiment 1

Condition	Sentence Example	Notes
choose-shiny	The clown will choose the shiny balloon.	Minimal Change, Adjective
inflate-shiny	The clown will inflate the shiny balloon.	Substantial Change, Adjective
choose-inflated	The clown will choose the inflated balloon.	Minimal Change, Participle

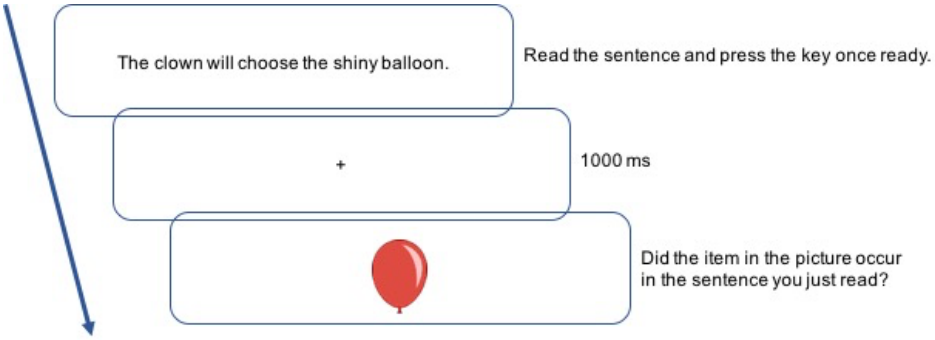
Procedure

The experiment was implemented in Gorilla Experiment Builder (www.gorilla.sc). The platform has been shown capable of running reaction-time sensitive studies (e.g. Anwyl-Irvine et al., 2019). As for the reliability of RTs in a sentence-picture verification task, a series of experiments reported by Zwaan & Pecher (2012) showed that RTs collected on-line are comparable to RTs collected in the lab. As a basis for our experiments, we used the experimental script from Chen et al. (2020).

The task started with four practice trials, followed by a mix of experimental and filler trials in a randomized order (total N = 96). Each trial started with a sentence. Participants were instructed to press the space key once they read and understood the sentence. A fixation cross appeared upon the key press and stayed on the screen for 1000 ms. It was followed by an image of an object. Participants were asked to respond, using the j and f keys, whether the object in the picture had occurred in the sentence they had just read (the procedure is summarized in Figure 1). Critically, filler trials always required a *No*-response, while experimental trials always required a *Yes*-response (although there is a caveat with respect to trials in the *choose-deflated* condition, and we return to this below). The experiment automatically proceeded to the next trial after a 3000 ms time-out in case no response was provided. Additionally, 25% of trials contained Yes/No comprehension questions (e.g. *Will the clown inflate the balloon?*), and feedback was provided about the participants' responses to these questions. This manipulation was added to ensure that participants attended to the meaning of the sentences.

Figure 1

Trial Procedure in Experiments 1 and 2 (Adapted from Zwaan & Pecher, 2012)



Analysis

All analyses were conducted in R v. 3.6.2 (R Core Team, 2013). First, participants whose accuracy on comprehension questions was below 80% were excluded from the analysis. This resulted in 236 participants whose data were included in the final analyses. Additionally, trials with RTs shorter than 300 ms and *No*-responses to critical images were also excluded. No-responses were not included in the reaction time analyses because in general they have longer reaction times in verification tasks (Kaup et al., 2005) and because the proportion of such responses in some of the conditions was very low (i.e. 3%, see Figure 2). Thus, the analysis of reaction times, in this and subsequent experiments, was conducted only on trials with *Yes*-responses.

Analyses was performed on both the proportion of Yes-responses and the log-transformed reaction times (RTs) using the generalized linear mixed effects (proportion of Yes-responses) and linear mixed effects models (RTs) available as part of the lme4 R package (Bates et al., 2015).

Results

We will focus on two critical comparisons. Comparing the *choose-shiny* condition to the *inflate-shiny* condition (Figures 2 and 3) will allow us to explore the accessibility of the initial and end states following change-of-state verbs. Comparing the *inflate-shiny* condition to the *choose-*

inflated condition (Figures 4 and 5) will allow us to address the same issue but using participles as the baseline rather than verbs that entail no or minimal change.

Minimal vs. Substantial State-Change Verbs: Proportion of Yes-Responses

See Figure 2. To analyze the relationship between the proportion of Yes-responses, picture type and sentence type, we ran generalized linear mixed effects models using the *glmer* function (the model automatically converted responses to logit scale). In the baseline model, we estimated the fixed effects of Picture type and Sentence type. Participant and Item were entered as the random effects. We used an *optimx* optimizer because models with the default *bobyga* optimizer didn't converge. Models with the same settings were run for the remaining comparisons of the proportion of *Yes*-responses.

Proportion of Yes-responses ~ Picture type + Sentence type + (1 | Participant) + (1 | Item)

In order to evaluate the significance of the main effects of Picture type and Sentence type and their interaction, the above model was iteratively compared to models without the factors of interest to evaluate the main effect of factors or to the model with the added interaction term to evaluate the effect of interaction.

Proportion of Yes-responses ~ Picture type * Sentence type + (1 | Participant) + (1 | Item)

Proportion of Yes-responses ~ Picture type + (1 | Participant) + (1 | Item)

Proportion of Yes-responses ~ Sentence type + (1 | Participant) + (1 | Item)

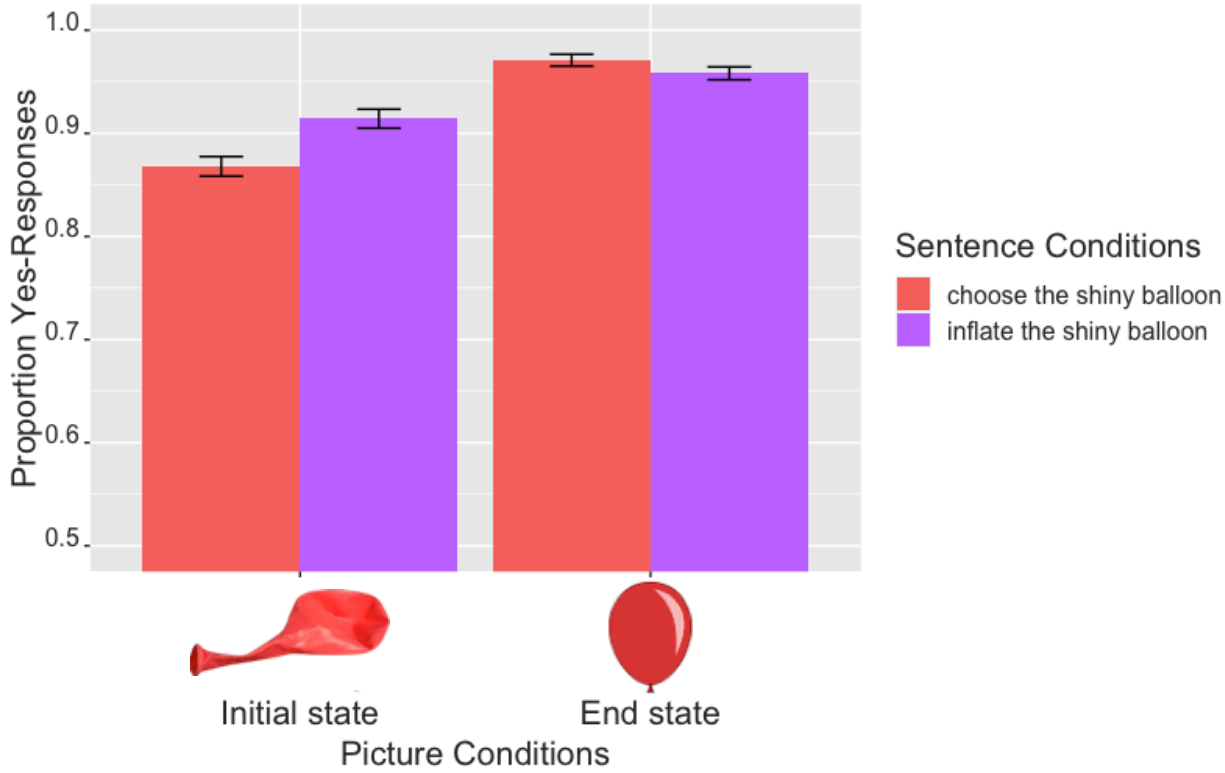
To assess the goodness of fit, we compared the models using the $\chi 2$ -distributed likelihood ratio and its associated p-value. The model with a smaller Akaike Information Criterion (AIC) and

the Bayesian Information Criterion (BIC) (both of which are sensitive to the trade-off between model fit and complexity) was considered a better fit.

We found a significant fixed effect of Picture type ($\chi 2$ (1) = 170.6, $p < .001$) and Sentence type ($\chi 2$ (1) = 9.58, $p < .002$). There was also a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 22.14, $p < .001$.

Figure 2

Proportion of Yes-Responses for the Choose-Shiny and Inflate-Shiny Conditions in Experiment 1. Error bars represent standard error. In this and subsequent figures, the initial and end states are labelled relative to the "inflate" (state-change) condition, and both Sentence and Picture conditions are labelled, for clarity, using the same single exemplar from the main text.



We then used the model with both fixed effects and the interaction term to run pairwise post hoc comparisons. Below, we report p-values for comparisons run on the estimated means in the logit/log space, however for the sake of interpretability, we provide raw mean proportion scores/reaction times along with these p-values. The initial state (the uninflated balloon) gained

significantly more Yes-responses in the *inflate-shiny* condition (mean = 0.91, SE = 0.01) than in the *choose-shiny* condition (mean = 0.87, SE = 0.01; z = -5.09, p < .01). Conversely, there was no difference in the proportion of Yes-responses to the end state (the inflated balloon) in the *choose-shiny* (mean = 0.97, SE= 0.01) and *inflate-shiny* conditions (mean = 0.96, SE = 0.01; z = 2.35, p = 0.09).

Minimal vs. Substantial State-Change Verbs: Reaction Times

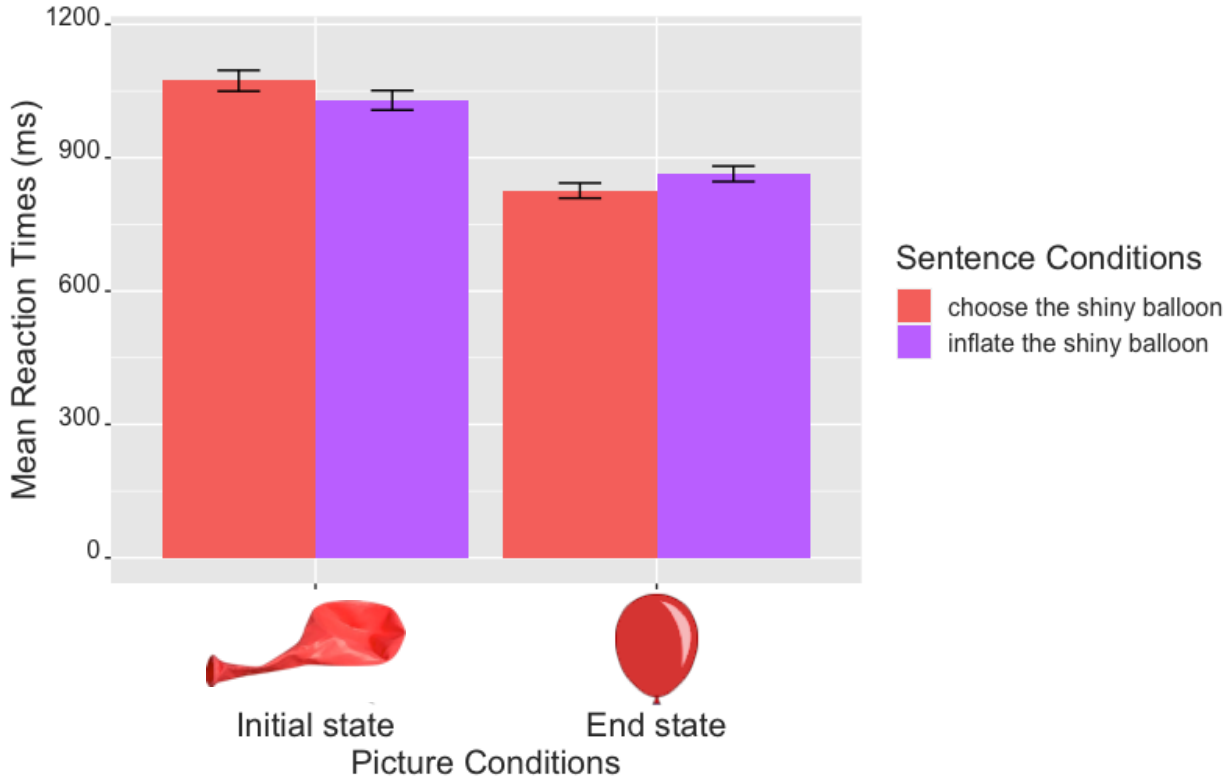
See Figure 3. To analyze the relationship between reaction time, picture type and sentence type, we ran linear mixed effects models using the *lmer* function following the same routine outlined earlier for the proportion of Yes-responses. All models converged with a default *bobyga* optimizer. Models with the same settings were run for the remaining comparisons of the reaction times.

We found a significant fixed effect of Picture type, $\chi 2$ (1) = 613.88, p < .001, and a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 20.5, p < .001.

Post hoc comparisons indicated that the initial state (the uninflated balloon) was verified faster following sentences in the *inflate-shiny* conditions (mean = 1029 ms, SE = 22 ms) than sentences in the *choose-shiny* conditions (mean = 1073 ms, SE = 23.5 ms; t = 2.91, p = 0.02), while the end state (the inflated balloon) was verified faster following sentences in the *choose-shiny* conditions (mean = 826 ms, SE = 17 ms) than sentences in the *inflate-shiny* conditions (mean = 864, SE = 17.4; t = 3.51, p = .003).

Figure 3

Mean Raw Reaction Times to Pictures Following Sentences in the Choose-Shiny and Inflate-Shiny Conditions on Trials with Yes-Responses. Error bars represent standard error.



