Representing Situation Types in Language

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Abstract

Two experiments examined whether situation types (Vendler, 1957) are represented differently during sentence comprehension. In the first experiment participants read sentences of different situation types followed by a star-clicking task. Situation type did not influence response times on the subsequent task. The second experiment showed that matching situation types did not prime each other, but participants judged achievement sentences more accurately than accomplishments and activities. These results suggest that situation types are not represented differently, but we argue that their underlying characteristics may affect sentence processing causing task specific effects. Implications of these data with respect to the classical and experiential based theories are also discussed.

Representing Situation Types in Language

A topic that has been of particular interest in psycholinguistics is the mental representation of language. There has been much debate concerning this subject over the past five decades, without researchers having reached a consensus (e.g., Barsalou, Simmons, Barbey, & Wilson, 2003; Chomsky, 1968; Kintsch, 1988). There is, however, one aspect of language representation which psycholinguists agree upon, which is the idea that people construct situation models in order to comprehend language (e.g., Kintsch, 1988; Zwaan & Radvansky, 1998). Situation models are mental representations of language influenced by both data driven information (e.g., linguistic input) and top down information (e.g., world knowledge). The construction of these situation models is explained in various ways (e.g., Kintsch, 1988; Zwaan & Radvansky, 1998). One particular model, the event indexing model, explains how coherent situation models are formed. The event indexing model of language comprehension proposes that when understanding a sentence or a story, a mental model is constructed online while reading (Zwaan & Radvansky, 1998). According to this model, when reading a particular clause a mental model is formed that is referred to as the *current model*. As one reads more clauses or sentences, distinct models are connected and form the *integrated model*. All of the cues that are stored in the short-term working memory and all the information about a situation that is stored in the long-term working memory is referred to as the *complete model*. So the representation of an event that is described in the text is constructed while reading. The relative ease with which clauses or events are connected is hypothesized to depend on the number of shared indexes or dimensions between them. Zwaan and Radvanky (1998) claim that there are at least five dimensions i.e., space, causality, intentionality, protagonist, and time which may influence the construction and integration of the situation model. Research conducted on several dimensions indeed seems to provide some support for their importance in forming coherent mental models (e.g., Rinck, Hähnel, & Becker, 2001; Zwaan, Magliano, & Graesser, 1995; Zwaan & Radvansky, 1998), but much work still has to be done.

One of the five dimensions that has received little empirical attention is the temporal dimension, and for this reason it is of particular interest in this paper. Temporal notions in narratives are essential for understanding the order and duration of situations or events, and can be found in every sentence or clause in the English language (Zwaan & Radvansky, 1998). But just how do language comprehenders draw inferences about the temporal properties of a situation? There is evidence that comprehenders have the tendency to interpret the order of successive sentences (which can be considered separate events) as the chronological order between the actual events (Van der Meer, Beyer, Heinze, & Badel, 2002). This tendency is called the *iconicity assumption* (Zwaan, 1996). There is also a stronger version of the iconicity assumption that proposes that contiguous sentences in a text are easily integrated as being part of a contiguous event or sequence of events. Hence, they can be integrated into the same situation model. This assumption together with the former assumption is referred to as the *strong iconicity assumption* (Zwaan, 1996). There is support for this stronger version. Zwaan (1996) found that reading times for contiguous sentences with a short duration (e.g., “a moment later”) were shorter than for sentences that implied a longer narrative time shift (e.g., “an hour” or “a day later”). Thus it seems that readers attempt to integrate contiguous sentences into a contiguous timeline and processing difficulties arise when they are unable to do so.

Another manner by which comprehenders draw inferences about the temporal properties between events is by making use of *tense*. Tense can be an effective cue used for integrating events into a situation model (Radvansky, Zwaan, Federico, & Franklin, 1998). Radvansky and colleagues (1998) had participants study sentences, in which a single agent (e.g., “the lawyer”) appeared in three sentences. The agent performed a different activity in each sentence and each activity was compatible within the same time frame (e.g., “tying his shoe/biting his lip/feeling ill”). The sentences were either presented in the same tense (e.g., “past”) or in different tenses (e.g., “past/present/future”). In a recognition test that followed, participants had slower reaction times in the different tense condition in comparison to the same tense condition indicating that integrating events that have the same tense is easier than integrating events that have a different tense. These results support the idea that temporal information may help in the construction of an integrated situation model. Thus, the strong iconicity assumption together with tense, explain how time between successive events is comprehended most readily.

However, tense provides considerably less information on how comprehenders represent different time notions within an event, and the strong iconicity assumption does not provide any information on this subject at all, since it does not make any prediction on temporal notions within events. Time within an event refers to an event’s duration as well as its onset and completion status. Take for example the following two sentences “Johnny crashed the car” and “Johnny parked the car”. Here the duration of both situations are different in that it probably takes Johnny longer to park a car than to crash one. You can imagine that crashing a car only takes a split second, but parking a car would take relatively long, even if Johnny was an excellent driver. Now consider a third sentence “Johnny drove the car", which does not tell you anything about the duration of the situation, but it does suggests that it is in progress for some time (e.g., Johnny could have been driving around for a minute or until he ran out of gas). Thus it seems clear that these three sentences have different time notions, but how do we draw inferences about the duration or completion of situations like these? One way is by making use of linguistic cues (Zwaan, Madden, & Stanfield, 2001).

