Priming Effects on Event Types Classification: Effects of Word and Picture Stimuli

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Abstract

Event types (ET) have been widely addressed in linguistic literature, but few studies have dealt with the questions of how they are represented, retrieved and processed in the mental lexicon. We report two experiments in which ET categories were found to give rise to semantic priming effects, both with word and picture stimuli. These effects are argued to provide empirical correlates for ET categories in the mental lexicon not only at the lexical level but also at a deeper conceptual level.

Keywords: Semantic priming; event types; verb processing; verb semantics; psycholinguistics.

Introduction

Event Types

Event types (ET) are an important component of the "event structure template" (Kemmerer & Gonzales-Castillo, 2010) of the verb, and play crucial role in the temporal constitution of the sentence. We refer here to Vendler's (1967) standard classification of predicates into *states* (STA), *activities* (ACT), *accomplishments* (ACC) and *achievements* (ACH)[1]. These categories can be further cross-classified with respect to the features of dynamicity (DYN), durativity (DUR) and resultativity (RES)[2] (see Table 1).

Table 1: Features of Vendler's event types

ET	[dyn]	[dur]	[res]
STA	−	+	−
ACT	+	+	−
ACC	+	+	+
ACH	+	−	+

In particular, we focused on ACHs and ACTs, because they contrast with respect to DUR and RES: ACH $[-dur, +res]$ (e.g., *land*, *die*); ACT $[+dur, -res]$ (e.g. *sing*, *walk*).

[1] **STA** denote properties and situations experienced by the subject as being static (e.g. *to know*, *to be tall*); **ACT** denote non-resultative activities (e.g. *to sing*, *to walk*); **ACC** denote activities with a clear goal or outcome (e.g. *to write a book*, *to walk to the fence*); **ACH** denote a change of state (e.g. *to stumble*, *to die*).

[2] *DYN* distinguishes among stative events and dynamic events (e.g. *to live*, *to know*, vs. *to run*, *to stumble*). *DUR* events are events perceived as lasting over time (e.g. *to knit*, *to stir*), *non-DUR* events are perceived as punctual (e.g. *to fall*, *to die*). *RES* events entail the existence of a clear outcome or resulting state that has to be reached for the event to be considered completed (e.g. *to land*, *to write a book*, vs. *to fly*, *to talk*).

Empirical Correlates of Event Types

Event types (ET) have been widely addressed in linguistic literature, but few studies have dealt with the questions of how they are represented, retrieved and processed in the mental lexicon. Noteworhy exceptions are: Gennari and Poeppel (2002, 2003); Finocchiaro and Miceli (2002); Heyde-Zybatow (2004); Bott (2008); Bonnotte (2008).

In particular, Bonnotte (2008) shows semantic priming effects of ET for ACTs and ACHs in French, reporting differences between processing of durativity and resultativity: "facilitation was shown on the former with similar and opposite priming, whereas it was shown on the latter only with similar priming".

Goal of the work

The main goal of the work was the investigation of ETs in the mental lexicon, their representation and retrieval. We report two experiments based on the semantic priming paradigm (see McNamara, 2005, for a review), aimed at providing empirical correlates for ET categories.

Our starting point was the study in Bonnotte (2008), which we replicated for Italian with some crucial design innovations (Experiment 1). This experiment was conducted at a lexical level, using word stimuli. A second experiment (Experiment 2) introduced picture primes, in order to compare lexical semantic priming with non-linguistic priming, with the aim of delving into a deeper conceptual level than word stimuli.

ET categories were found to give rise to semantic priming effects, both with word and picture stimuli, but with a different pattern of results than in Bonnotte (2008): crucial differences were found at the ET level, and not between processing of durativity and resultativity. Priming effects were registered not only at the lexical level but also at a deeper conceptual level.

Experiment 1

Experiment 1 replicated the study conducted for French by Bonnotte (2008). As in Bonnotte (2008), Experiment 1 was designed to explore semantic priming effects of ET categories in Italian.

Nevertheless, two main differences were introduced. First of all, prime-target pairs and ACH-ACT sets were checked and tagged with respect to their semantic class, in order to rule out influences of the semantic class and to isolate effects of features pertaining to ETs, i.e. DUR and RES. Semantic

Table 2: Examples of prime-target pairs in Experiment 1

	target ACH	target ACT
neutral prime	XXX - sparare XXX - *to shoot*	XXX - dormire XXX - *to sleep*
opposite prime	ballare - sparare *to dance - to shoot*	entrare - dormire *to enter - to sleep*
similar prime	entrare - sparare *to enter - to shoot*	ballare - dormire *to dance - to sleep*

classes correspond to WordNet topnodes for verbs (Fellbaum, 1998). The prime and target of each test pair never belong to the same semantic class. Semantic classes were also used as a source of variance in the inferential statistic model. As a further difference with Bonnotte (2008) a slightly longer stimulus onset asyncrony (SOA) was used (300ms), in order to avoid spillover effects with longer stimuli.