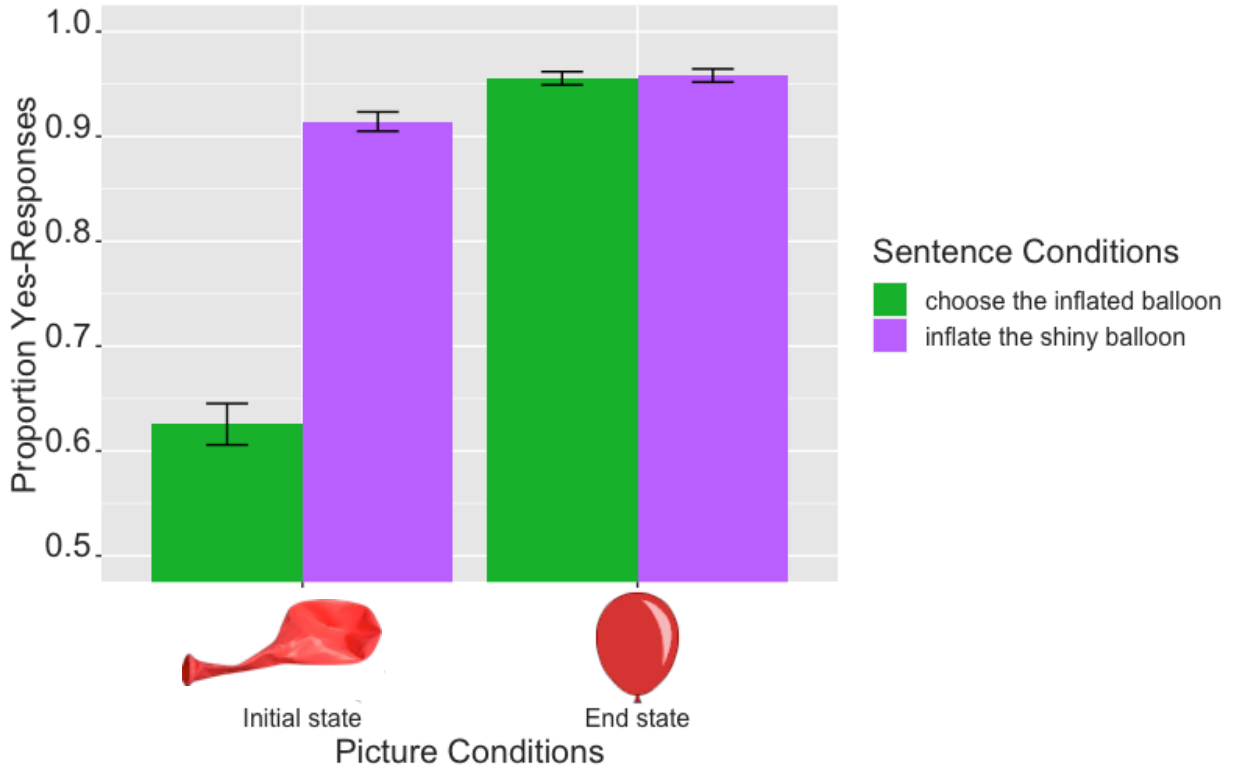
State-Change Verbs vs. Participles: Proportion of Yes-Responses

We found a significant fixed effect of Picture type ($\chi 2$ (1) = 713.12, $p < .001$) and Sentence type ($\chi 2$ (1) = 447.32, $p < .001$). There was also a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 120.28, $p < .001$.

Post-hoc comparisons indicated that the initial atypical state (the uninflated balloon) gained significantly more Yes-responses in the *inflate-shiny* condition (mean = 0.91, SE = 0.01) than in the participial *choose-inflated* condition (mean = 0.63, SE = 0.02, z = 21.35, $p < .001$), while there was no significant difference in the proportion of Yes-responses to the end typical state (the inflated balloon) following the *choose-inflated* (mean = 0.96, SE = 0.01) and *inflate-shiny* (mean = 0.96, SE = 0.01, z = 0.13, p = 1) conditions.

Figure 4

Proportion of Yes-Responses for the Choose-Inflated and Inflate-Shiny Conditions in Experiment 1. Error bars represent standard error.



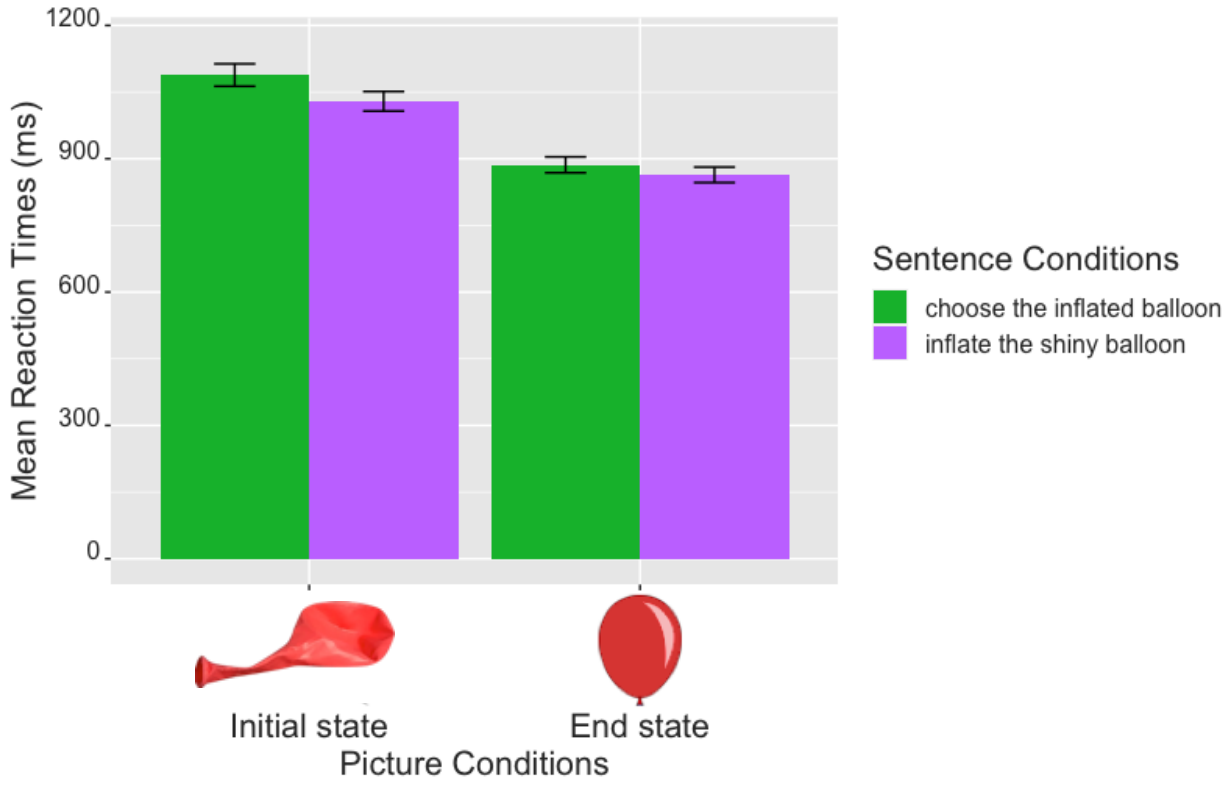
State-Change Verbs vs. Participles: Reaction Times

See Figure 5. We found a significant fixed effect of Picture type, $\chi 2$ (1) = 451.38, $p < .001$ and Sentence type, $\chi 2$ (1) = 29.12, $p < .01$. There was also a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 6.78, $p < .01$.

Post hoc comparisons indicated that the initial atypical state (the uninflated balloon) was verified faster in the *inflate-shiny* condition (mean = 1029 ms, SE = 22 ms) than in the *choose-inflated* condition (mean = 1088 ms, SE = 25.3 ms; t = 5.51, $p < .001$), while the end typical state (the inflated balloon) was verified as fast in the *inflate-shiny* condition (mean = 864 ms, SE = 17.4 ms) as in the *choose-inflated* condition (mean = 886 ms, SE = 17.9 ms, t = 2.37, p = .08).

Figure 5

Mean Raw Reaction Times to Pictures Following Sentences in the Choose-Inflated and Inflate-Shiny Conditions on Trials with Yes-Responses. Error bars represent standard error.



Discussion

Our results demonstrated increased accessibility of the initial, atypical, state following state-change verbs ("*inflate*") compared to minimal-change verbs ("*choose*"), as reflected both in the increased proportion of Yes-responses and faster reaction times following state-change verbs. We interpret this result to suggest that when comprehending events that change objects from their atypical to typical states, we activate the initial, atypical, state as a part of the event representation.

In support of our conclusion that *both* the initial and end states are activated as a part of the event representation associated with state-change verbs, the proportion of Yes-responses to the visual depiction of the initial (uninflated) state was considerably larger and reaction times faster

after sentences with state-change verbs than after sentences with participles. Also, no differences in accessibility of the end state were found, whether in the proportion of Yes-responses or in the reaction times. The contrast between the accessibility of the uninflated balloon after "*The clown will inflate the shiny balloon*" and after *"The clown will choose the inflated balloon*" is informative insofar as in neither case is an uninflated balloon explicitly referenced, and both entail that the balloon had once been in a state of deflation. In the former, that state is a part of the event structure associated with the inflating event – the focus of the sentence, and in the latter, it is a part of an event structure that caused the balloon to be in its current state, but crucially, is not a part of the event structure that is the focus of the sentence. The contrast suggests that the initial state is more readily accessible, and hence activated, in the *inflate-shiny* case, but is less activated in the participial *choose-inflated* case. Indeed the difference in Yes-responses to the depiction of initial state after *choose-inflated* (63%) and after *choose-shiny* (87%) suggests that the initial state is activated even in the minimal state change condition more than it is in the participial condition, reflecting, presumably, the activation after "*choose the shiny balloon*" of both the typical and atypical states (i.e. inflated and uninflated) in proportion to their typicality, and the lesser activation, after "*choose the inflated balloon*", of the initial (atypical) state. Whether this lesser activation is due to active suppression, or simply greater activation of the end state relative to the initial state, is not clear; the sentence-picture verification task is sensitive to the *congruity* of the content depicted in the picture and the information conveyed by the sentence, and the congruity effects we observe in this task do not speak to the mechanisms modulating activation of that informational content. Henceforth we shall refer to the lesser activation of one state relative to the other as *defocusing*, while remaining agnostic as to the mechanism by which one state is more

focused, and hence more accessible, than the other. We return to those 63% of Yes-responses after *choose-inflated* in Experiment 4.

In Experiment 2, we ask whether reduced activation of the initial state in the participial construction is independent of the typicality of that state. We use change-of-state verbs, and associated participles, in which objects change from their typical state to their atypical state (c.f. Kang et al., 2019); in these cases, the initial state to be defocused in the participial condition is the typical state. In Experiment 1, depictions of the initial state (the atypical state) following minimal change verbs (e.g. "*choose*") engendered Yes-responses on 87% of trials. Depictions of the more typical end state engendered Yes-responses on 97% of trials. Would we see an equivalent increase in Yes-responses to the initial state following "*choose the deflated balloon*", where the initial state is now the more typical one? Perhaps, when the initial state is the more typical, there is greater activation (and accessibility) of that state in the participial condition.

Experiment 2

After "*The clown will choose the inflated balloon*" in Experiment 1, participants responded on 96% of trials that an inflated balloon depicted an object mentioned in the sentence, but on only 63% of trials that an uninflated balloon depicted such an object. In Experiment 2 we ask how these patterns would change after sentences such as "*The clown will choose the <u>deflated</u> balloon*", in which the initial state is not the atypical (uninflated) case, but the typical (inflated) case. We revert to the change-of-state pattern employed by Kang et al. (2019) in which state-change verbs entailed changes from the typical to the atypical state. At issue is whether the activation of the initial state is relatively greater than we observed in Experiment 1, when that state is the typical generic state of the object.

Participants

Three hundred native speakers of English were recruited via Prolific (153 female, mean age 36, range 18-69). See Experiment 1 for sample size justification. The experiment lasted approximately 15 minutes and participants received $1.70 for their participation.

Materials & Design

The design was identical to that used in Experiment 1. There were 48 sentence triples, with example sentences shown in Table 2. The full list of sentences is provided in Appendix B. All sentences were normed for the degree of change that the verb entailed in a separate off-line norming task. Fifty-nine participants were asked to read sentences and indicate, on a scale from 1 to 7, the extent to which the object in each sentence changes as a result of the action described. Sentences in the *choose-shiny* condition received an average object-state change rating of 2.93 (SD = 0.63); sentences in the *deflate-shiny* condition received an average rating of 5.16 (SD = 0.58), while sentences in the *choose-deflated* condition received an average rating of 3.03 (SD = 0.59). Verbs in the *Minimal* and *Substantial Change* conditions as well as adjectives and participles were matched on length and frequency. Pairwise comparisons showed that state change ratings for the *choose-shiny* and *inflate-shiny* conditions were significantly different ($t(47) = 18.5$, $p < .01$). There was no significant difference in the state change ratings for the *choose-shiny* and *choose-deflated* conditions ($t(47) = 0.7$, $p = .46$).

Objects in their original and modified states were normed for how typical they are. Participants (N = 100) were asked to indicate, on a scale of 1 to 7, how well the image corresponds to how they would typically think of that specific object. Forty-eight images which depicted experimental objects in their initial (more typical) state received an average rating of 5.87 (SD =

0.57), while forty-eight images depicting the same objects in their end (atypical) states received an average rating of 4.38 (SD = 0.87). This difference was significant ($t(47) = 9.5$, $p < .01$).

Table 2

Examples of Experimental Stimuli Used in Experiment 2

Condition	Sentence Example	Notes
choose-shiny	The clown will choose the shiny balloon.	Minimal Change, Adjective
deflate-shiny	The clown will deflate the shiny balloon.	Substantial Change, Adjective
choose-deflated	The clown will choose the deflated balloon.	Minimal Change, Participle

Procedure

Procedure was the same as in Experiment 1.

Analysis

All analyses were conducted in R v. 3.6.2 (R Core Team, 2013). First, participants whose accuracy on comprehension questions was below 80% were excluded from the analysis. This resulted in 228 participants whose data were included in the final analyses. Additionally, trials with RTs shorter than 300 ms were also excluded, as were, for the reaction time analyses, trials with *No*-responses to the critical images.

Analyses was performed on both the proportion of Yes-responses and the log-transformed reaction times (RTs) using the generalized linear mixed effects (proportion of Yes-responses) and linear mixed effects models (RTs) available as part of the lme4 R package (Bates et al., 2015).

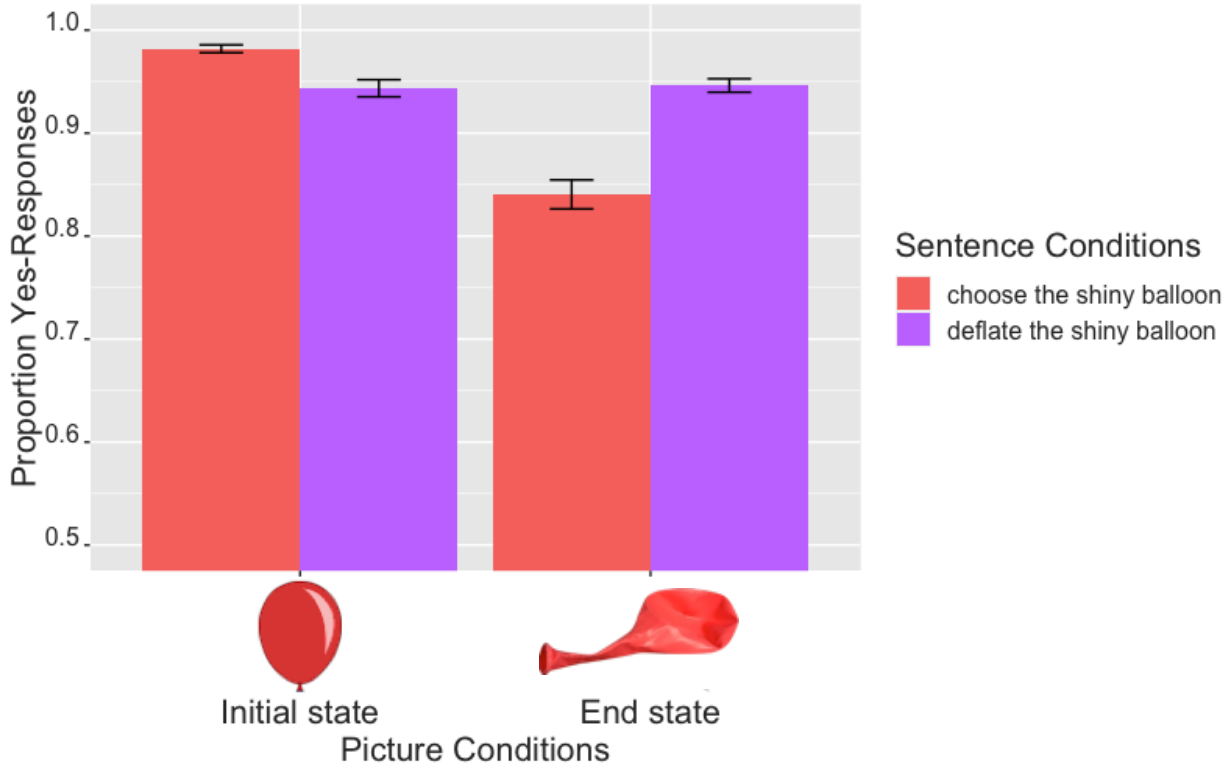
Results

Minimal vs. Substantial State-Change Verbs: Proportion of Yes-Responses

See Figure 6. We found a significant fixed effect of Picture type ($\chi 2$ (1) = 137.89, $p < .001$) and Sentence type ($\chi 2$ (1) = 33.22, $p < .001$). There was also a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 122.69, $p < .001$.