Although tense seems to be an important linguistic cue in that it provides information about time between successive events, *aspect* seems to be a more valuable cue when it comes to providing within event sentence information. Aspect tells the comprehender if a situation is still ongoing, how long its duration is and if it is completed. It may also provide information concerning the presence or absence of objects, agents, and locations and it may do so independent of tense (Moens & Steedman, 1988). Aspect is distinguished into two types, i.e., *grammatical aspect* (or verb aspect) and *lexical aspect* (or situational aspect). Grammatical aspect refers to the conjugation part of a verb that determines the temporal characteristics of an event. For example, "I am walking" and "I have walked" both describe the same situation in the present tense, but the grammatical aspect of the first sentence implies that it is still ongoing, whereas the grammatical aspect of the second sentence implies that it is completed. In the present study, we will focus on lexical aspect, which refers to the inherent classification of situations and their verbs based on their temporal characteristics. Vendler (1957) described different ways by which verbs and their associated situations may provide information regarding these temporal characteristics. He classified four types of verbs on the basis of certain temporal characteristics: *activity terms*, *accomplishment terms*, *achievement terms*, and *states*. The first three types of verbs are the same in the way that at some point in time one cold point out that an event is actually happening, as opposed to states, which in most cases do not refer to dynamic events. It is important to note that the temporal properties of a sentence do not rely solely on the verb or its aspect since they are context dependent. A single verb could well be classified as various types without context. To be more specific, let us consider the four different types more closely.

Activities describe continuous situations that may go on for an indefinite amount of time. For example, "Sam carried the gun" suggests that Sam is carrying the gun the entire time until it is said otherwise. This situation is *durative* in the sense that at any point in time one could point out that Sam is carrying the gun, and it is indefinite in the sense that Sam could be carrying the gun for a couple of seconds, two hours, or even a whole day. Notice that nothing about a natural progression towards an endpoint of the event is implied in activities and therefore they are said to be *atelic*, although Sam will probably stop carrying the gun at some point in time he will never complete carrying the gun.

In contrast to activities, accomplishments describe situations that have an endpoint. When situations imply that there is a natural endpoint they are said to be *telic*. The following sentence, “Sam assembled the gun” is an example of a telic situation, because it implies that Sam makes progress towards a natural endpoint, that is, he assembles the gun until it is fully put together. Like activities, accomplishments are also durative situations in the sense that as long as the endpoint is not reached, Sam is assembling the gun at any given point in time. In addition, the fact that accomplishments are both telic and durative causes that they have another quality, which separates them from activities, achievements, and states, that is, accomplishments evolve in stages. At any point prior to the endpoint of assembling, the current situation changes over time (e.g., if Sam keeps assembling his gun the state of the gun at t_1 could never be equal to the state of the gun at t_2). In contrast, activities never imply an evolving state of the situation (e.g., Sam could carry a gun where the situation of Sam or the gun at t_1 could be equal to t_2). Thus, activities and accomplishments both are durative in nature, and only accomplishments are telic. Furthermore, accomplishments necessarily change over time thus they consist of *multiple stages*, whereas the other types do not.

Achievements, like accomplishments, have a certain endpoint but have no duration (e.g., “Sam shot the gun”). As soon as the event of shooting begins, the event of shooting is over. Achievements thus have the property of being *instantaneous*. So accomplishments and achievements have in common that they both are telic, but they are different in that sense that the onset of an achievement also marks its termination, whereas for accomplishments onset and termination are two different points in time. Because onset and termination are both at t_1, achievements only have a single stage.

State terms cannot be defined as events, because they do not refer to specific dynamic actions of objects or agents, and more important, they do not provide temporal information concerning objects or agents. Take for example the following sentence, “Sam wanted the gun”. When reading this clause, one might find it hard to draw any kind of inference about the onset, duration, or the endpoint of “wanting the gun”. When is it going on exactly? States do not provide answers to questions like these, because they refer to the physical, cognitive, or emotional state of the protagonist (e.g., loving, hating, knowing, wanting, being), rather than an event or action of the protagonist. Verbs denoting states thus can be considered a different class than the former three verb types (i.e., activities, accomplishments, and achievements). The current study is interested in the temporal properties of situations, and because states do not provide temporal information with respect to the onset, the duration and termination of situations they will not be considered further. The three remaining verb types discussed above will now be referred to as *situation types*[1]. The situation types and their temporal characteristics e.i., duration, telicity, and stage progression, can be found in Table 1 below.

[Insert Table 1 here]

These situation types and their characteristics may determine what aspects in a text are salient to a comprehender (Moens & Steedman, 1988). For instance, achievements and accomplishments are both telic and therefore they are associated with an endpoint, that when reached, will lead to a new state that is called the *consequent state* (Moens & Steedman, 1988). Activities however, are atelic and do not terminate, therefore a consequent state will not be automatically inferred. Now consider the following sentences again “Johnny parked the car” and “Johnny drove the car”. The former sentence describes a situation in which Johnny parks a car that is a *preparatory process* before the endpoint. When this point is reached, this will lead to a new situation, in which the car is parked (i.e., the consequent state). Since the event terminated, the emphasis is not placed on the parking of the car itself but rather on the consequent state, this is what should be most important to the comprehender (Moens & Steedman, 1988). An endpoint does not characterize the second sentence, and therefore the consequent state is absent, never inferred, or not important. The emphasis will be on the event it self, in this case the driving. Thus these different situation types denote different underlying time notions about situations, which in term have consequences for different aspects of a sentence (e.g., the absence or presence of objects or locations). Because of these implications, it is possible that some situation types are conceptually easier or more difficult to represent than others. This is exactly the aim of the current paper; exploring whether these different situation types are represented differently in our situation models. Previous empirical research on this topic suggests that this could be the case.