Method

Participants 48 native Italian speakers from the University of Pisa and the Scuola Normale Superiore in Pisa volunteered to participate in the experiment and were paid for their participation. All had normal or corrected-to-normal vision.

Materials Two groups of 18 intransitive ACT Italian verbs and 18 intransitive ACH Italian verbs were pair-wise balanced for variables known to affect processing costs, such as length, frequency, syntactic frame frequency, ET polysemy; they were used as targets in the priming experiment.

The average length was 8 characters for ACTs (SD = 1.5) and 8 for ACHs (SD = 1.5) and did not differ significantly between the two groups (Kruskal-Wallis: df $= 1, \chi_2 = 0, p = 1$). Mean frequency (estimated from ColFis, Laudanna et al., 1995) was 129.5 occurrences per 3 million words for ACTs (SD = 165.5), and 88 for ACHs (SD = 173.5) and did not differ significantly between the two groups (Kruskal-Wallis: df $= 1, \chi_2 = 1.683, p = 0.2$). Syntactic frame frequencies were estimated from Repubblica corpus (Lenci et al., 2010): all verbs were intransitive and strongly monoargumental; ET polysemy was assessed with pre-test 1.

Each target appeared in one of three prime contexts: after a neutral prime (a string of Xs), after a similar prime (a verb of the same ET), after an opposite prime (a verb of opposite ET). As prime verbs we used different verbs than the target verbs. See examples in Table 2. Each prime-target pair was assigned to one of three lists so that an equal number of pairs per each condition appeared on each list, so that exactly one version of each target appeared on each list and so that each participant saw not more than one version of each target.

Pre-test 1 Italian lacks morphological clues for ET, and verbs tend to be ambiguous with respect to their ET category. Our experiments required non-ambiguous verbs, to be assessed with an inter-annotators pre-test inspired by the one in Bonnotte (2008).

Pre-test 1 was carried out to check our annotation of the verbs according to their ET. Materials for pre-test 1 were 136 predicates (114 transitive VPs - verb + object - and 22 intransitive verbs). Both transitive and intransitive verbs showing all four of Vendler's (1967) ET categories were used, both to have less constrained answers and to have a broader stimuli set for further experiments.

20 native Italian-speaking students performed the test in a web-based format. Per each event, subjects were asked to choose one of four pictures, one representative of each ET:

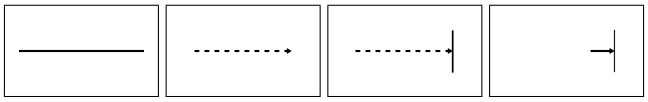

Figure 1: Pictures used in pre-test 1: the long continuous line depicts a state that lasts in time, the long dashed arrow depicts a process that develops over a certain period of time, the long dashed arrow ending with a vertical dash depicts a process that develops over a certain period of time and leads to a result, the short arrow ending with a vertical dash depicts an event that causes a change of state.

Results showed a mean accuracy of .61, inter-subject observed agreement of .5, inter-subject expected agreement of .25 and a kappa mean value of .33. Kappa was .46 on intransitive ACHs and .34 on intransitive ACTs. Agreement values were above chance and significantly good, since the subjects were naive to linguistics and ET classification. 3 ACHs and 3 ACTs showing low agreement (< 0.19) were ruled out for future experiments.

Procedure Participants were instructed to read the prime and the target and perform a semantic decision task. Half of the subjects were assigned a durativity decision task, the other half were assigned a resultativity decision task. Within the DUR task, subjects were asked:

Does the target denote a process
lasting over a period of time?

Within the RES task, subjects were asked:

Does the target denote an event with a clear outcome?

The semantic decision task directly references the manipulated variables, but nevertheless it was preferred over a more neutral lexical decision task for a better comparison with previous results and procedures in Bonnotte (2008). Task choice was later supported by the good accuracy results achieved.

Prime-target stimuli were presented on a screen in white upper-case letters on a black background with an SOA of 300ms. The target was deleted after the response. Participants answered by pressing one of two buttons on a button box, which recorded the decision latencies (DL) to one tenth of ms accuracy. DL were recorded as the time between the target onset and the response. Participants were given a detailed description of the experimental trials and were trained during a special simulation session (9 practice trials) before beginning the experiment.