Figure 6

Proportion of Yes-Responses for the Choose-Shiny and Deflate-Shiny Conditions in Experiment 2. Error bars represent standard errors.



Post hoc comparisons indicated that the initial state (the inflated balloon) gained significantly more Yes-responses in the *choose-shiny* condition (mean = 0.98, SE = .00) than in the *deflate-shiny* condition (mean = 0.94, SE = .01; z = 5.64, $p < .001$). Conversely, the end state (the deflated balloon) gained significantly fewer Yes-responses in the *choose-shiny* condition

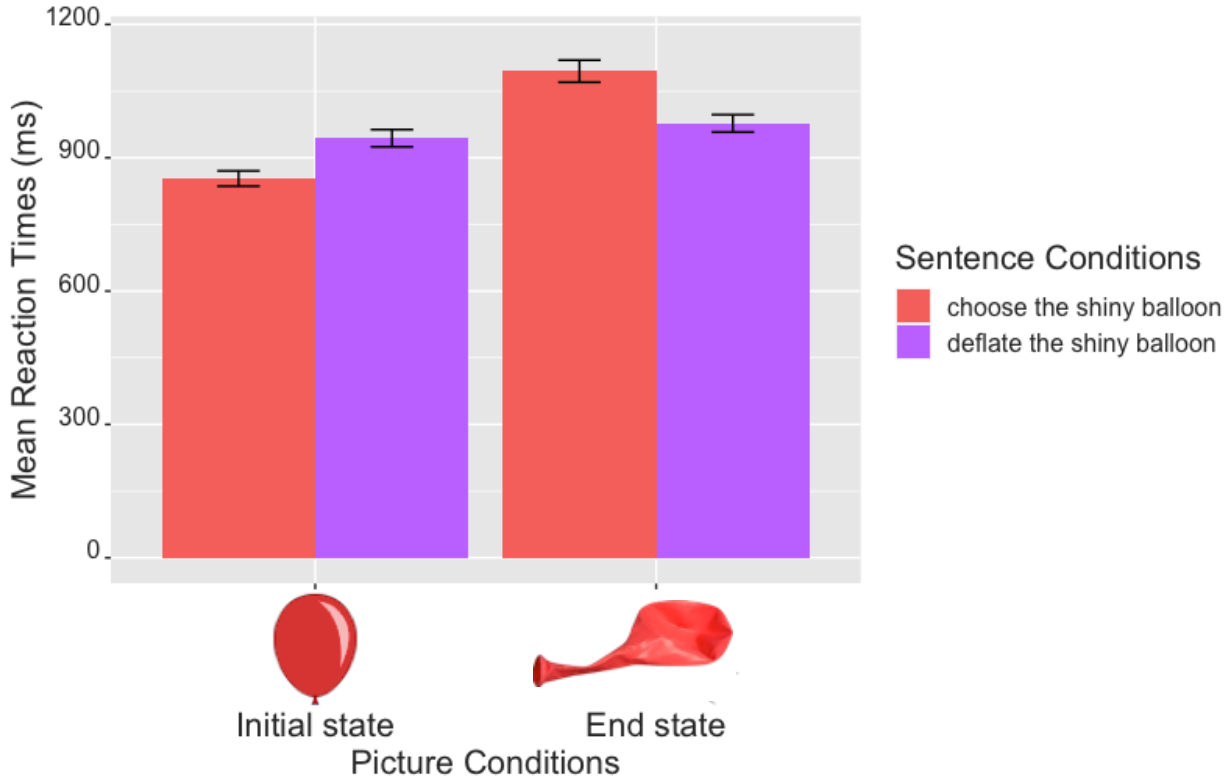
(mean = 0.84, SE = .01) than in the *deflate-shiny* condition (mean = 0.95, SE = .01, z = 10.25, p < .001).

Minimal vs. Substantial State-change verbs: Reaction Times

See Figure 7. We found a significant fixed effect of Picture type, $\chi 2$ (1) = 259.12, p < .001, and a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 140.45, p < .001.

Figure 7

Mean Raw Reaction Times to Pictures Following Sentences in the Choose-Shiny and Deflate-Shiny Conditions on Trials with Yes-Responses. Error bars represent standard error.



Post hoc comparisons, using the model with both fixed effects and the interaction term, indicated that the initial state (the inflated balloon) was verified faster in the *choose-shiny* condition (mean = 853 ms, SE = 17 ms) than in the *deflate-shiny* condition (mean = 944 ms, SE = 19 ms, t = -8.7, p < .001), while the end state (the deflated balloon) was verified slower in the

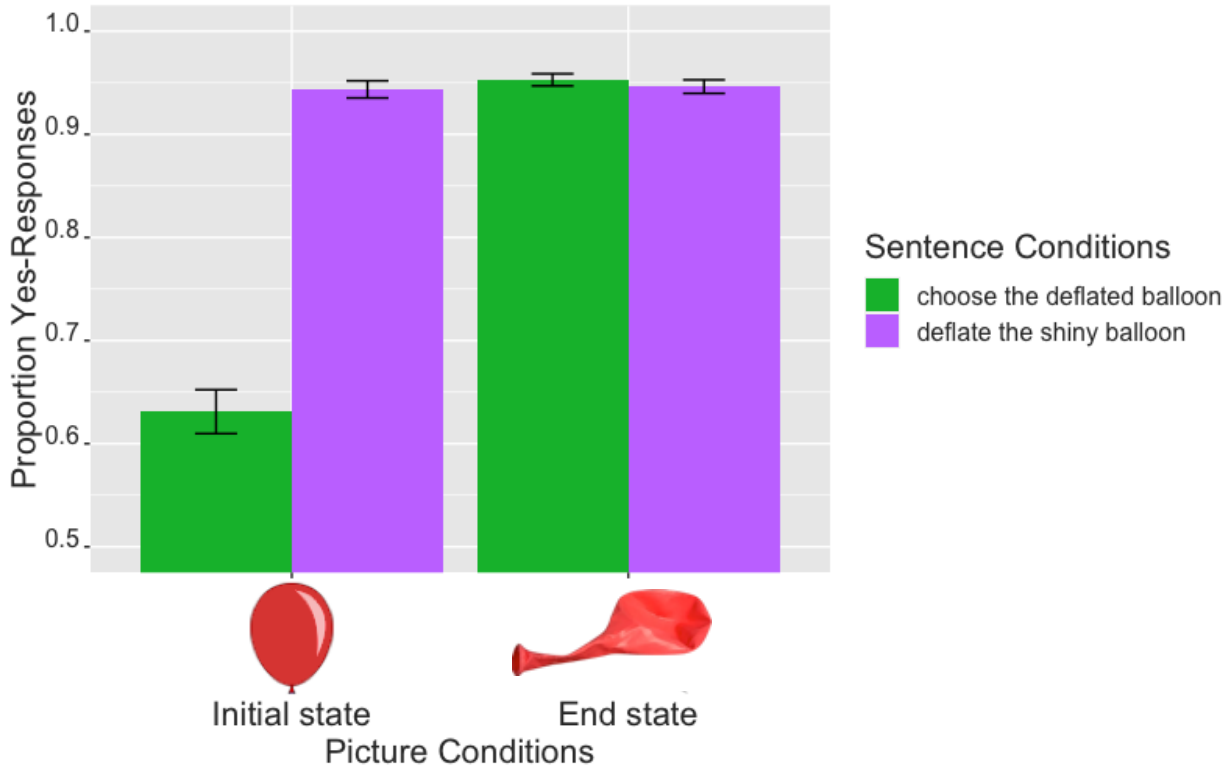
choosy-shiny condition (mean = 1095 ms, SE = 25 ms) than the *deflate-shiny* condition (mean = 977 ms, SE = 20 ms, t = 8.2, p < .001).

State-change verbs vs. Participles: Proportion of Yes-Responses

See Figure 8. We found a significant fixed effect of Picture type ($\chi 2$ (1) = 560.58, p < .001) and Sentence type ($\chi 2$ (1) = 496.82, p < .001). There was also a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 222.85, p < .001.

Figure 8

Proportion of Yes-Responses for the Choose-Deflated and Deflate-Shiny Conditions in Experiment 2. Error bars represent standard error.



Post-hoc comparisons indicated that the initial typical state (the inflated balloon) gained significantly more Yes-responses following the *deflate-shiny* condition (mean = 0.94, SE = 0.01) than the *choose-deflated* condition (mean = 0.63, SE = 0.02, z = - 22.48, p < .001), while there was

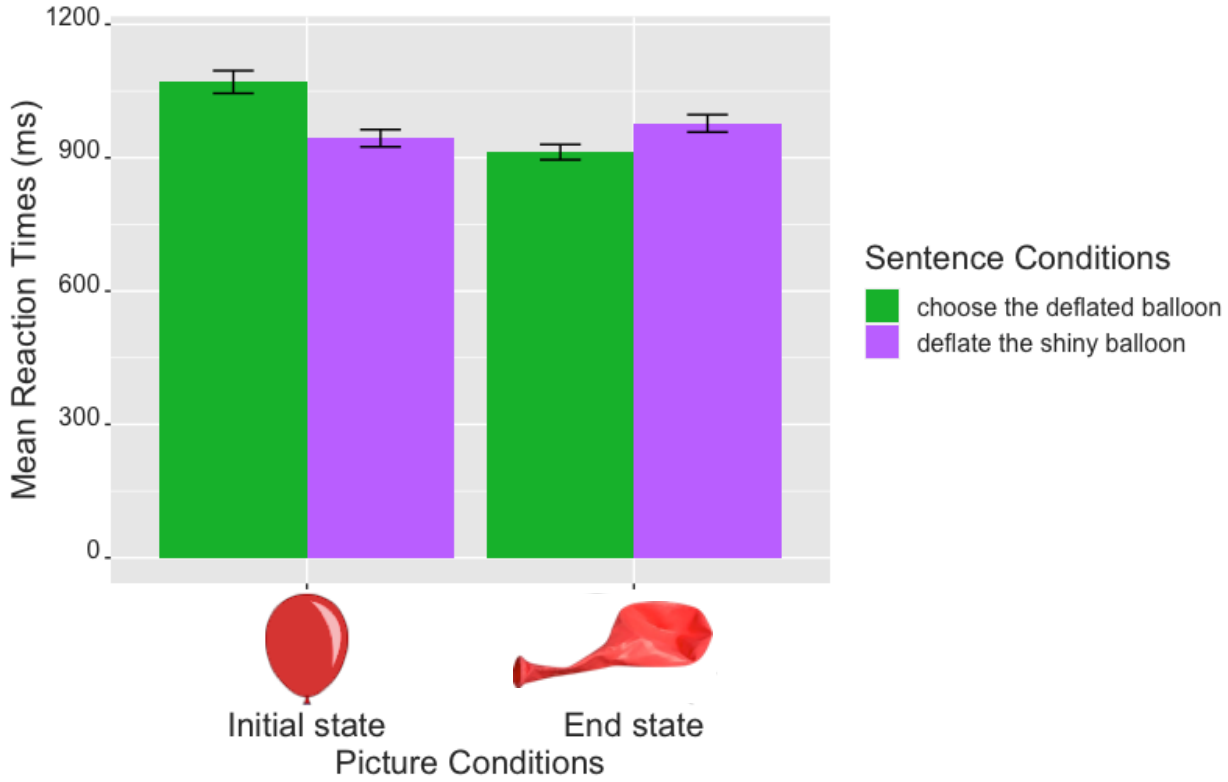
no significant difference in the proportion of Yes-responses to the end atypical state (the deflated balloon) following the *choose-deflated* (mean = 0.95, SE = 0.01) or *deflate-shiny* (mean = 0.95, SE = 0.01, z = 0.98, p = 0.76) conditions.

State-change verbs vs. Participles: Reaction Times

See Figure 9. We found a significant fixed effect of Picture type ($\chi 2$ (1) = 23.557, p < .001) and Sentence type ($\chi 2$ (1) = 7.735, p < .05). There was also a significant interaction between Picture type and Sentence type, $\chi 2$ (1) = 120.2, p < .001.

Figure 9

Mean Raw Reaction Times to Pictures Following Sentences in the Choose-Deflated and Deflate-Shiny Conditions on Trials with Yes-Responses. Error bars represent standard error.



Post hoc comparisons indicated that the initial typical state (the inflated balloon) was verified faster following the *deflate-shiny* condition (mean = 944 ms, SE = 19 ms) than the *choose-deflated* condition (mean = 1071 ms, SE = 26 ms; t = 10.1, p < .001), while the end atypical state (the deflated balloon) was verified slower following the *deflate-shiny* condition (mean = 977 ms,

SE = 20 ms) compared to the *choose-deflated* condition (mean = 913 ms, SE = 17 ms, t = -5.2, p < .001).

Discussion

In Experiment 1, the initial state (the atypical state) was more accessible after substantial-change verbs ("*inflate*") than after minimal-change verbs ("*choose*"). We interpreted this to reflect the activation of that initial state as a part of the event representation associated with the inflation event. In Experiment 2, however, we found *decreased* accessibility of the initial (now typical inflated) state following substantial-change verbs ("*deflate*") than after minimal-change verbs. Before speculating why the pattern reverses between Experiments 1 and 2 we note, crucially, that in Experiment 2 we again observe greater accessibility of the initial (typical inflated) state of the balloon after "*deflate the shiny balloon*" than after "*choose the deflated balloon*". Using this latter participial case as a baseline, we can conclude that some representation of the initial state, and not just of the end state, is active at the end of the "*deflate*" sentence, although *why* it is active is unclear – in the Introduction we pointed out that when the initial state is also the more typical state, it may not be activated through being a part of the event representation associated with *deflating*, but through being activated bottom-up and independently of the context at "*balloon*" (c.f. Kukona et al., 2014). Interestingly, the proportion of Yes-responses in response to depictions of the initial state following *"the clown will choose the deflated balloon"* was again 63% (c.f. Experiment 1), even though in Experiment 2 this initial state was the more typical state associated with the class of object referenced by the head noun (i.e. balloons) – in Experiment 1 the initial state was the less typical state associated with this class of object. In other words, the defocusing of the initial state does not appear to have been modulated by the typicality of that state. We note, however, that this comparison contrasts the 63% in Experiment 2 with the 63% in the *separate* Experiment 1 and that

such comparisons should be treated with caution; we return to this issue in discussion of Experiment 4 below, which included the "*choose the inflated balloon*" condition of Experiment 1, albeit with somewhat changed stimuli. For now, we return to the differences we observed across the two experiments in the accessibility of the initial state as a function of minimal vs. substantial change verbs.