One study addressing the temporal properties of events suggests that events that imply a difference in the completion status of an event may be represented differently. Madden and Zwaan (2003) investigated if grammatical aspect influences the mental representation of an event. They exposed their participants to sentences that were described in the perfective or imperfective past tense (e.g., “The boy *walked*/*was walking* to the store”, respectively). When a sentence is described in the imperfective aspect, one could infer that the event is in progress, because it does not imply an endpoint was actually reached (Moens & Steedman, 1988).

Consider the following sentence, “The boy *was walking* to the store when he realized that the stores were closed on Sunday”, in which it is never implied that the boy completed his trip to the store. Thus the imperfective aspect emphasizes the part after the boy starts walking to the store to the point before he got there, and even though this event is described in the past tense it is represented as being in progress. Madden and Zwaan reasoned that if grammatical aspect influences our mental representation it is plausible to assume that when we form situation models of events described in the imperfective aspect they are represented as being in progress. In contrast, the perfective aspect of a described event does not suggest that the event is still in progress, but rather implies that it is complete since it is definite that the endpoint is reached (Moens & Steedman, 1988). Now consider the following sentence, “The boy *walked* to the store when he realized that the stores were closed on Sunday”, in which the event of walking to the store is no longer salient, because the boy definitely completed his journey to the store and the emphasis is put on the part after he arrived at the store and realizes it is closed. Hence, one could assume that the representation of a perfective clause reflects a complete event. Madden and Zwaan hypothesized that if this were to be true, pictures that match the completion status of a described event should lead to faster reaction times. In one of their experiments participants were asked to judge if pictures of either an event in progress or a completed event were similar to the sentences that preceded them. Their results showed that participants were faster to respond to pictures of completed events when they were preceded by perfective sentences compared to imperfective sentences. There was no difference for in-progress pictures. In addition they found that response times to perfective sentences were facilitated after viewing pictures of a completed event relative to an event in progress, but the imperfective sentences did not show such an effect (Madden & Zwaan, 2003). According to Madden & Zwaan this is because perfective sentences put more constraint on a representation of an event, making a picture describing a completed event the most possible candidate for selection. On the other hand, no such a constraint is implied by the imperfective sentence, where both types of pictures match the described event since is possibly represented in multiple stages (progressive).

Ferretti, McRrae & Kutas (2007) found similar results investigating if grammatical aspect influences the activation of specific features of an event. As in the study of Madden and Zwaan (2003), sentences that were in the perfect form were hypothesized to be more likely to represent completed events, whereas sentences that were in the imperfective form were hypothesized to be more likely to represent events in progress. According to the model that Moens & Steedman (1988) propose, location information should be more apparent in imperfective sentences relative to perfect sentences since locations are more important when an event is in progress whereas the consequent state is more important when an event is completed. Ferretti et al (2007), tested this by having participants read prime phrases that were either in the perfect or in the imperfective form (e.g., “had skated/was skating” vs. “had prayed/was praying”), followed by a target phrase denoting a likely location or an unlikely location (e.g., “arena”, which is likely location for skating, but unlikely for praying). If grammatical aspect highlights an ongoing situation, then the features of that situation should be more activated. In this case, likely locations should be facilitated relative to unlikely locations in the imperfective condition; such an effect is not predicted for the perfect condition. This is exactly what they found, that is, likely targets were named faster than unlikely targets in the imperfective condition as opposed to the perfect condition where no such an effect was found. The results of Madden & Zwaan (2003) and Ferretti and colleagues (2007) support the idea that the implied completion status of described events influences the way these events are represented.

Other findings suggest that telicity also has implications for the online processing of sentences. O’Bryan (2003) found that in reduced relative clauses the reading times were elongated for clauses containing an atelic verb relative to clauses containing a telic verb. This suggests that sentence comprehension can be facilitated by the implied telicity of an event. One thing that might be interesting to note is that as the processing of sentences seems to be affected by telicity, the implied telicity of an event may also be reflected by different underlying grammatical structures of sentences in several different languages (e.g., Slabakova, 2001; for a review on event structures and telicity see, Folli & Harley, 2006).

As the implied completion status and telicity of situations affect how events are processed, this seems to hold for the implied duration of an event as well. Kelter, Claus, and Kaup (2004), performed a study on the impact that the temporal remoteness of an event has on the accessibility of a previous event. They exposed participants to short stories that described three chronological events. The first event would introduce a target, which later would have to be accessed again (e.g., “Mrs. Strube throws a *tantrum*” target word is italicized here, but not in experimental presentation). The second event was the sentence of interest, where the protagonist of the story performs an activity which has either a long duration (e.g., “She goes into the kitchen and bakes some cookies to put on the Christmas plates”) or short duration (e.g., “She goes into the kitchen and puts some cookies on the Christmas plates”). The last event was a filler sentence (e.g., “After doing this, the kitchen is sweet with the smell of Christmas”). When they showed their participants an anaphoric sentence (e.g., “Now she regrets her *tantrum*”) they found that the participants were faster to respond after reading the short duration condition relative to the long one suggesting that the duration of an event influences how fast an event that occurred in the protagonist’s past is accessed (Kelter et al, 2004). Or to put it in other words, the duration of an event affects the processing time of that event.