We have interpreted the data as indicating that the initial state was more accessible after substantial-change verbs than after minimal-change verbs in Experiment 1, with the opposite being true in Experiment 2, However, the faster response times and increased Yes-responses in *both* experiments corresponded to the conditions in which participants responded to the depiction of the *inflated* balloon (and equivalent across the different trials). Thus, it is conceivable that the inflated balloon was a better match to "the shiny balloon" than was the deflated balloon, and that this could have led to, or contributed to, the reversal in pattern across Experiments 1 and 2. We note, however, that in a study conducted by the 2nd author, incorporating the same image stimuli and predominantly the same minimal/substantial-change sentences from Experiment 1, but *without the adjective* "*shiny*" (i.e. "*The clown will choose the balloon*" vs. "*The clown will inflate the balloon*"), the exact same patterns of response times and Yes-responses were observed as in Experiment 1.[4]

[4] Sixty four stimuli, across 4 conditions (minimal vs substantial, initial/end state depicted) were presented over Prolific to 179 participants (after exclusion criteria were applied). There were faster RTs to initial state depictions after substantial change (824 ms) than minimal change verbs (849 ms, $p=.005$) and faster RTs to end state depictions after minimal (748 ms) than substantial change verbs (773 ms, $p<.001$). There was a main effect of picture type ($p<.001$) and an interaction between picture type and verb type ($p<.001$). Statistical analyses were performed using the same model described in the main text. The larger number of stimuli (Experiment 1 had 48) was to accommodate a subsequent study with more conditions. Of the 64 stimuli in this study, 48 used the same visual depictions as used in Experiment 1 with only slight and occasional changes to the associated sentential stimuli.

Further, Experiment 2 reported here corresponds (with somewhat modified items) to Experiment 3 of Kang et al. (2019), who also omitted the adjectives (i.e. "*.. will choose the balloon*" vs. "*..will deflate the balloon*"), and who reported the exact same patterns (of response times – Yes-responses were not reported) as we observed in Experiment 2. Consequently, we do not believe that the inflated balloon was a better match to "*the shiny balloon*" than was the deflated balloon (or at least, that this possibility did not impact on our results). Why, then, that reversal?

First, the contrast between "*choose the shiny balloon*" and "*inflate the shiny balloon*" (Experiment 1): Uncontroversially, we claim that after "*choose*", the more typical feature set associated with balloons is the more active – hence the greater number of Yes-responses after "*choose*" to the more typical inflated balloon than to the less typical uninflated balloon (see Figure 2). Following Altmann & Ekves (2019), we claim that the feature set associated with this less typical (uninflated) state of a balloon, although not particularly active after "*choose*", is (more) activated after "*the clown will inflate the shiny balloon*", because it is a part of the event structure associated with the interpretation of that sentence. Hence the pattern in Experiment 1. But this is the reverse of the pattern we observed in Experiment 2: For the "*choose*" condition here we again assume that same typicality effect – greater activation of the typical feature set associated with (inflated) balloons than of the atypical feature set associated with uninflated balloons (see Figure 6). But after "*the clown will deflate the shiny balloon*" we speculate that the atypical feature set, associated with the result of the deflating, must be activated at the expense of the typically more active (inflated) feature set (generally, time runs forward unless a temporal adverbial such as "*earlier*" or "*but first*" indicates a temporal reversal, hence our assumption that the end state in these cases is the more activated); that is, the more typical feature set associated with balloons, although a part of the event structure associated with the sentence, is defocused to enable the

atypical end-state to become the more focused, salient, state after "*deflate the balloon*". In Experiment 1, the atypical feature set associated with the initial state does not require that same defocusing given the pre-potency of the more typical feature set. Whether defocusing the more typical feature set involves active suppression (c.f. competition) or more passive selection of one feature set rather than another, is a topic for future research.

In Experiment 3 we ask whether the Yes-responses to the entailed initial state of the balloon after "*The clown will choose the inflated balloon*" reflect some residual activation of that initial state, notwithstanding its function to focus attention on the end-state. In principle, those 63% of Yes-responses to the depicted uninflated balloon after "*… the inflated balloon*" and to the depicted inflated balloon after "*… the deflated balloon*" could instead reflect just the *semantic overlap* between the depicted balloon and the intended end state conveyed by the participial phrase. The deflated balloon is a balloon, just as an inflated balloon is a balloon, and they therefore match on *semantic type* – the depicted balloon, regardless of the specific state it is in, is a *type* of object that was mentioned in the immediately prior sentence – hence the "Yes" response. To test this, in Experiment 3 we contrast responses to a deflated balloon preceded by the sentences "*The clown will choose the inflated balloon*" and "*The clown will choose the completely inflated balloon*". If semantic overlap is driving those 63% of Yes-responses, it should not matter whether the balloon is inflated or completely inflated – in both cases it is a balloon and matches the depicted image on the basis of semantic type. Similarly for the comparison between "*The clown will inflate the balloon*" and "*The clown will completely inflate the balloon*".

Experiment 3

In this study, we introduced additional conditions which contained amplifiers, i.e. a type of intensifier adverb. See Table 3.

Table 3

Examples of Experimental Stimuli Used in Experiment 3

Condition	**Sentence Example**	Notes
inflate	The clown will inflate the shiny balloon.	Bare Verb
completely-inflate	The clown will completely inflate the shiny balloon.	Amplified Verb
choose-inflated	The clown will choose the inflated balloon.	Bare Participle
choose-completely-inflated	The clown will choose the completely inflated balloon.	Amplified Participle

We assumed that the amplifier increases the contrast between the end state and the initial state because the end state is now further along the dimension of change than is the un-intensified version; Quirk et al., 1985. If Yes-responses in Experiments 1 and 2 reflect semantic type overlap between the depicted initial state and the representation of the end state that carried forward, the adverbial modifier should have no impact on the Yes-responses. There would be no reason for a difference, for example, in Yes-responses to the image of an uninflated balloon after "*The clown will inflate the shiny balloon*" or "*The clown will completely inflate the shiny balloon*" – in principle, Yes-responses should reflect the match between "*the shiny balloon*" and the depicted balloon, regardless of the adverbial amplifier "*completely*". If instead Yes-responses reflect graded reduction in activation of the initial state (coupled with graded activation of the end state) as a function of that contrast, the amplifier should reduce the proportion of Yes-responses in both the *completely-inflate* and *choose-completely-inflated* conditions relative to the bare *inflate* and *choose-inflated* conditions.

Participants

Two hundred eleven native speakers of English were recruited via Prolific (119 female, mean age 37, range 18-75). See Experiment 1 for sample size justification. The experiment lasted approximately 15 minutes and participants received $1.70 for their participation.

Materials & Design

In this experiment, there were four critical sentence conditions, where we manipulated the presence of an amplifier (we will refer to this factor as Amplifier), e.g. *inflate* vs *completely inflate*, and sentential structure (we will refer to this factor as Structure) such that the sentence contained either a state-change verb and an adjective or a minimal-change verb and a participle. The conditions are summarized in Table 3 above and the full list of sentences is provided in Appendix C. Each experimental sentence was followed by a depiction of the initial state only.

All state-change verbs described change from a less to a more typical state. We reused 23 items from experiment 2 and designed 9 more new items. In addition to 32 critical items, there were 96 fillers, 32 of which contained depictions of objects in their end states (relative to the state change events described by the preceding sentences) and 64 of which contained objects which were not mentioned in the sentences they followed. This way we kept the ratio of matching objects the same in all three experiments reported here. Across all thirty-two experimental items (those reused from Experiment 2 and those designed specifically for this study), the initial state (mean = 4.39, SD = 0.79) was rated as a less typical instance of an object than the end state (mean = 5.92, SD = 0, 43, $t(31) = 10.94$, $p < 0.001$). All sentences were normed for the degree of change that the verb entailed in a separate off-line norming task. One hundred thirty participants were asked to read sentences and indicate, on a scale from 1 to 7, the extent to which the object in each sentence changes as a result of the action described. Sentences in the *choose-inflated* condition received an

average object-state change rating of 1.51 (SD = 0.34) and sentences in the *choose-completely-inflated* condition received an average rating of 1.59 (SD = 0.39), while sentences in the *inflate* condition received an average rating of 4.32 (SD = 0.73) and sentences in the *completely-inflate* condition received an average rating of 4.65 (SD = 0.84). Pairwise comparisons showed that state change ratings for the *choose-inflated* and *inflate* conditions were significantly different ($t(31) = 18.65$, $p < .001$). The same was true for the *choose-completely-inflated* vs *completely-inflate* comparison ($t(31) = 20.47$, $p < .001$).

Procedure

Procedure was the same as in Experiment 1.

Analysis

All analyses were conducted in R v.3.6.2 (R Core Team, 2013). First, participants whose accuracy on comprehension questions was below 80% were excluded from the analysis. This resulted in 164 participants whose data were included in the final analyses. Trials with RTs shorter than 300 ms were excluded, and for the reaction time analyses trials with *No*-responses to the critical images were also excluded.

Analyses were performed on both the proportion of Yes-responses and the log-transformed reaction times (RTs) using the generalized linear mixed effects (proportion of Yes-responses) and linear mixed effects models (RTs) available as part of the lme4 R package (Bates et al., 2015).

Proportion of Yes-Responses

To analyze the relationship between the proportion of Yes-responses to the depiction of the initial state and sentence type, we ran generalized linear mixed effects models using the *glmer* function (the model automatically converted responses to logit scale). In the baseline model, we estimated the fixed effects of Amplifier and Structure. Participant and Item were entered as the

random effects. We used an *optimx* optimizer to keep the settings consistent across the three experiments.

Proportion of Yes-responses ~ Amplifier + Structure + (1 | Participant) + (1 | Item)

In order to evaluate the significance of the main effects of Amplifier and Structure and their interaction, the above model was iteratively compared to models without the factors of interest to evaluate the main effect of factors or to the model with the added interaction term to evaluate the effect of interaction.

Proportion of Yes-responses ~ Amplifier * Structure + (1 | Participant) + (1 | Item)

Proportion of Yes-responses ~ Amplifier + (1 | Participant) + (1 | Item)

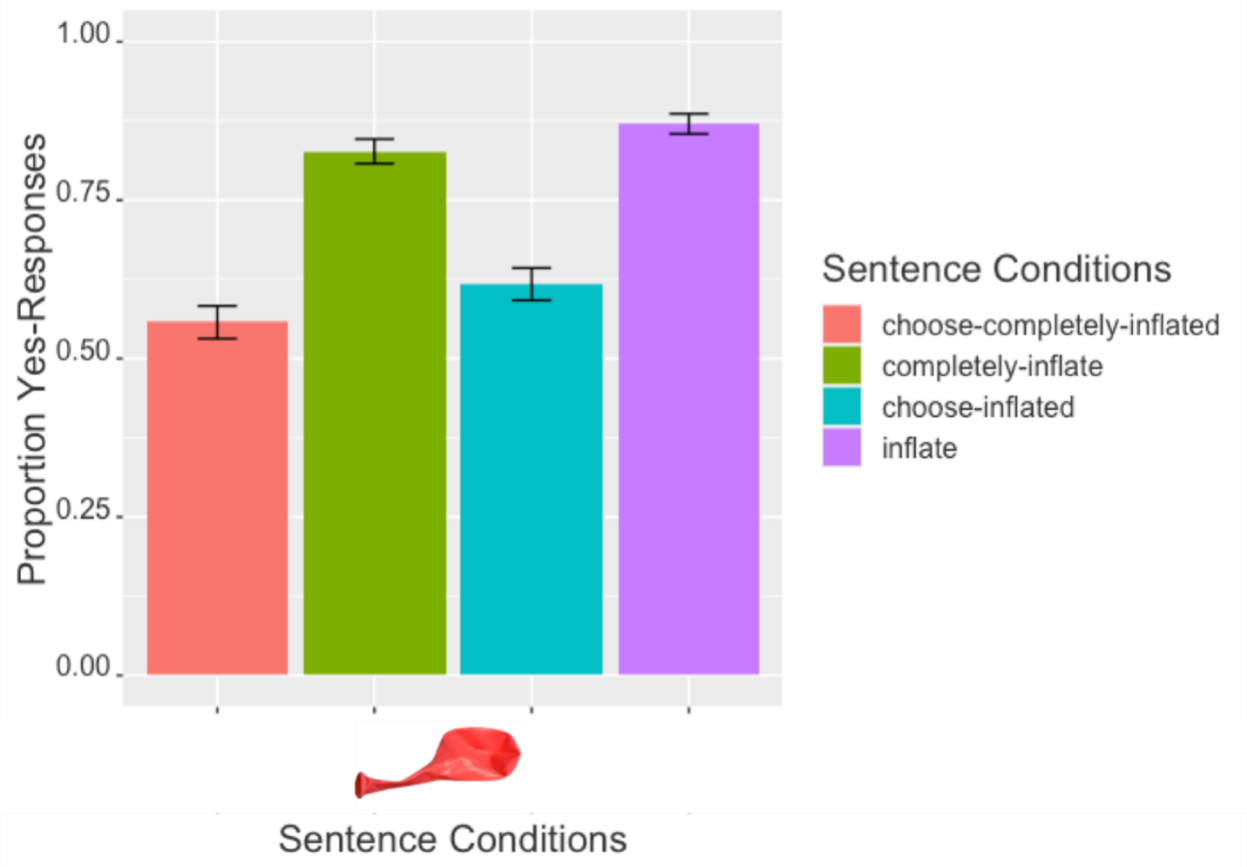
Proportion of Yes-responses ~ Structure + (1 | Participant) + (1 | Item)

To assess the goodness of fit, we compared the models using the $\chi 2$ -distributed likelihood ratio and its associated p-value. The model with a smaller Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) was considered a better fit.

The results are illustrated in Figure 10. We found a significant fixed effect of Amplifier ($\chi 2$ (1) = 29.7, $p < .001$) and Structure ($\chi 2$ (1) = 684.52, $p < .001$). The interaction wasn't significant.

Figure 10

Proportion of Yes-Responses in Experiment 3.



Note. Error bars represent standard error. For the ease of interpretation, we provide the raw proportions and standard errors for all conditions: *completely-inflated – 0.56, 0.03; completely inflate – 0.83, 0.02, inflated – 0.62, 0.03; inflate – 0.87, 0.02.*

We used the model with both fixed effects to run pairwise planned comparisons to test the predictions that the amplifier should reduce the proportion of Yes-responses in the *completely-inflate* and *choose-completely-inflated* conditions relative to the bare *inflate* and *choose-inflated* conditions respectively. These comparisons indicated that the initial state (the deflated balloon) gained significantly fewer Yes-responses following the *completely-inflate* condition (mean = 0.83, SE = .02) compared to the *inflate* condition (mean = 0.87, SE = .02; $z = 5.49$, $p < .001$). Similarly, the initial state gained significantly fewer Yes-responses following the *choose-completely-inflated*

condition (mean = 0.56, SE = .03) compared to the *choose-inflated* condition (mean = 0.62, SE = .03; $z = 5.49$; $p < .001$).

Reaction Times

The results are illustrated in Figure 11. We found a significant fixed effect of Structure, $\chi 2$ (1) = 21.86, $p < .001$. The effects of Amplifier and the interaction were not significant.

Post hoc comparisons run on the model containing only the Structure predictor indicated that depictions of the initial state were verified slower following sentences with participles (mean = 1079 ms, SE = 22 ms) than sentences without them (M = 1042 SE = 19 ms; $t = 4.67$, $p < 0.001$).

Figure 11

Reaction times in Experiment 3.

Note. Error bars represent standard error. For the ease of interpretation, we provide the raw means and standard errors for all conditions: *choose-completely-inflated* – 1086 ms, 32.71 ms; *completely-inflate* – 1057 ms, 27.26 ms, *choose-inflated* – 1071 ms, 29.00 ms; *inflate* –1027 ms, 25.57 ms.

Discussion

As expected given the prior experiments, we found an effect of Structure (e.g. "*inflate the balloon*" vs. "*choose the inflated balloon*") on accessibility of the initial state as reflected in both the reaction times and the proportions of Yes-responses.

The effect of Amplifier (e.g. "*the completely inflated balloon*" vs. "*the inflated balloon*") on the proportion of Yes-responses suggests that an adverb with an intensifying property modulates accessibility of event participants, i.e. in this case, the initial state of an object which

participated in a state change event. That is, those 62% (Expt 3) and 63% (Expts. 1 and 2) of responses in which participants responded “Yes” to a depiction of the initial state entailed by the adjectival passive do not solely reflect semantic type overlap. If they did, we would not expect any effect of the intensifier. Rather, we believe that the intensifier increases the contrast between the intended end-state and the entailed initial state, leading to (even) less activation of that initial state. We do note that, in principle, we could instead explain these data by supposing that the mental representation of a “completely inflated balloon” is a worse match to a depiction of an uninflated balloon than is the mental representation of an “inflated balloon”. But how could this be if not through some modulation of activation equivalent to that proposed increase in the contrast between the end state and the entailed (and depicted) initial state?

We conclude, therefore, that those 63% of responses in Experiments 1 and 2, and 62% in Experiment 3, in the bare participial conditions reflect defocusing of the initial-state (relative to the end-state), with scope for further defocusing when additionally modulated by intensifier adverbs. Those Yes-responses are likely to arise through both residual activation of the initial state (i.e. the feature set associated with that state) *and* semantic overlap (in respect of semantic features). Conceivably, they reflect also whatever activation there may be of some representation of a *contrast* object (for “*the inflated balloon*” this would be an uninflated balloon). A challenge going forward will be to distinguish empirically, in the participial conditions, between responses due to semantic/contrast overlap, due to the residual activation of the initial state, or due to both these factors. In Experiment 4, we again consider the provenance of those mismatched Yes-responses, and whether they indicate residual activation of the entailed initial state of the balloon after "*The clown will choose the inflated balloon*", but from the perspective of a more methodological question: What proportion of responses should we expect when the primary

dimension of overlap between the language-generated representation of the target object, and the depiction of that object, is only through the objects being of the same type?

Experiment 4

After "*The clown will choose the inflated balloon*" in Experiments 1 and 3, participants responded on 96% of trials that an inflated balloon depicted an object mentioned in the sentence, but on only 63% and 62%, respectively, of trials that an uninflated balloon depicted such an object. We conjectured that these Yes-responses reflected a combination of (a) some representation of the entailed uninflated state being activated, and (b) *type* overlap between representations corresponding to an inflated and uninflated balloon (both being balloons, that is). There are other possibilities also (e.g. representations of pragmatically licensed contrasts), but here we shall focus on matches and mismatches of state and type. Specifically, we shall contrast the Yes-responses (and associated RTs) when the depicted object is in the mismatching state in the participial condition (e.g. "*choose the inflated balloon*" with a depiction of an uninflated (yellow) balloon) with when the depicted object mismatches the adjectival description in the *choose* condition (e.g. "*choose the purple balloon*" with a depiction of that same uninflated yellow balloon). In this latter case, the state of the balloon mismatches the more typical state (i.e. inflated) that would be more highly active after "*choose*", and it mismatches on the property dimension referenced by the adjective (in this case, color, but in other cases, pattern, substance, shape, etc. – see Appendix D). As such the mental representation generated by the language, and the visual depiction overlap only in respect of semantic type (e.g. that it is a balloon, albeit in a possible, but atypical, state licensed by semantic knowledge of balloons). The rationale for this contrast is as follows: Notwithstanding the results from Experiment 3, an issue of concern is whether in a sentence such as "*the clown will choose the inflated balloon*" there is any residual activation of some representation of that same

balloon but in its uninflated state. At one extreme, one might argue that both the inflated and entailed uninflated state are equally accessible, in which case the depiction of an uninflated balloon would constitute a straightforward match, yielding high proportions of Yes-responses. At the other extreme, one might argue that the uninflated state is not activated at all, in which case the depiction of the uninflated balloon would mismatch in state and match only through semantic type overlap. The sentence "*the clown will choose the purple balloon*" constitutes a baseline, insofar as in this case also the depiction of the uninflated balloon would mismatch in state (relative to the pre-potent more typical state) and color, leaving just semantic type overlap as the basis for a Yes response. But of course, even in this case, one might suppose that the different state-representations that are possible for a balloon, both inflated (typical) and uninflated (atypical), would be activated in proportion to their typicality, in which case even in this case, there should be some residual activation of the mental representation corresponding to the balloon in its uninflated state. Thus, if both "*the clown will choose the inflated balloon*" and "*the clown will choose the purple balloon*" engender similar numbers of Yes-responses to a depiction of an uninflated (yellow) balloon, this most likely reflects some residual activation of the uninflated balloon in both the *choose-inflated* condition and the *choose-purple* condition. However, whereas the *choose-inflated* condition *entails* that uninflated state (as a part of the history of the balloon, and hence as a part of its representation, according to the Intersecting Object Histories account of event representation; Altmann & Ekves, 2019), the *choose-purple* condition does not. We would thus expect greater activation of the uninflated state in the former condition than in the latter, and hence more Yes-responses (and correspondingly faster RTs). To turn the argument around: More Yes-responses and faster RTs to the uninflated balloon in the *choose-inflated* than *choose-purple* conditions would imply greater activation of the uninflated-state representation in the participial case than in

the adjectival case, and hence that there *is* residual activation of that uninflated-state representation in the participial case (and we note that in both cases, there could be bottom-up activation of the semantically licensed uninflated state just due to the lexical item "*balloon*", in which case we do expect some potential residual activation of this state representation in both cases, but the key issue is whether there is *more* activation of this state in the entailing participial case).

Participants

Two hundred native speakers of English were recruited via Prolific (77 female, mean age 40, range 19-75). See Experiment 1 for sample size justification. The experiment lasted approximately 15 minutes and participants received $1.70 for their participation.

Materials & Design

The design was a 2 x 2 fully factorial design with modifier type (adjective vs. participle) and picture match (match vs. mismatch). The sentences in this study consisted of 32 sentence triples describing 32 objects. The full list of sentences is provided in Appendix D. We used 64 clipart images depicting the same 32 objects in two alternative states.

Participles in our sentences were the same across the match and mismatch conditions, although we used different adjectives to introduce the mismatch in the adjectival conditions (see table 4 for examples). All adjectives and participles were matched on length and frequency. All participants saw each sentence in just one of the four conditions paired with an image depicting an object in one of the two possible states. The stimuli were divided into four lists using a Latin square design.

The stimuli also included 32 fillers, where the image depicted an object of a different type than the one mentioned in a sentence. For example, participants heard a sentence *The girl will examine the blue bowl*, and were presented with a picture of a blue chair. Across the 32 fillers, half

contained an adjective and half a participle, and half contained a match on the property dimension (be it a state or something else), and half a mismatch.

Procedure

The procedure was the same as in the previous experiments.

Table 4

Examples of Experimental Stimuli Used in Experiment 4

Condition	Sentence Example	Picture Description
Adjective-match	The clown will choose the yellow balloon.	Inflated yellow balloon
Adjective-mismatch	The clown will choose the purple balloon.	Deflated yellow balloon
Participle-match	The clown will choose the inflated balloon.	Inflated yellow balloon
Participle-mismatch	The clown will choose the inflated balloon.	Deflated yellow balloon

Analysis and Results

All analyses were conducted in R v. 3.6.2 (R Core Team, 2013). First, participants whose accuracy on comprehension questions was below 80% were excluded from the analysis. This resulted in 155 participants whose data were included in the final analyses. Additionally, trials with RTs shorter than 300 ms and, for the reaction time analyses, *No*-responses to critical images were also excluded.

Analyses was performed on both the proportion of Yes-responses and the log-transformed reaction times (RTs) using the generalized linear mixed effects (proportion of Yes-responses) and linear mixed effects models (RTs) available as part of the lme4 R package (Bates et al., 2015).

We used the same approach as in experiments 1-3. In order to evaluate the significance of the main effects of Prenominal Modifier (Adjective or Participle) or Picture Match (Match or Mismatch) and their interaction, the full model was iteratively compared to models without the

factors of interest to evaluate the main effect of factors or to the model with the added interaction term to evaluate the effect of interaction. The following models (starting with the full model) were compared in a pairwise fashion:

Log(RTs)/Proportion of Yes-responses ~ Prenominal Modifier + Picture Match + (1 | Participant) + (1 | Item)

Log(RTs)/Proportion of Yes-responses ~ Picture Match + (1 | Participant) + (1 | Item)

Log(RTs)/Proportion of Yes-responses ~ Prenominal Modifier + (1 | Participant) + (1 | Item)

Log(RTs)/Proportion of Yes-responses ~ Prenominal Modifier * Picture Match + (1 | Participant) + (1 | Item)

The results are summarized in Figures 12 and 13. For the proportion of Yes-responses, we found a significant fixed effect of Picture Match ($\chi2$ (1) = 3526.2, $p < .001$) and Prenominal Modifier ($\chi2$ (1) = 161.3, $p < .001$). The interaction was also significant ($\chi2$ (1) = 69.63, $p < .001$).

The Match picture condition resulted in no significant difference between sentences with participles and adjectives ($\beta = -0.22$, SE = 0.21, $z = -1.05$, $p = .293$). And in the Mismatch picture condition, there were more Yes-responses after sentences with participles than sentences with adjectives ($\beta = 1.52$, SE = 0.12, $z = 12.78$, $p < .001$).

The analysis of log RTs resulted in significant effects of Picture Match ($\chi2$ (1) = 122.49, $p < .001$), Prenominal Modifier ($\chi2$ (1) = 15.76, $p < .001$) and their interaction ($\chi2$ (1) = 16.4, $p < .001$).

For the Match picture condition, responses to matching pictures were slower after sentences with participles than after sentences with adjectives ($\beta = 0.067$, SE = 0.013, $t = 5.266$, p

< .001). Conversely, in the Mismatch picture condition, responses were faster after sentences with participles than after sentences with adjectives (β = 0.063, SE = 0.03, t = -2.14, p = .032).

Figure 12

Proportion of Yes-Responses in Experiment 4. Error bars represent standard errors.

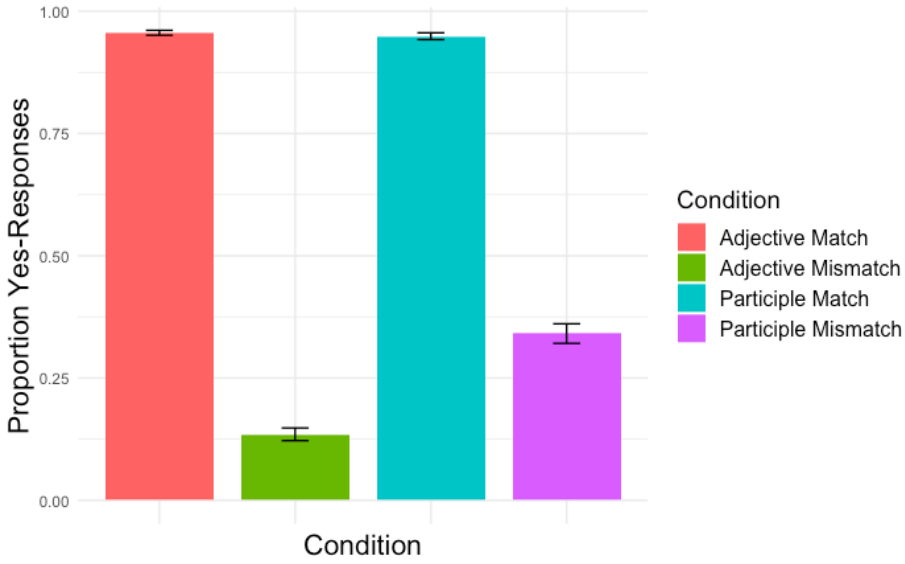
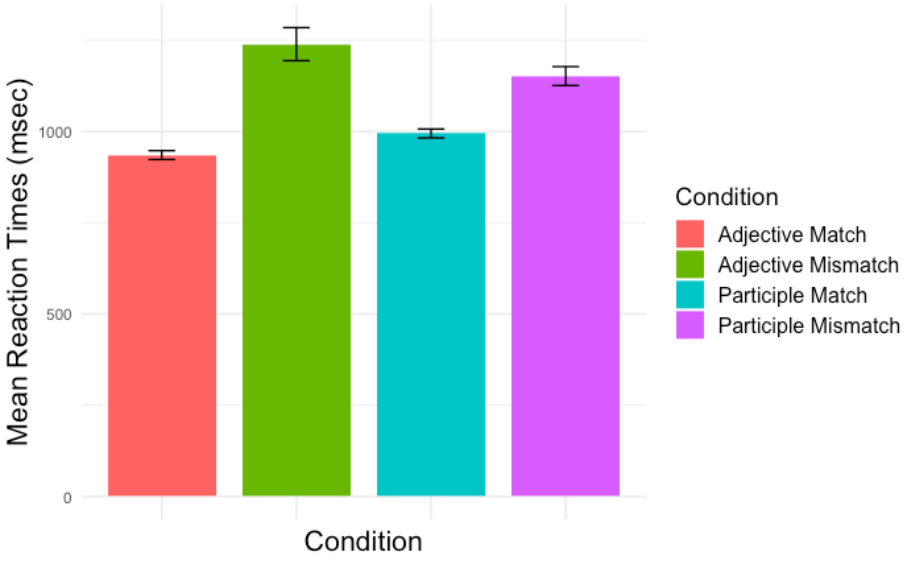


Figure 13

Mean Raw Reaction Times in Experiment 4. Error bars represent standard error.