In summary, these results suggest that the completion status, duration and telicity of events affect how language is processed. These results contribute to our confidence in finding a difference between the processing of situation types.

Experiment 1

While linguists have made the distinctions clear, to our knowledge there is no direct empirical evidence that achievements, accomplishments, and activities are represented differently. To investigate this, we conducted two experiments that could provide us with empirical evidence concerning this question. The first experiment measures speed of processing on a subsequent task after reading sentences of different situation types. For this experiment we formulated three hypotheses of which two are based on the studies described in the introduction and one hypothesis that combines them. The first hypothesis is the duration hypothesis of temporal representation (based on the findings from Kelter et al, 2004). According to the duration hypothesis one would expect that an instantaneous event should be faster to process than a durative event. In other words, it should take longer to process activity and accomplishment sentences (“Billy carried/assembled the gun.”) than achievement sentences (“Billy shot the gun.”). The second hypothesis we propose is the telicity hypothesis of temporal representation (based on the findings of O’Bryan, 2003). It does not say anything specific about a processing difference between durative and instantaneous events, but instead proposes that telic events are easier to process. So according to this view one would expect that it takes longer to process activities (“Billy carried the gun”) than achievements and accomplishments (“Billy shot/assembled the gun.”), because activities are atelic. The third and final hypothesis we propose is the additive hypothesis, which is a combination of the former two. According to this additive hypothesis, both duration and telicity affect processing in an additive way. This hypothesis makes two predictions. First, it predicts that achievements would be easier to process than both accomplishments and activities because the implied duration of achievements is shorter than that of accomplishments and activities, also achievements would be facilitated by telicity relative to activities. The second prediction is that accomplishments would be easier to process than activities because of their implied telicity, nothing particular is said about the difference in duration for these two situation types. So if the additive hypothesis is true then achievements should be the fastest to process and activities the slowest, accomplishments should be in between those two. We test these three hypotheses indirectly by presenting sentences of different situation types and measuring subsequent responses to a target that appears somewhere on a computer monitor. If processing is more difficult for a certain situation type, then this increase in processing speed should carry over to the immediately following task, and reaction times for clicking on a target should be slower when preceded by that type of situation. The sentences describing the situations themselves could not be measured because any differences observed could result from features of the sentences such as word frequency and length. To make sure that the participants are actually reading the sentence, questions were presented at the end of some of the trials. To their knowledge, what is important is their speed and accuracy on those questions.

Method

Participants. 67 Students from the Erasmus University of Rotterdam participated in this experiment. For participating they received partial course credit for the bachelors program. All participants were native Dutch speakers.

Materials. The experiment was conducted on a personal computer. The instructions and response stimuli were presented on a 20 inch monitor. The stimuli consisted of 144 target sentences (48 Achievement types, 48 Accomplishment types, & 48 Activity types) and 12 statements (4 for each sentence type). A given item (e.g., gun) was used to create a set of three sentences, one in each of the three situation type conditions, with only the verb changing between conditions (e.g., “Billy shot/assembled/carried the gun”). At the end of the experiment participants had to correctly respond to true or false statements about the sentences they had just read (e.g., “Billy assembled a gun”), which is only true in one of the three conditions mentioned above. Three lists of counterbalanced sentences were developed, such that only one of the three possible sentences of an item set appeared on a given list. Participants were only presented with one of three lists. All stimuli appeared in Dutch in the center of the screen in 18 point black font. Responses to the test stimuli were made by clicking a mouse button.

Procedure. The participants read instructions on the monitor. They were instructed to read the sentences that would appear on the screen once at a normal pace, and then use the mouse to click on the sentence once they had read it. A “*” symbol then appeared at a random place on the computer monitor, participants then had to click on it as fast as they could. Participants were exposed to eight practice trails and experimental 48 trials. Between successive trials was an interval of 500ms. At the end of the experiment the participants had to correctly respond to 12 true or false statements that related to the sentences they had previously read to make sure they had read the sentences, they were told of this beforehand. If the statement was true, participants had to press the J key, whereas if the statement was false, they had to press the F key. Once participants finished the experiment they received their partial course credit.

Design. This experiment incorporated sentence type (activity vs. accomplishment vs. achievement) as a within subjects variable and list as a between subjects variable. Reaction time in the symbol-clicking task was the dependent variable. The true false accuracy on the statements was also measured to control if participants were actually reading the sentences.

Results

Participants who had an accuracy score that was below 50 percent on the control questions were not included in the analysis. This resulted in the exclusion of 11 participants. Participants’ reaction times and accuracy scores to perform a subsequent star-clicking task after reading a sentence were recorded. Incorrect responses were excluded from further analyses, as well as reaction times that fell outside 2 standard deviations of the participants condition mean. This constituted in the removal of 3.8 percent of the data of the data. A repeated-measures-ANOVA was performed with list as between-subjects factor and situation type (achievement, accomplishment, activity) as within-subjects factor. Although list was included as a between subjects factor it will not be reported because of lack of theoretical relevance (Pollatsek & Well, 1995; Raaijmakers, Schrijnemakers, & Gremmen, 1999). Table 2 shows the mean reaction times and standard deviations for each condition. There was no significant effect of situation type [$F(2,106) < 1$], suggesting that there was no significant difference in reaction times among the three situation types. These results contradicted our expectations and reasons for these findings will be further elaborated in the general discussion.