Discussion

As expected, when *choose-yellow* and *choose-inflated* conditions were accompanied by a matching depiction (an inflated yellow balloon), proportions of Yes-responses were high (95%), with the fastest RTs to generate those Yes-responses in the *choose-yellow* condition relative to the *choose-inflated* condition. We would conjecture that this difference, across the two matching conditions, reflects interference between the event-entailed inflated *and* uninflated state representations in the *choose-inflated* condition that is absent in the *choose-yellow* condition. Critically, there were more Yes-responses in the mismatching *choose-inflated* condition (36%) than the mismatching *choose-purple* condition (14%), and correspondingly faster RTs in the mismatching *choose-inflated* condition (1152 ms) than the mismatching *choose-purple* condition (1240 ms). Thus, we conclude greater residual activation of the representation of the uninflated state in the participial *choose-inflated* condition than in the adjectival *choose-purple* condition. Correspondingly, we conclude that semantic overlap is not the only driver of those increased Yes-responses and faster RTs in the participial condition, but that the event-entailed initial-state representation (i.e. the balloon before it has been inflated) is driving that increase.

Interestingly, the proportion of Yes-responses in the *choose-inflated* condition when followed by a picture of the entailed initial state (an uninflated balloon) was considerably lower in this experiment (36%) than in Experiments 1 to 3, where it was 63%. We conjecture that this is due both to differences in the target items, but also the inclusion of a condition in which semantic type overlapped but some other feature (e.g. color) did not. Participants may have therefore been less liberal in their Yes-responses when the target picture overlapped in semantic type with the object mentioned in the sentence. We note that Yes-responses to fillers which did not overlap in semantic type were rare, less than 4%. Again, we believe that the equal response rates in

Experiments 1 and 2, where initial states were either more (Experiment 2) or less (Experiment 1) typical should be treated with caution and does not necessarily indicate that the amount of residual activation of the initial state in the participial construction is independent of its typicality. Further research would be required to resolve this particular issue.

General Discussion

Experiments 1 and 2 examined the representational content of sentences with verbs which entail either minimal ("*choose the balloon*") or substantial change ("*inflate the balloon*") or with participles derived from state-change verbs ("*the inflated balloon*"). We probed state activation by using images of objects in different states (e.g. depicting an inflated or an uninflated balloon). These states were either initial or end states relative to the event described by the state-change verb. Our primary concern was whether, and under what conditions, both the initial- and end-state representations of an object are accessible at the ends of sentences which describe events culminating in the object in one state, but entailing that object having entered into that event in another state. Crucially, in Experiment 1, the verbs (and participles derived from them) described objects' transition from atypical to more typical states; finding evidence of the activation of the initial state at the offset of each sentence could not, therefore, be attributed to the greater activation of that state due to its typicality, as would be the case if the transitions went from more typical to less typical – in that case, evidence of the accessibility of the initial state could simply reflect the pre-potency of the more typical feature set associated with the object concept. We showed that the initial state of the changed object (e.g. the balloon in its uninflated state) was more accessible after state-change verbs (e.g. "*inflate the balloon*") than minimal-change verbs (e.g. "*choose the balloon*"). This study also showed that the initial state (e.g. as an uninflated balloon) was considerably more accessible after state-change verbs (e.g. "*inflate the balloon*") and minimal-

change verbs (e.g. "*choose the balloon*") than after participles (e.g. "*the inflated balloon*"). In the second study, the state-change verbs entailed changes from the typical to atypical state (e.g. "*deflate the balloon*"). We adopted this design to further explore the participial conditions from Experiment 1. We observed largely the same patterns, although in this case we found that the initial state (the typical, inflated, state of the balloon) was *less* accessible after the state-change verb than minimal-change verbs, not more, as in Experiment 1. We attribute this to the need to select as the more focal state the atypical state at the expense of, and with a relative cost to, the more typical state. But again, responses to the adjectival participle suggested substantial defocusing of the initial state in those cases, highlighting the increased accessibility of the initial state after both change-of-state verbs (in which case both are a part of the associated event representation) and minimal-change verbs (such as "*choose*", in which case both are a part of the lexical concept associated with "*balloon*", and each is probabilistically associated, in proportion to their respective typicalities, with the event representation associated with the choosing event – see Altmann & Mirkovic, 2009, for discussion of how thematic role assignment can proceed within a probabilistic framework in which there are multiple candidates for such roles). The fact that responses in the sentence-picture verification task were modulated by the addition, in the third experiment, of intensifier adverbs (e.g. "*completely*"), suggested that the defocusing of the initial state by the adjectival participial construction is not absolute but is graded, and can be further enhanced by increasing the contrast between the focal end-state and that initial state. Future research will be needed to contrast our studies with examples such as "*The clown will choose the barely inflated balloon*", in which "*barely*" (a "diminisher", Quirk et al., 1985) decreases the contrast between the focal end state and the entailed initial state; we would predict in such cases relatively greater activation (i.e. less defocusing) of the initial state and more Yes-responses in the sentence-picture

verification paradigm that we used in the current studies. The studies reported here, as well as others using different kinds of modifier expression, demonstrate how different linguistic devices (participles, verbs and amplifying adverbs) modulate the representational products of sentence comprehension.

We have assumed, until now, that the end state is the primary focus of the expression "*the inflated balloon*", even though an initial (uninflated) state is entailed. The interpretation of such adjectival passives is not without controversy (c.f. Embick, 2004; Sleeman, 2011). At issue is the degree to which the different components of the event representation are accessible at the end of the linguistic expression; a *resultative* interpretation would imply that being inflated is the result of an inflating event and that the balloon was not always inflated. And whereas the focus of the resultative is on the state that the balloon finds itself in (c.f. pure *statives* as in "*the dry towel*" which do not entail a prior alternative state), the focus of an *eventive* is on the process by which the balloon changed from one state to another. Participles like "*inflated*" are ambiguous between the two ("*the balloon was inflated*" can be interpreted as a resultative or an eventive). Embick (2004; see also Kratzer, 2000) argues that the adjectival passive in "*the inflated balloon*" cannot be interpreted as an eventive, whereas Sleeman (2011) argues that it can be. The behavioral evidence is mixed, with evidence both for (e.g. Kaup et al., 2010) and against (Ferretti et al., 2003) an eventive reading. Our own evidence leads us to conjecture that there is active suppression of the entailed initial state following an adjectival passive (i.e. that the defocusing we observed across our studies is an active process with the representation of the initial state being actively inhibited in the participial case), but that there *is* nonetheless some residual activation (hence permitting the intensifier to *further* reduce its activation in Experiment 3, and mitigating the effects of mismatch against that initial state in Experiment 4). We assume that such constructions possess both eventive

and stative qualities and that the distinct components of an event representation (minimally, the initial and end states of the objects taking part in the event) can each be activated to different extents. Thus, we view the stative/eventive/resultative distinction as reflecting not a unidimensional continuum but a continuous multi-dimensional (event) space. Regardless, the data are unambiguous: the initial state of the (uninflated) balloon after "*The clown will inflate the balloon*" is more accessible – its representation more activated – than after "*The clown will choose the balloon*", and this initial object-state representation, although activated to an extent, is relatively inaccessible after "*The clown will choose the inflated balloon*". Simultaneous activation of multiple object-state representations pertaining to the same object is thus a hallmark of event comprehension (Altmann & Ekves, 2019).

While a consistent picture does emerge across the four studies we have reported above, the task and stimuli we adopted are not without their limitations. For example, in response to the task instruction "*Did the item in the picture occur in the sentence you just read?*" the sentence "*The girl will buy the new camera*", followed by a picture of a tiger (one of the filler items) will clearly engender a "No" response. But the response to a picture of an inflated balloon after the sentence "*The clown will choose the deflated balloon*" is less obvious – and subtle changes to the task instruction could have significant impact on performance (consider the alternative instruction "*Did an item of the kind shown in the picture take part in the event described by the sentence you just read?*"). Future studies should consider a more naturalistic version of the paradigm that does not require a meta-linguistic task associated with the dependent variable. For example, Claus & Kriukova (2009) describe a task in which each sentence is followed by a picture which the participant must merely identify, pressing a button as soon as they've done so. At that point, a word appears that either matches the picture or does not. In this case, the speed with which the

picture can be identified is presumed to be affected by pre-activated, and overlapping, representations (i.e. priming) due to the prior sentence. Participants' response time to the image would therefore reflect the availability of the depicted object state as a function of the prior sentential content. A second limitation, inherent to any such task, involves the potential for backward priming (Koriat, 1981), and the possibility that atypical states can prime typical states (Connell & Lynott, 2009). Equally, the sentence-picture verification paradigm is not immune to response biases of various types; subtle changes to the instruction set (as already noted), the relative proportions of "yes" and "no" responses, and experiential differences across participants, can have both systematic and idiosyncratic effects on response biases. Our approach here has been to assume an account of the data that requires fewest assumptions or distinct mechanisms across the different conditions across all four studies. We believe that the consistent patterns across all four studies, coupled with converging data from both the same paradigm (Kang et al., 2019; Horchak and Garrido, 2020) and different paradigms (e.g. Solomon et al., 2015), do support the conclusion that change-of-state verbs generate event representations in which both the initial and end states (at a minimum) are represented and subsequently accessible, albeit to different degrees, and that morphosyntactic variants, such as passive participles derived from those same verbs, modulate the accessibility of those (episodic) representations.

A further limitation, albeit one that is common across many psycholinguistic studies of sentence processing: Our task consisted in sentence after sentence barely varying in syntactic structure, and crucially, in the absence of the prior contexts typical of natural discourse which generally set up antecedents to the referring expressions contained within the subsequent sentences of the discourse. In this sense, the processing of these sentences did not reflect the natural processes that most likely accompany the processing of sentences "in the wild". We do note, however, that

in the study by Solomon et al. (2015), the sentences there were a little more natural insofar as discourse entities were introduced with an indefinite referring expression and subsequently referred to with a definite: "*The chef will weigh/chop an onion. And then, she will smell the onion*". Nonetheless, the convergence we see across several studies (e.g. Solomon et al., 2015; Kang et al., 2019; Horchak & Garrido, 2021; the present study) increases the confidence that the effects we have observed here reflect sentence processing more generally. This said, a further limitation of the stimuli is that we have not considered the possible impact of tense and aspect on event representation and object-state activation. A sentence such as "*The clown will inflate the balloon*" entails that between the time of the event and some earlier time, the balloon will be in its uninflated state, while being agnostic as to what state it is in at utterance-time itself. "*The clown inflated the balloon*" entails that between event-time and some later time the balloon was in an inflated state, but it is similarly agnostic as to what state the balloon is in at utterance-time. The participial cases "*the clown will choose / chose the inflated balloon*" are also agnostic in this respect, requiring only that the balloon is in its inflated state at event-time and for some time before ("*will choose*") or after ("*chose*"). "*The clown has inflated the balloon*" is slightly different – suggesting that at utterance-time, the balloon is (still) in its inflated state. Further research is required to explore how the state of the critical object at utterance-time, or between utterance-time and event-time, affects, if at all, the subsequent accessibility of particular object-states during or after the processing of the utterance.

Going forward, the time-course of the accessibility of the distinct states of the acted-upon object remains to be explored – Solomon et al., (2015; see also Hindy et al., 2012) found effects of competition between the alternate states of the same token object (but not the alternate states reflected across different tokens) at the end of a subsequent sentence (e.g. "*The clown inflated a*

balloon. Then, he pointed to <u>the/another balloon</u>"). We presume that as more of the discourse unfolds, the likelihood of referring back to the initial state decreases (in the absence of reorienting temporal adverbial phrases such as "*but first*" or "*but even before all that*") and that the accessibility of that initial state likewise decreases. But this remains to be tested; the sentence-picture paradigm, while advantageous in part through being suited to large participant numbers tested remotely, is not suited to addressing questions pertaining to time-course. Other tasks, such as the visual world paradigm (e.g. Tanenhaus et al., 1995), which are now also suited to remote testing in large numbers (e.g. Prystauka, Altmann, & Rothman, 2023), would be required to explore the time-course of activation (and change in activation) of representations during event comprehension.

In addition to contributing to the literature on object-state representations and the meaning of participles, our findings have implications more broadly for theories of sentence-level meaning representation (e.g. the theory of situation models by Zwaan & Radvansky, 1998). They add to the growing body of work investigating how grammatical devices of language guide the construction of situation models by emphasizing particular aspects of meaning to be retrieved. Previous work on situation models suggests that the ease of integration of the incoming language into the current sentence-level meaning representation depends on how much overlap there is between the current representation and the incoming information on the following five dimensions: time, space, causation intentionality and protagonist (Zwaan & Radvansky, 1998). And yet, there is another important dimension which has not been explicitly accounted for by the work on sentence-level meaning – the amount of change an object undergoes as a result of someone or something acting upon it. We believe that our approach to investigating the meaning of different parts of speech (in this study: Participles, verbs and intensifying adverbs) within the framework of object-state

histories and event representation (Altmann & Ekves, 2019) has the potential to become an integral part of theories of morphosyntactic processing. This framework examines how events (both those directly perceived and those described by language) are comprehended from the perspective of the interplay between episodic and semantic memory, with different morphosyntactic devices sending different instructions to these different kinds of memory, allowing the speaker/writer to focus the listener/reader's attention on the objects that the discourse is about, their states at one moment to the next, or their interactions with other objects that brought about those changes in state.

Finally, one of the theoretical challenges for studies at the intersection of language and memory concerns the interplay between semantic and episodic memory during sentence comprehension: On the one hand, we *retrieve* semantic information associated with incoming words and phrases (from the meanings of individual words, to the typical objects or actions they denote, to schema-based knowledge about actions and events typical for a given situation). On the other, we use semantic memory to *instantiate* in episodic memory individual instances (*tokens*) of the semantic type from which they are drawn (see Altmann, 2017 and Altmann & Ekves, 2019 for an account of this instantiation, or tokenization, process). How is this interplay controlled at a neural level, given that the two types of memory are traditionally associated with different neural substrates (see e.g. Moscovitch, Rosenbaum, Bilboa., et al., 2005, for review)? And what is the relative timing of these two processes? For example, as described earlier, Kukona et al. (2014) observed that there is a stage during sentence processing (at least in the context of visual scenes) when semantic knowledge appears to be activated independently of its integration with the prior sentence or the (episodically based) situation described by the sentence. What are the factors that determine the temporal properties of the interplay between the different memory systems? Are such properties (e.g. the relative timing of one versus the other) determined solely by the separation

of representational content across different neural substrates, or are there other functional/contextual factors at play? Further research using methods from the behavioral, computational, and neurosciences will be required before we can address such questions.

Appendix A: Stimuli for Experiment 1

This appendix contains the materials used in Experiment 1. The first three rows of each cell of Table A1 contain the sentential stimuli, one per condition, and the last row contains the descriptions of the picture stimuli.