[Insert Table 2 here]

To make sure that these results were not due to artifacts such as word length or word frequency, two separate analyses were performed on the verbs used in each group. The rest of the sentence was not taken into account because the sentences were identical for each of the three conditions. Table 3 shows the mean verb length of the verbs in the three conditions. The first analysis that was conducted was to see if the verbs that were used in the three groups differed in length. An analysis of variance (ANOVA) showed no significant differences of verb length between the three groups [$F(2,142) = 1.141$, $p = .32$]. These results indicate that the findings in experiment 1 were not influenced by verb length even though activities had the shortest mean verb length. If it turned out that activity verbs were significantly shorter in length it could have helped explain why we did not find a difference among the three situation types in experiment 1, that is, a shorter verb length should facilitate processing, masking a possible difference between the types. The second analysis that was performed was to see if the verb frequencies differed between the three groups. An analysis of variance (ANOVA) did not show a significant effect of verb frequency [$F(2,134) = 1.365$, $p = .26$], indicating that there is no difference in verb frequency between the three groups[2]. If the activity verbs would have been more frequent than the other verbs this could have explained the results from experiment 1, that is, high verb frequencies would have facilitated sentence processing, masking a possible difference between the three types (e.g., Marinellie & Chan, 2006). Because these two analyses never reached significance they suggest that the null effect found in experiment 1 was not caused by artifacts such as verb length and verb frequency.

[Insert Table 3 here]

Altogether the results of the first experiment did not seem to support our proposed hypotheses. However, experiment 1 measured how sentences of different situation types affected responses on a subsequent task, rather than directly measuring the processing of the sentences themselves. Because experiment 1 used an indirect measure of situation type representation in sentence comprehension we conducted a second experiment in which we used a priming paradigm.

Experiment 2

In the first experiment we used an indirect measure to investigate whether or not situation types were represented differently. Therefore, in the second experiment we employed a more direct measure to see if this was the case. One way of doing this is by conducting a priming experiment where we test whether sentences of the same situation type prime each other relative to sentences of a different type. To investigate this we employed a paradigm in which participants were required to make sensibility judgments on sentences. Sentences that functioned as a prime were either of the same situation type as the target sentence (match condition) or of a different type (mismatch condition). For instance, when the sentence “Sam shot the gun” (achievement) is preceded by another achievement type sentence (e.g., “Peter crashed the car”) one would expect to find a shorter reaction time on the target sentence than if it was preceded by an activity type sentence (e.g., “Peter drove the car”). If sentences are represented as situation types, then reading a particular situation type sentence should facilitate processing a subsequent sentence of the same type.

Method

Participants. 51 students from the Erasmus University of Rotterdam participated in this experiment. None of the participants had participated in the first experiment. For participating they received partial course credit for the bachelors program. All participants were native Dutch speakers.

Materials. The experiment was conducted on a personal computer. The instructions and experiment were presented on a 20 inch monitor. Altogether 218 Dutch sentences were created, of which 48 were prime sentences, 48 were target sentences, and 122 were filler sentences. Of the 48 target sentences, 16 were achievement types, 16, were accomplishment types and 16 were activity types. The target sentences were the same sentences that were used in experiment 1, for the prime sentences we created 48 new sentences. Of the 122 filler sentences, 24 made sense and 98 were nonsensical. The 98 nonsensical filler sentences all required a no response, whereas all the other sentences required a yes response. Responses to the test stimuli were given on a keyboard. Participants were randomly assigned to one of nine counterbalanced lists (A to I). All stimuli appeared in Dutch in the center of the screen in 18 point black font.

Procedure. The participants read the instructions on a monitor. They were instructed to judge whether or not sentences made sense by pressing the F and J keys, indicating a no and yes response respectively. To the participants the experiment appeared to consist of a continuous list of unrelated sentences, but in fact some of the subsequent sentences were paired as prime and target. On each trial a fixation point marked by a "+" appeared in the center of the screen until the space bar was pressed. A sentence then appeared in the same position until a response was given. 122 of the sentences were filler sentences and 96 were prime and target pairs of the three situation types. 98 of the filler sentences were nonsensical (e.g., "Eddy ate the internet"), 24 made sense and were similar in structure and content to the situation type sentences accept with one difference, that is, we used state type sentences because we did not expect them to have an effect on a subsequent sentence. The situation type target sentences were preceded by sentences of the same type (e.g., prime: "Peter crashed the car", target: "Bart kicked the ball") or sentences of a different type (e.g., prime: "Peter drove the car", target: "Bart kicked the ball"). This is referred to as the match condition vs. the mismatch condition respectively. When participants gave an incorrect response they received feedback displaying "FOUT". Because of the great number of trials the participants were exposed to and the fact that they had to make speeded responses, we incorporated three breaks into the experiment dividing it up into 4 blocks. After each block a short intermission allowed the participants to relax and prepare for the following block. During this intermission participants were informed of their accuracy on the previous block. When they had an accuracy score that was above 95 percent they were told, "you have an excellent accuracy score, keep up the good work". If they had an accuracy score below 95 percent they were shown "your accuracy score is too low, try to be more accurate". When participants felt that they were ready to continue they pressed the space bar. Once participants finished the experiment they received their partial course credit.