Table A1

The Sentential Stimuli and the Descriptions of the Picture Stimuli Used in Experiment 1

1	The athlete will select the plastic water bottle. The athlete will crush the plastic water bottle. The athlete will select the crushed water bottle. *Intact water bottle; crushed water bottle.*
2	The bartender will select the greenish glass bottle. The bartender will fill the greenish glass bottle. The bartender will select the filled glass bottle. *Empty bottle; filled bottle.*
3	The boy will adjust the stylish bowtie The boy will untie the stylish bowtie. The boy will adjust the untied bowtie. *Tied bowtie; untied bowtie.*
4	The boy will select the cute flower. The boy will cut the cute flower. The boy will select the cut flower. *Flower in the ground; plucked flower*.
5	The businessman will clench the purple umbrella. The businessman will close the purple umbrella. The businessman will clench the closed umbrella. *Open umbrella; closed umbrella.*
6	The camper will grab the waterproof sleeping bag. The camper will pack the waterproof sleeping bag. The camper will grab the packed sleeping bag. *Deployed sleeping bag; packed sleeping bag.*
7	The camper will select the lightweight tent. The camper will disassemble the lightweight tent. The camper will choose[5] the disassembled tent. *Assembled tent; packed tent.*
8	The child will admire the impressive sandcastle. The child will decorate the impressive sandcastle. The child will admire the decorated sandcastle. *Plain sandcastle; decorated sandcastle.*
9	The child will hold the colorful pool float. The child will deflate the colorful pool float. The child will hold the deflated pool float.

[5] Items 7 and 29 contain typographical errors which we believe didn't influence the results of the experiment.

Intact pool float; deflated pool float.

10 The clown will choose the shiny balloon.
The clown will deflate the shiny balloon.
The clown will choose the deflated balloon.
Inflated balloon; deflated balloon.

11 The coach will inspect the professional soccer ball.
The coach will deflate the professional soccer ball.
The coach will inspect the deflated soccer ball.
Inflated soccer ball; deflated soccer ball.

12 The father will inspect the bedroom window.
The father will crack the bedroom window.
The father will inspect the cracked window.
Intact window; broken window.

13 The father will inspect the modern washing machine.
The father will damage the modern washing machine.
The father will inspect the damaged washing machine.
Intact washing machine; broken washing machine.

14 The father will measure the backyard pool.
The father will drain the backyard pool.
The father will measure the drained pool.
Filled pool; drained pool.

15 The father will smell the fresh ham.
The father will slice the fresh ham.
The father will smell the sliced ham.
Intact ham; sliced ham.

16 The girl will choose the sweet ice-cream.
The girl will drop the sweet ice-cream.
The girl will choose the dropped ice-cream.
Upright ice-cream; dropped ice-cream.

17 The girl will feel the polyester shirt.
The girl will rip the polyester shirt.
The girl will feel the ripped shirt.
Intact shirt; ripped shirt.

18 The girl will hold the lightweight jump rope.
The girl will break the lightweight jump rope.
The girl will hold the broken jump rope.
Intact rope; broken rope.

19 The girl will reject the expensive gift.
The girl will unwrap the expensive gift.
The girl will reject the unwrapped gift.
Wrapped gift; unwrapped gift.

20 The girl will sit on the comfortable bed.
The girl will mess up the comfortable bed.
The girl will sit on the messed-up bed.
Made-up bed; messy bed.

21 The grandmother will choose the fresh apple.

The grandmother will slice the fresh apple.
The grandmother will choose the sliced apple.
Intact apple; sliced apple.

22 The grandmother will inspect her favorite book.
The grandmother will rip her favorite book.
The grandmother will inspect the ripped book.
Intact book; ripped book.

23 The grandmother will look at the exquisite plant.
The grandmother will tip over the exquisite plant.
The grandmother will look at the tipped over plant.
Intact plant; tipped over plant.

24 The hipster will photograph the decadent cup of coffee.
The hipster will spill the decadent cup of coffee.
The hipster will photograph the spilled cup of coffee.
Intact cup of coffee; spilled cup of coffee.

25 The janitor will curse at the sturdy trash can.
The janitor will tip over the sturdy trash can.
The janitor will curse at the tipped over trash can.
Upright trashcan; tipped over trashcan.

26 The janitor will scrutinize the wooden bench.
The janitor will break the wooden bench.
The janitor will scrutinize the broken bench.
Intact bench; broken bench.

27 The lumberjack will admire the enormous tree.
The lumberjack will chop the enormous tree.
The lumberjack will admire the chopped tree.
Intact tree; chopped tree.

28 The maid will feel the fluffy towel.
The maid will soak the fluffy towel.
The maid will feel the soaked towel.
Dry towel; wet towel.

29 The man will grab the menthol cigarette.
The man will light the menthol cigarette.
The man will choose the lit cigarette.
Intact cigarette; lit cigarette.

30 The man will wipe his designer glasses.
The man will break his designer glasses.
The man will wipe his broken glasses.
Intact glasses; broken glasses.

31 The mechanic will examine the automatic car.
The mechanic will smash the automatic car.
The mechanic will examine the smashed car.
Intact car; smashed car.

32 The mechanic will scrutinize the durable tire.
The mechanic will deflate the durable tire.
The mechanic will scrutinize the deflated tire.

Inflated tire; deflated tire.

33 The mother will admire the greenish candle.
The mother will extinguish the greenish candle.
The mother will admire the extinguished candle.
Lit candle; extinguished candle.

34 The mother will approach her favorite canopy.
The mother will disassemble her favorite canopy.
The mother will approach the disassembled canopy.
Assembled canopy; disassembled canopy.

35 The mother will look at the large egg.
The mother will crack the large egg.
The mother will look at the cracked egg.
Intact egg; cracked egg.

36 The mother will point to the plush rug.
The mother will roll the plush rug.
The mother will point to the rolled rug.
Unrolled rug; rolled rug.

37 The nanny will scan the colorful puzzle.
The nanny will disassemble the colorful puzzle.
The nanny will scan the disassembled puzzle.
Assembled puzzle; disassembled puzzle.

38 The officer will grab the fluorescent traffic cone.
The officer will tip over the fluorescent traffic cone.
The officer will grab the tipped over traffic cone.
Upright traffic cone; tipped over traffic cone.

39 The player will inspect the high-quality basketball.
The player will deflate the high-quality basketball.
The player will inspect the deflated basketball.
Inflated basketball; deflated basketball.

40 The skydiver will examine the sturdy parachute.
The skydiver will repack the sturdy parachute.
The skydiver will examine the repacked parachute.
Deployed parachute; closed parachute.

41 The squirrel will hold the brown acorn.
The squirrel will crack the brown acorn.
The squirrel will hold the cracked acorn.
Intact acorn; cracked acorn.

42 The squirrel will sniff the brown walnut.
The squirrel will crack the brown walnut.
The squirrel will sniff the cracked walnut.
Intact walnut; cracked walnut.

43 The student will hold the yellow ruler.
The student will break the yellow ruler.
The student will hold the broken ruler.
Intact ruler; broken ruler.

44 The teenager will wear the baggy t-shirt.

The teenager will tie dye the baggy t-shirt.
The teenager will wear the tie-dyed t-shirt
White t-shirt; tie-dyed t-shirt.

45 The veteran will admire the patriotic flag.
The veteran will fold the patriotic flag.
The veteran will admire the folded flag.
Unfolded flag; folded flag.

46 The waitress will scrutinize the ceramic plate.
The waitress will break the ceramic plate.
The waitress will scrutinize the broken plate.
Intact plate; broken plate.

47 The woman will observe the antique mirror.
The woman will shatter the antique mirror.
The woman will observe the shattered mirror.
Intact mirror; shattered mirror.

48 The writer will hold the lead pencil.
The writer will break the lead pencil.
The writer will hold the broken pencil.
Intact pencil; broken pencil.

Appendix B: Stimuli for Experiment 2

This appendix contains materials used in Experiment 2. The first three rows of each cell of Table B1 contain the sentential stimuli, one per condition, and the last row contains the descriptions of the picture stimuli.

Table B1

The Sentential Stimuli and the Descriptions of the Picture Stimuli Used in Experiment 2

1	The athlete will select the plastic water bottle. The athlete will straighten the plastic water bottle. The athlete will select the straightened water bottle. *Smashed water bottle; straightened water bottle.*
2	The bartender will select the greenish glass bottle. The bartender will empty the greenish glass bottle. The bartender will select the emptied glass bottle. *Filled bottle; empty bottle.*
3	The boy will adjust the stylish bowtie. The boy will tie the stylish bowtie. The boy will adjust the tied bowtie. *Untied bowtie; tied bowtie.*
4	The boy will smile at the colorful piñata. The boy will knock down the colorful piñata. The boy will smile at the knocked down piñata. *Intact piñata; the knocked down piñata.*
5	The businessman will clench the purple umbrella. The businessman will open the purple umbrella. The businessman will clench the opened umbrella. *Closed umbrella; open umbrella.*
6	The camper will grab the waterproof sleeping bag. The camper will unroll the waterproof sleeping bag. The camper will grab the unfolded[6] sleeping bag. *Packed sleeping bag; unfolded sleeping bag.*
7	The camper will select the lightweight tent. The camper will assemble the lightweight tent. The camper will select the assembled tent. *Packed tent; assembled tent.*
8	The chef will admire the decadent cupcake. The chef will frost the decadent cupcake. The chef will admire the frosted cupcake. *Plain cupcake; frosted cupcake.*
9	The chef will smell the delicious sugar cookie. The chef will ice the delicious sugar cookie. The chef will smell the iced sugar cookie.

[6] Items 6 and 26 contain typographical errors which we believe didn't influence the results of the experiment.

Plain sugar cookie; iced sugar cookie.

10 The child will admire the colorful kite.
The child will string the colorful kite.
The child will admire the strung kite.
Kite without a string; strung kite (with a string).

11 The child will hold the colorful pool float.
The child will inflate the colorful pool float.
The child will hold the inflated pool float.
Deflated pool float; inflated pool float.

12 The clown will choose the shiny balloon.
The clown will inflate the shiny balloon.
The clown will choose the inflated balloon.
Deflated balloon; inflated balloon.

13 The coach will inspect the professional soccer ball.
The coach will inflate the professional soccer ball.
The coach will inspect the inflated soccer ball.
Deflated soccer ball; inflated soccer ball.

14 The daughter will walk around the massive Christmas tree.
The daughter will decorate the massive Christmas tree.
The daughter will walk around the decorated Christmas tree.
Plain Christmas tree; decorated Christmas tree.

15 The father will inspect the bedroom window.
The father will repair the bedroom window.
The father will inspect the repaired window.
Cracked window; repaired/intact window.

16 The father will inspect the modern washing machine.
The father will repair the modern washing machine.
The father will inspect the repaired washing machine.
Broken washing machine; repaired/intact washing machine.

17 The father will measure the backyard pool.
The father will fill the backyard pool.
The father will measure the filled pool.
Drained pool; filled pool.

18 The girl will feel the polyester shirt.
The girl will repair the polyester shirt.
The girl will feel the repaired shirt.
Ripped shirt; repaired/intact shirt.

19 The girl will hold the lightweight jump rope.
The girl will repair the lightweight jump rope.
The girl will hold the repaired jump rope.
Broken rope; repaired/intact rope.

20 The girl will reject the expensive gift.
The girl will wrap the expensive gift.
The girl will reject the wrapped gift.
Unwrapped gift; wrapped gift.

21 The girl will sit at the wooden desk.

The girl will clean the wooden desk.
The girl will sit at the cleaned desk.
Messy desk; clean/organized desk.

22 The girl will sit on the comfortable bed.
The girl will make the comfortable bed.
The girl will sit on the made bed.
Messy bed; made-up bed.

23 The grandmother will inspect her favorite book.
The grandmother will repair her favorite book.
The grandmother will inspect the repaired book.
Torn book; repaired/intact book.

24 The grandmother will look at the exquisite plant.
The grandmother will prop up the exquisite plant.
The grandmother will look at the propped-up plant.
Tipped over plant; upright plant.

25 The grandmother will look toward the vintage lamp.
The grandmother will turn on the vintage lamp.
The grandmother will look toward the turned-on lamp.
Turned off lamp; turned on lamp.

26 The janitor will curse at the sturdy trash can.
The janitor will prop up the sturdy trash can.
The janitor will inspect the propped-up trash can.
Tipped over trashcan; upright trashcan.

27 The janitor will scrutinize the wooden bench.
The janitor will repair the wooden bench.
The janitor will scrutinize the repaired bench.
Broken bench; repaired/intact bench.

28 The maid will feel the fluffy towel.
The maid will dry the fluffy towel.
The maid will feel the dried towel.
Wet towel; dry towel.

29 The man will wipe his designer glasses.
The man will repair his designer glasses.
The man will wipe his repaired glasses.
Broken glasses; repaired/intact glasses.

30 The mechanic will choose the steel gear.
The mechanic will clean the steel gear.
The mechanic will choose the cleaned gear.
Rusty gear; cleaned gear.

31 The mechanic will examine the automatic car.
The mechanic will fix the automatic car.
The mechanic will examine the fixed car.
Smashed car; repaired/intact car.

32 The mechanic will scrutinize the durable tire.
The mechanic will inflate the durable tire.
The mechanic will scrutinize the inflated tire.

Deflated tire; inflated tire.

33 The mother will admire the greenish candle.
The mother will light the greenish candle.
The mother will admire the lit candle.
Unlit candle; lit candle.

34 The mother will approach her favorite canopy.
The mother will assemble her favorite canopy.
The mother will approach the assembled canopy.
Disassembled canopy; assembled canopy.

35 The mother will inspect the delicious cake.
The mother will decorate the delicious cake.
The mother will inspect the decorated cake.
Plain cake; decorated cake.

36 The mother will nudge the brand-new cookie jar.
The mother will fill the brand-new cookie jar.
The mother will nudge the filled cookie jar.
Empty cookie jar; filled cookie jar.

37 The mother will point to the plush rug.
The mother will unroll the plush rug.
The mother will point to the unrolled rug.
Rolled rug; unrolled rug.

38 The nanny will scan the colorful puzzle.
The nanny will assemble the colorful puzzle.
The nanny will scan the assembled puzzle.
Disassembled puzzle; assembled puzzle.

39 The player will inspect the high-quality basketball.
The player will inflate the high-quality basketball.
The player will inspect the inflated basketball.
Deflated basketball; inflated basketball.

40 The skydiver will examine the sturdy parachute.
The skydiver will deploy the sturdy parachute.
The skydiver will examine the deployed parachute.
Closed parachute; deployed parachute.

41 The student will clench the yellow pencil.
The student will sharpen the yellow pencil.
The student will clench the sharpened pencil.
Tipless pencil; sharpened pencil.

42 The student will hold the yellow ruler.
The student will repair the yellow ruler.
The student will hold the repaired ruler.
Broken ruler; repaired/intact ruler.

43 The veteran will admire the patriotic flag.
The veteran will unfold the patriotic flag.
The veteran will admire the unfolded flag.
Folded flag; unfolded flag.

44 The waitress will scrutinize the ceramic plate.

The waitress will repair the ceramic plate.
The waitress will scrutinize the repaired plate.
Broken plate; repaired/intact plate.

45 The welder will grab the sturdy blowtorch.
The welder will light the sturdy blowtorch.
The welder will grab the lit blowtorch.
Turned-off blowtorch; flaming blowtorch.

46 The woman will admire the elegant curtains.
The woman will open the elegant curtains.
The woman will admire the opened curtains.
Closed curtains; open curtains.

47 The woman will observe the antique mirror.
The woman will repair the antique mirror.
The woman will observe the repaired mirror.
Broken mirror; repaired/intact mirror.

48 The writer will hold the lead pencil.
The writer will repair the lead pencil.
The writer will hold the repaired pencil.
Broken pencil; repaired/intact pencil.

Appendix C: Stimuli for Experiment 3

This appendix contains materials used in Experiment 3. The first four rows of each cell of Table C1 contain the sentential stimuli, one per condition, and the last row contains the descriptions of the picture stimuli.

Table C1

The Sentential Stimuli and the Descriptions of the Picture Stimuli Used in Experiment 3

1	The chef will frost the decadent cupcake.
	The chef will overly frost the decadent cupcake.
	The chef will check the frosted cupcake.
	The chef will check the overly frosted cupcake.
	Plain cupcake.
2	The man will clean the professional desk.
	The man will extensively clean the professional desk.
	The man will sit at the cleaned desk.
	The man will sit at the extensively cleaned desk.
	Messy desk.
3	The pedestrian will open the purple umbrella.
	The pedestrian will completely open the purple umbrella.
	The pedestrian will clench the opened umbrella.
	The pedestrian will clench the completely opened umbrella.
	Closed umbrella.
4	The housekeeper will dry the fluffy towel.
	The housekeeper will thoroughly dry the fluffy towel.
	The housekeeper will feel the dried towel.
	The housekeeper will feel the thoroughly dried towel.
	Wet towel.
5	The daughter will decorate the massive wreath.
	The daughter will excessively decorate the massive wreath.
	The daughter will assess the decorated wreath.
	The daughter will assess the excessively decorated wreath.
	Plain wreath.
6	The seamstress will mend the pricey shirt.
	The seamstress will perfectly mend the pricey shirt.
	The seamstress will hold the mended shirt.
	The seamstress will hold the perfectly mended shirt.
	Ripped shirt.
7	The worker will unload the pickup truck.
	The worker will entirely unload the pickup truck.

The worker will see the unloaded pickup truck.
The worker will see the entirely unloaded pickup truck.
Loaded pickup truck.

8 The mom will assemble the lightweight canopy.
The mom will fully assemble the lightweight canopy.
The mom will appraise the assembled canopy.
The mom will appraise the fully assembled canopy.
Disassembled canopy.

9 The boy will unroll the warm sleeping bag.
The boy will totally unroll the warm sleeping bag.
The boy will see the unrolled sleeping bag.
The boy will see the totally unrolled sleeping bag.
Rolled sleeping bag.

10 The clown will inflate the shiny balloon.
The clown will completely inflate the shiny balloon.
The clown will choose the inflated balloon.
The clown will choose the completely inflated balloon.
Deflated balloon.

11 The mechanic will clean the useful gear.
The mechanic will thoroughly clean the useful gear.
The mechanic will choose the cleaned gear.
The mechanic will choose the thoroughly cleaned gear.
Rusty gear.

12 The traveler will pack the practical suitcase.
The traveler will overly pack the practical suitcase.
The traveler will weigh the packed suitcase.
The traveler will weigh the overly packed suitcase.
Empty suitcase.

13 The girl will wrap the expensive gift.
The girl will entirely wrap the expensive gift.
The girl will accept the wrapped gift.
The girl will accept the entirely wrapped gift.
Unwrapped gift.

14 The veteran will unfold the patriotic flag.
The veteran will fully unfold the patriotic flag.
The veteran will hold the unfolded flag.
The veteran will hold the fully unfolded flag.
Folded flag.

15 The handyman will repair the rustic bench.
The handyman will perfectly repair the rustic bench.

The handyman will scrutinize the repaired bench.
The handyman will scrutinize the perfectly repaired bench.
Broken bench.

16 The nanny will assemble the large puzzle.
The nanny will wholly assemble the large puzzle.
The nanny will scan the assembled puzzle.
The nanny will scan the wholly assembled puzzle.
Disassembled puzzle.

17 The woman will restore the antique mirror.
The woman will totally restore the antique mirror.
The woman will view the restored mirror.
The woman will view the totally restored mirror.
Broken mirror.

18 The father will fill the deep pool.
The father will entirely fill the deep pool.
The father will measure the filled pool.
The father will measure the entirely filled pool.
Empty pool.

19 The father will repair the wooden fence.
The father will fully repair the wooden fence.
The father will inspect the repaired fence.
The father will inspect the fully repaired fence.
Broken fence.

20 The mother will decorate the delicious cake.
The mother will overly decorate the delicious cake.
The mother will inspect the decorated cake.
The mother will inspect the overly decorated cake.
Plain cake.

21 The assistant will unroll the plush rug.
The assistant will completely unroll the plush rug.
The assistant will sell the unrolled rug.
The assistant will sell the completely unrolled rug.
Rolled rug.

22 The worker will mend the designer glasses.
The worker will perfectly mend the designer glasses.
The worker will hold the mended glasses.
The worker will hold the perfectly mended glasses.
Broken glasses.

23 The driver will inflate the durable tire.
The driver will thoroughly inflate the durable tire.

The driver will evaluate the inflated tire.
The driver will evaluate the thoroughly inflated tire.
Deflated tire.

24 The groom will tie the stylish bowtie.
The groom will appropriately tie the stylish bowtie.
The groom will adjust the tied bowtie.
The groom will adjust the appropriately tied bowtie.
Untied bowtie.

25 The man will straighten the modern frame.
The man will perfectly straighten the modern frame.
The man will appreciate the straightened frame.
The man will appreciate the perfectly straightened frame.
Crooked frame.

26 The performer will open the red curtain.
The performer will entirely open the red curtain.
The performer will see the opened curtain.
The performer will see the entirely opened curtain.
Closed curtain.

27 The shopper will fill the helpful cart.
The shopper will overly fill the helpful cart.
The shopper will inspect the filled cart.
The shopper will inspect the overly filled cart.
Empty cart.

28 The athlete will inflate the high-quality basketball.
The athlete will excessively inflate the high-quality basketball.
The athlete will select the inflated basketball.
The athlete will select the excessively inflated basketball.
Deflated basketball.

29 The adventurer will unfold the complex map.
The adventurer will fully unfold the complex map.
The adventurer will view the unfolded map.
The adventurer will view the fully unfolded map.
Folded map.

30 The butler will clean the deep pot.
The butler will totally clean the deep pot.
The butler will store the cleaned pot.
The butler will store the totally cleaned pot.
Dirty pot.

31 The mechanic will fix the inexpensive car.
The mechanic will completely fix the inexpensive car.

The mechanic will examine the fixed car.
The mechanic will examine the completely fixed car.
Broken car.

32 The student will sharpen the little pencil.
The student will thoroughly sharpen the little pencil.
The student will grip the sharpened pencil.
The student will grip the thoroughly sharpened pencil.
Blunt pencil.

Appendix D: Stimuli for Experiment 4

This appendix contains materials used in Experiment 4. The first column of Table D1 contains the sentential stimuli, one per condition, and the second column contains the descriptions of the picture stimuli.

Table D1

The Sentential Stimuli and the Descriptions of the Picture Stimuli Used in Experiment 4

1	The bartender will select the transparent glass bottle.	*empty transparent greenish bottle*
	The bartender will select the emptied glass bottle.	*empty transparent greenish bottle*
	The bartender will select the brownish glass bottle.	*filled transparent greenish bottle*
	The bartender will select the emptied glass bottle.	*filled transparent greenish bottle*
2	The boy will adjust the yellow bowtie.	*tied yellow bowtie*
	The boy will adjust the tied bowtie.	*tied yellow bowtie*
	The boy will adjust the plaid bowtie.	*untied yellow bowtie*
	The boy will adjust the tied bowtie.	*untied yellow bowtie*
3	The boy will smile at the colorful piñata.	*ripped colorful piñata*
	The boy will smile at the ripped piñata.	*ripped colorful piñata*
	The boy will smile at the silver piñata.	*intact colorful piñata*
	The boy will smile at the ripped piñata.	*intact colorful piñata*
4	The businessman will clench the purple umbrella.	*opened purple umbrella*
	The businessman will clench the opened umbrella.	*opened purple umbrella*
	The businessman will clench the yellow umbrella.	*closed purple umbrella*
	The businessman will clench the opened umbrella.	*closed purple umbrella*
5	The camper will grab the stripy sleeping bag.	*cleaned stripy sleeping bag*
	The camper will grab the cleaned sleeping bag.	*cleaned stripy sleeping bag*
	The camper will grab the maroon sleeping bag.	*dirty stripy sleeping bag*
	The camper will grab the cleaned sleeping bag.	*dirty stripy sleeping bag*
6	The camper will select the green tent.	*assembled green tent*
	The camper will select the assembled tent.	*assembled green tent*
	The camper will select the orange tent.	*disassembled green tent*
	The camper will select the assembled tent.	*disassembled green tent*
7	The chef will admire the chocolate cupcake.	*frosted chocolate cupcake*
	The chef will admire the frosted cupcake.	*frosted chocolate cupcake*
	The chef will admire the vanilla cupcake.	*plain chocolate cupcake*

	The chef will admire the frosted cupcake.	*plain chocolate cupcake*
8	The chef will smell the oval cookie.	*iced oval cookie*
	The chef will smell the iced cookie.	*iced oval cookie*
	The chef will smell the square cookie.	*plain oval cookie*
	The chef will smell the iced cookie.	*plain oval cookie*
9	The clown will choose the yellow balloon.	*inflated yellow balloon*
	The clown will choose the inflated balloon.	*inflated yellow balloon*
	The clown will choose the purple balloon.	*deflated yellow balloon*
	The clown will choose the inflated balloon.	*deflated yellow balloon*
10	The father will measure the circular pool.	*filled circular pool*
	The father will measure the filled pool.	*filled circular pool*
	The father will measure the rectangular pool.	*empty circular pool*
	The father will measure the filled pool.	*empty circular pool*
11	The girl will feel the white shirt.	*intact white shirt*
	The girl will feel the repaired shirt.	*intact white shirt*
	The girl will feel the red shirt.	*torn white shirt*
	The girl will feel the repaired shirt.	*torn white shirt*
12	The girl will hold the purple jump rope.	*intact purple jump rope*
	The girl will hold the repaired jump rope.	*intact purple jump rope*
	The girl will hold the yellow jump rope.	*broken purple jump rope*
	The girl will hold the repaired jump rope.	*broken purple jump rope*
13	The girl will sit on the twin bed.	*made twin bed*
	The girl will sit on the made bed.	*made twin bed*
	The girl will sit on the queen bed.	*messy twin bed*
	The girl will sit on the made bed.	*messy twin bed*
14	The grandmother will inspect the blue book.	*intact blue book*
	The grandmother will inspect the repaired book.	*intact blue book*
	The grandmother will inspect the red book.	*torn blue book*
	The grandmother will inspect the repaired book.	*torn blue book*
15	The grandmother will look at the green plant.	*upright green plant*
	The grandmother will look at the propped-up plant.	*upright green plant*
	The grandmother will look at the yellow plant.	*knocked-down green plant*
	The grandmother will look at the propped-up plant.	*knocked-down green plant*
16	The janitor will curse at the metal trash can.	*upright metal trashcan*

	The janitor will inspect the propped-up trash can.	*upright metal trashcan*
	The janitor will curse at the plastic trash can.	*knocked-down metal trashcan*
	The janitor will inspect the propped-up trash can.	*knocked-down metal trashcan*
17	The janitor will scrutinize the wooden bench.	*intact wooden bench*
	The janitor will scrutinize the repaired bench.	*intact wooden bench*
	The janitor will scrutinize the metal bench.	*broken wooden bench*
	The janitor will scrutinize the repaired bench.	*broken wooden bench*
18	The maid will feel the yellow towel.	*dried yellow towel*
	The maid will feel the dried towel.	*dried yellow towel*
	The maid will feel the green towel.	*wet yellow towel*
	The maid will feel the dried towel.	*wet yellow towel*
19	The man will wipe his rectangular glasses.	*intact rectangular glasses*
	The man will wipe his repaired glasses.	*intact rectangular glasses*
	The man will wipe his aviator glasses.	*broken rectangular glasses*
	The man will wipe his repaired glasses.	*broken rectangularglasses*
20	The mechanic will choose the gray gear.	*clean gray gear*
	The mechanic will choose the cleaned gear.	*clean gray gear*
	The mechanic will choose the yellow gear.	*rusty gray gear*
	The mechanic will choose the cleaned gear.	*rusty gray gear*
21	The mechanic will examine the modern car.	*intact modern car*
	The mechanic will examine the fixed car.	*intact modern car*
	The mechanic will examine the antique car.	*broken modern car*
	The mechanic will examine the fixed car.	*broken modern car*
22	The mother will admire the greenish candle.	*lit greenish candle*
	The mother will admire the lit candle.	*lit greenish candle*
	The mother will admire the pink candle.	*put down greenish candle*
	The mother will admire the lit candle.	*put down greenish candle*
23	The mother will approach her purple canopy.	*assembled purple canopy*
	The mother will approach the assembled canopy.	*assembled purple canopy*
	The mother will approach her greenish canopy.	*disassembled purple canopy*
	The mother will approach the assembled canopy.	*disassembled purple canopy*
24	The mother will inspect the round cake.	*decorated round cake*
	The mother will inspect the decorated cake.	*decorated round cake*
	The mother will inspect the square cake.	*plain round cake*

	The mother will inspect the decorated cake.	*plain round cake*
25	The mother will nudge the transparent cookie jar.	*filled transparent cookie jar*
	The mother will nudge the filled cookie jar.	*filled transparent cookie jar*
	The mother will nudge the opaque cookie jar.	*empty transparent cookie jar*
	The mother will nudge the filled cookie jar.	*empty transparent cookie jar*
26	The nanny will scan the colorful puzzle.	*assembled colorful puzzle*
	The nanny will scan the assembled puzzle.	*assembled colorful puzzle*
	The nanny will scan the monochromatic puzzle.	*disassembled colorful puzzle*
	The nanny will scan the assembled puzzle.	*disassembled colorful puzzle*
27	The student will clench the wooden pencil.	*sharpened wooden pencil*
	The student will clench the sharpened pencil.	*sharpened wooden pencil*
	The student will clench the mechanical pencil.	*blunt wooden pencil*
	The student will clench the sharpened pencil.	*blunt wooden pencil*
28	The student will hold the yellow ruler.	*intact yellow ruler*
	The student will hold the repaired ruler.	*intact yellow ruler*
	The student will hold the transparent ruler.	*broken yellow ruler*
	The student will hold the repaired ruler.	*broken yellow ruler*
29	The veteran will admire the patriotic flag.	*unfolded American flag*
	The veteran will admire the hoisted flag.	*unfolded American flag*
	The veteran will admire the Ukrainian flag.	*folded American flag*
	The veteran will admire the hoisted flag.	*folded American flag*
30	The waitress will scrutinize the ceramic plate.	*intact ceramic plate*
	The waitress will scrutinize the repaired plate.	*intact ceramic plate*
	The waitress will scrutinize the wooden plate.	*cracked ceramic plate*
	The waitress will scrutinize the repaired plate.	*cracked ceramic plate*
31	The child will hold the colorful pool float.	*inflated colorful pool float*
	The child will hold the inflated pool float.	*inflated colorful pool float*
	The child will hold the beige pool float.	*deflated colorful pool float*
	The child will hold the inflated pool float.	*deflated colorful pool float*
32	The girl will sit at the wooden desk.	*clean brown desk*
	The girl will sit at the cleaned desk.	*clean brown desk*
	The girl will sit at the black desk.	*messy brown desk*
	The girl will sit at the cleaned desk.	*messy brown desk*

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