Design. This experiment incorporated a 3 (situation type: achievement vs. accomplishment vs. activity) by 2 (match: match vs. mismatch) within subjects design with list as a between subjects variable. Reaction time on the target sentences was the dependent variable. The accuracy scores were also measured to assure that participants were actually reading the sentences.

Results

Participants who had an accuracy score below 90% at the end of the experiment were not included in the analysis. This resulted in the exclusion of nine participants. Reaction times and accuracy scores were recorded while participants made sensibility judgments on prime and target sentences. Incorrect responses were not considered in the analyses reported here. In addition, reaction time latencies above 5,000 ms and below 500 ms and reaction times that were 2 standard deviations above or below a participants mean were excluded from analysis[3]. This constituted removal of .6 percent of the data. A repeated-measures-ANOVA was performed with list as a between-subjects factor and situation type (achievement, accomplishment, activity) and match (match, mismatch) as within-subjects factors. As in experiment 1 list will not be reported because of lack of theoretical relevance (Pollatsek & Well, 1995; Raaijmakers, et al, 1999). Table 4 shows the mean reaction times and standard deviations for each condition. The overall ANOVA did not show a significant main effect for situation type [$F(2,66) = 1.296$, $p = .280$] or match [$F(1,33) < 1$]. The interaction between situation type and match did not reach significance [$F(2,66) < 1$]. These results, especially the lack of a match effect, contradict the proposed hypothesis that sentences of the same situation type will prime each other, as the correct responses to target items were not facilitated when the preceding prime sentence was of the same situation type. Reasons for these findings will be further elaborated in the general discussion.

[Insert Table 4 here]

A separate analysis was conducted to investigate if accuracy scores differed among the three situation types. A repeated-measures-ANOVA was performed with list as a between-subjects factor and situation type (achievement, accomplishment, activity) and match (match, mismatch) as within-subjects factors. Table 4 shows the mean accuracy scores and standard deviations for each condition. A test of within-subjects effects showed that there were no effects of match [$F(1,33) < 1$] and no interaction between match and situation type [$F(2,66) < 1$], but there was a significant main effect for situation type [$F(2,66) = 5.225$, $p < .01$]. These results indicate that there is a difference between the three types of situations in how accurate participants' sensibility judgments were. To determine exactly from where this difference arose, we conducted three univariate tests. They showed that the accuracy scores of achievements were significantly higher than those of accomplishments [$F(1,33) = 5.790$, $p < .05$] and those of activities [$F(1,33) = 10.032$, $P < .01$]. No significant differences were found between accomplishments and activities [$F(1,33) < 1$]. These results indicate that participants were more accurate in correctly identifying target sentences as sensible in the achievement condition relative to the accomplishment and activity conditions. These results seem to be consistent with the duration hypothesis. Accuracy on sensibility judgments seem to be negatively affected by events with duration, such as those in accomplishment and activity type sentences. Implications of these data will be further elaborated in the general discussion.

General Discussion

The aim of the present study was to test whether the situation types described by Vendler (1957) are represented differently in our situation models. We conducted two experiments to address this question. In the first experiment we used an indirect measure to investigate whether the situation types were represented differently. Participants read different situation type sentences followed by a subsequent task in which they had to click on a star symbol that appeared in a random place on the computer screen. We predicted differences in the processing time among the three different types, thus influencing the time needed to respond to the star symbol. We formulated three hypotheses that made specific predictions on how these differences would arise in the subsequent task performance; i.e., "the telicity hypothesis, the duration hypothesis, and the additive hypothesis." The telicity hypothesis proposes that achievement and accomplishment type sentences are processed faster than activity type sentences, because the former two types have an endpoint, which aids processing. As opposed to the later type that does not imply an endpoint. The duration hypothesis on the other hand predicts that only the duration of situations influences the processing time, therefore achievement type sentences should be faster to process than accomplishments and activities. This is because achievements are instantaneous, whereas the other two are durative. The final hypothesis is a combination of the former two hypotheses and it predicts that achievements are faster to process than the other two types, because achievements are telic and have an instantaneous nature. Accomplishments in turn, should be faster to process than activities, because they benefit from the implied telicity in a sentence.

The results of the first experiment did not show a difference of situation type on the reaction time in a subsequent task, thus none of the hypotheses mentioned above were supported. To make sure that possible differences in task performance were not masked by confounding variables such as verb length and verb frequency we performed two separate analyses. The analyses showed that the situation types did not differ in verb frequency or verb length, this suggests that the results were not influenced by artifacts.

Since the first experiment was an indirect measure of situation type representation we conducted a second experiment in which a priming paradigm was used to see if priming situation types with a matching sentence would facilitate the processing of a subsequent target sentence relative to priming a subsequent target sentence with a mismatching type. To test this, participants judged whether or not sentences made sense. The results did not support our hypothesis since they showed that matching primes did not facilitate the processing of subsequent target sentences relative to the mismatching primes.

Taken together, the data of both experiments did not show any significant results that could be considered support for our hypotheses. We propose two possible explanations. The first one is that there are no differences in how these situation types are represented. The second explanation is that we did not find a difference because of methodological issues. For example, it could be that we did not use adequate procedures to assess the situation type representation problem. However, we reason that this explanation is unlikely since similar procedures have been used in language research and they should be reliable measures in finding a difference between the types if it were to be there (e.g., Madden & Pecher, 2007). Interestingly however, was that although we did not predict it we found an unexpected result in our second experiment; there was an effect of accuracy such that judging achievement type sentences was done more accurately than judging accomplishments and activities type sentences. It could be that achievements enhanced performance, because of their instantaneous (and telic) nature. However, this analysis compares separate sentences, so it is open to confounds related to the individual sentences. It should be noted that the experimental sentences were identical to those used in the first experiment, so the analyses on verb frequency and verb length also apply here, diminishing the chances that our results are due to surface-level confounds between the sentences. We nonetheless remain cautious in interpreting these data as being adequate support for the idea that the three situation types are represented differently. An alternative more modest interpretation; that telicity and duration may influence task performance causing task specific effects (in some cases), is a more plausible account, but even this is a premature conclusion based on solely these results.

Although none of our hypotheses have been supported in the present study, there are theories that account for our results and thus explain why we did not find a difference between the situation types. These theories are referred to as the classical theories of language representation. They typically assume that language constructed out of *abstract*, *amodal* representations that are *arbitrarily* related to their environment (e.g., Anderson, 1974, Chomsky, 1968; Jones, Kintsch, & Mewhort, 2006; Kintsch, 1988, 1998; Landauer & Dumais, 1997; for a review see Markman & Dietrich, 2000). We will now briefly review some of the key assumptions that are shared by most of these classical theories and explain how they relate to situation type representation. First of all, according to some of these theories, language can be broken down into a set of *propositions* (i.e., abstract concepts underlying the meaning of a sentence), these propositions are made up out of different entities that have a specific relation to each other, for instance "The player kicked the ball" can be broken down into KICK[PLAYER, BALL] where "player" and "ball" are true entities in the real world as well as true entities that are internally represented by abstract symbols (e.g., Anderson, 1974; Kintsch, 1988, 1998). Classical models also propose that these internally represented entities have steady features that last over time as, that is, although context may influence what becomes activated of concepts the essence of these internal representations are fairly consistent on different occasions, for example, semantic features such as "barks" or "has four legs" have a high probability of becoming activated when encountering the word "dog" (e.g., Kintsch, 1988, 1998; Markman & Dietrich, 2000).

Furthermore, these entities are thought to be largely amodal which means that no matter what modality receives linguistic input, the representations that are activated are the same for these different modalities for example, reading or hearing the word "dog" activates the same symbol (e.g, Kintsch, 1988, 1998, Markman & Dietrich, 2000). This idea also holds when you are producing language, where the same abstract representations are activated when you write or when you speak. Thus, in amodel theories the relation between language comprehension and the brain areas that are activated during language comprehension are unspecified. The final key assumption that most classical theories share is that they propose that the abstract representations have an arbitrary relationship to their environment (e.g., Kintsch, 1998), that is, an abstract representation is randomly linked to its referent in the real world. For instance, a symbol that represents a ball is a randomly used symbol and it bears no relation to a ball (i.e., it does not look or sound like a ball).

These classical theories are able to explain our lack of a representational difference between the situation types. Consider the following two sentences, "The player kicked the ball" and "The player dribbled the ball", which are converted into the following propositions, KICK[PLAYER, BALL] and DRIBBLE[PLAYER, BALL]. Both propositions have two entities and one relational term, which all have abstract symbols that represent them. Thus processing the former and the later sentence should take the same time, because they both have three symbols that represent them and there is no reason to assume that some symbols are processed faster than others, so according to the classical models there is no reason to assume that some situation types are processed faster than others.

It seems that the classical theories are in accordance with our results, but what if we would have found a difference between how these situation types are represented? For instance, if in Experiment 1 we found that achievements and accomplishments facilitate performance on a subsequent task and in Experiment 2 we found that achievements and accomplishments prime each other, but not activities, the telicity hypothesis would have been supported. The telicity hypothesis accounts for these data as sentences with a natural endpoint facilitate performance on a subsequent task relative to atelic sentences and telic sentences facilitate each other relative to atelic sentences. Although telicity has been found to aid sentence processing in a number of studies, this given fact on its own is not an explanation of the current results.

One possible explanation for this advantage comes from the experiential based theories (e.g., Barsalou et al, 2003; Feldman & Narayanan, 2004; Garbarini & Adenzato, 2004; for a review see Ziemke, 2002). These theories propose that language comprehension works much in the same way as comprehending non-verbal information we perceive in everyday life. Rather than language being amodal and understood by transforming linguistic input into propositional representations, language is thought to be grounded in sensory-motor activity patterns. One example of such a theory is the perceptual symbol systems theory (PSS; Barsalou et al, 2003). PSS proposes that sensory input activates neurons within different modalities in the brain (e.g., motor areas, somato-sensory areas, auditory areas and visual areas) and these sensory experiences are stored within these same modalities. The sensory experiences (perceptual symbols) are analog to their referent in the real world, for example, when you are thinking of a yellow school bus, you are actually simulating parts of the experiences you had with them. This mechanism is also thought to be involved in language comprehension, thus when you read a particular clause you simulate perceptual symbols that are associated with the words. The advantage of experiential theories such as PSS over the classical theories is that the relations between language comprehension and brain sites is specified giving such theories not only explanatory power but also predictive power.

Because PSS assumes that knowledge is grounded in sensory-motor activity patterns it is able to account for the telicity hypothesis. For instance, it could be that simulating telic events is relatively easy because running a specific simulation is terminated after it is completed, thus the representation simulation is constrained by the temporal properties of a situation. On the other hand, the simulation of atelic events is not constrained by time and therefore they will not be terminated unless other cues imply that they should. Consider the following sentence, “Johnny was dribbling the ball, when the rain started pouring and he went home”. Even though this sentence never explicitly implied that he stopped dribbling and he could have dribbling the ball as he went home, it is unlikely that we infer that he continued dribbling the ball after it started pouring because our world knowledge tells us so. There is growing body of evidence that seems to support the experiential based theories like PSS (e.g., Gallese & Goldman, 1998; Glenberg & Kaschak, 2002; Glenberg & Robertson, 2000; Zwaan, Madden, Yaxley, & Aveyard, 2004; Zwaan, Stanfield & Yaxley, 2002; Zwaan & Taylor, 2006), but like the classical approaches they are unable to account for all the aspects of language comprehension (Markman & Diertich, 2000).

The short comings of the experiential based theories also relate to the problem at hand. We already explained how PSS is able to predict that telic and atelic events are processed differently, but the problem is that a telic advantage is not the only thing PSS predicts. It is also plausible to assume that instantaneous events are faster to simulate than durative events, thus the durative hypothesis is explained just as easily by PSS. However, classical theories are able to account for these effects as well by assuming variations of link strength between entities in a neural network. If the relational terms between two propositions differ in that one has a higher activation level than the other, it could influence the processing of sentences. If instantaneous events would have been faster than durative events, this could have been explained because of stronger links according to the classical approaches. Still, PSS is a more useful model in dealing with differences between the situation types, because PSS is able to predict a difference between the types and it is able to predict a direction beforehand, whereas the classical approaches are unable to do so because one does not know the link strength between two concepts.

In summary, our results suggest that the three situation types examined in this study are not represented differently. The classical theories of language representation are in accordance with this idea. Even though we did not find support for any of our hypotheses, we argue that telicity and duration may influence sentence processing causing task specific effects. In addition, our data pose no threat to the experiential based theories such as PSS, because they do not contradict its assumptions. However, if would we have found a difference of situation type this would have been more in alignment with the experiential based theories, because they do not only explain how such a result could arise they also predict in which direction one would expect to find a difference.

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Footnotes

[1] The situation types described here have also been referred to as event types or event structures in other literature (e.g. Folli & Harley, 2006; Moens & Steedman, 1988; O'Bryan, 2003). We prefer to use the term situation types, because we feel that not all types are accurately defined by the term events.

[2] All verb frequencies reported here are derived from the lemma verb forms rather than the past tense forms that were used in this experiment. The verb frequencies are derived from the CELEX lexical database (Baayen, Piepenbrock & van Rijn, 1993).

[3] In experiment 2 we used stricter trimming procedure than in the first experiment, because the sensibility judgment procedure is a less constrained procedure than the star clicking procedure causing greater subject variability between subjects and trials. By having a stricter trimming procedure we hoped to eliminate participants' error and increase our chances in finding an effect.

Table 1.

The Situation Types (i.e., Achievements, Accomplishments, Activities) and their Properties

	Achievements	**Accomplishments**	**Activities**
Telicity	*Telic*; implies that a situation has a natural endpoint.	*Telic*; implies that a situation has a natural endpoint.	*Atelic*; does not imply a natural endpoint.
Duration	*Instantaneous*; the onset of the situation also denotes its termination.	*Durative*; the situation is in progress during different points in time, where onset and termination of the situation are independent.	*Durative*; the situation is in progress during different points in time, where onset and termination of the situation are independent.
Stages	*Single stage*; the situation occurs at t_1 only.	*Multiple stages*; the situation evolves over time i.e., $t_1 \neq t_2 \neq t_3$ etc.	*Single stage*; the situation never changes.

Table 2.

Mean Reaction Times and Standard Deviations (in ms) on the Star Clicking Task after Reading Sentences of the Three Situation Types in Experiment 1

Type	Achievements		Accomplishments		Activities	
	Mean	SD	Mean	SD	Mean	SD
Reaction Time (in ms)	898.68	122.65	902.27	136.78	894.21	127.59

Table 3.

Mean Length and Frequency of Verbs and their Standard Deviations for the Three Situation Types in Experiment 1

Type	Achievements		Accomplishments		Activities	
	Mean	SD	Mean	SD	Mean	SD
Verb length (in letters)	6.88	2.29	7.08	2.24	6.44	1.86
Verb frequency (per 42,4 mln words)	11979	27490	5710	15322	11542	16096

The mean verb length is the number of letters in a given verb. The mean verb frequencies are based on their occurrence in a corpus consisting of 42,4 million words.

Table 4.

Mean Reaction Times (in Milliseconds) and Mean Accuracy Scores (in Percentages) and Standard Deviations for the Three Situation Types in Experiment 2

	Reaction Time (in ms)				Accuracy (in %)			
	Match		Mismatch		Match		Mismatch	
Situation type	M	SD	M	SD	M	SD	M	SD
Achievements	1498.05	295.96	1462.85	257.44	97.2	6.9	95.9	6.2
Accomplishments	1563.76	404.36	1563.76	404.36	94.5	8.8	93.6	7.2
Activities	1514.36	374.3	1550.43	307.96	92.1	11.6	93.7	6