Table 3: Experiment 1 - Mixed Effect Model: $log(dl) \sim prime + et + task + (1|subj) + (1|verb) + (1|sem\_cl)$

	Estimate	MCMCmean	HPD95lower	HPD95upper	pMCMC	$Pr(>\|t\|)$	
(Intercept)	9.49	9.66	−12.78	30.79	0.16	0.00	
primeopp	−0.09	−0.09	−0.14	−0.04	0	0.00	***
primesim	−0.05	−0.05	−0.10	−0.01	0.02	0.02	*
etACT	−0.10	−0.11	−0.21	0.01	0.06	0.04	*
taskris	0.09	0.09	0.00	0.18	0.06	0.12	

Table 4: Experiment 1 - Separate analyses: $log(dl) \sim prime + (1|subj) + (1|verb) + (1|sem\_cl)$

	Estimate	MCMCmean	HPD95lower	HPD95upper	pMCMC	$Pr(>\|t\|)$	
DUR, ACH targets							
(Intercept)	9.48	9.48	9.34	9.62	0	0	
opp	−0.1	−0.1	−0.18	−0.02	0.02	0.02	*
sim	−0.03	−0.03	−0.11	0.05	0.47	0.45	
DUR, ACT targets							
(Intercept)	9.4	9.4	9.23	9.56	0	0	
opp	−0.06	−0.06	−0.15	0.02	0.13	0.12	
sim	−0.11	−0.11	−0.20	−0.03	0.01	0.01	**
RES, ACH targets							
(Intercept)	9.61	9.6	9.45	9.77	0	0	
opp	−0.15	−0.15	−0.26	−0.04	0.01	0.01	**
sim	−0.06	−0.06	−0.16	0.06	0.32	0.29	
RES, ACT targets							
(Intercept)	9.45	9.45	9.32	9.58	0	0	
opp	−0.07	−0.07	−0.17	0.03	0.16	0.14	
sim	−0.02	−0.02	−0.12	0.08	0.71	0.66	

Design Experiment 1 had a 2x3 within-subjects design (2-levels factor being the ET of the target, and 3-levels factor being the type of prime context) with one between-subjects factor (DUR task, RES task).

Results

The neutral prime level was used as a baseline to evaluate the effect of opposite and similar prime on decision latencies (DL): both primes show smaller mean DL, suggesting a general facilitation effect (see Figure 2, more detailed information on Table 5). A mixed effect model (see Table 3) of DLs[3] showed that the difference between the neutral prime and the opposite prime was highly significant, and the difference between the neutral prime and the similar prime was significant; furthermore, it yielded a significant effect of the target's ET.

General accuracy was .86 (.89 for DUR, .82 for RES). A logistic regression analysis performed on errors did not yield any effect of the priming context or of any other factor.

Separate analyses Four separate analyses were conducted, one for each ET (ACH and ACT) within each task (DUR and RES), using four smaller-scale mixed effect models (see Table 4). A significant difference between the neutral prime level and the opposite prime level was found on ACH targets for both DUR and RES tasks. A significant difference between the neutral prime level and the similar prime level was found on ACT targets in the DUR task.

[3]Fixed effects were prime, task, ET of the target; random effects were subject, target verb, semantic class of the target.

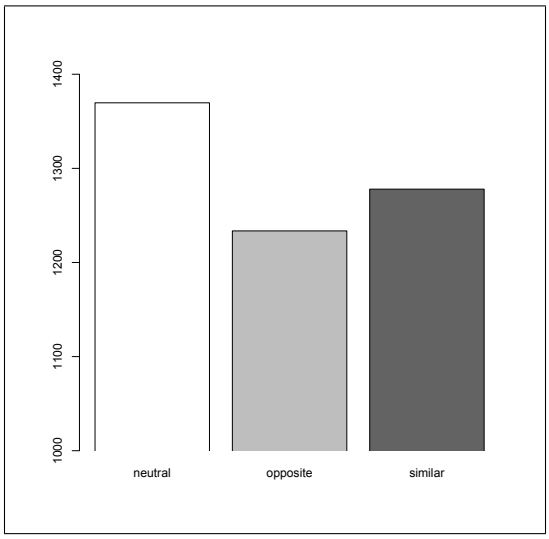

Figure 2: RT means for the different priming contexts in Experiment 1.

In the DUR task, ACTs are able to prime both ACT and ACH targets; on the other hand, in the same task ACHs never prime either ET. This might depend on the fact that ACT are positively marked with the feature of DUR, which is relevant for this task. However, in the RES task, only ACTs have a significant priming effect on ACH targets, suggesting that priming occurs in this case only when the target is positively marked with the feature of RES, activated in this task. Here

Table 5: RT means (in ms) and standard deviations in Experiment 1 and Experiment 2

	Experiment 1								Experiment 2							
	DUR				RES				DUR				RES			
	ACH		ACC		ACH		ACC		ACH		ACC		ACH		ACC	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
neu	1370	403	1291	501	1558	539	1309	484	1226	409	1076	332	1305	426	1316	360
opp	1242	382	1186	456	1335	428	1227	465	1238	421	1128	372	1289	380	1297	327
sim	1312	370	1100	305	1472	530	1296	434	1302	472	1102	325	1422	474	1358	380

it is more the contrast between the [−res] of ACTs and the [+res] of ACHs to produce a priming effect.

Experiment 2

Experiment 1 showed significant priming effects of ET at the lexical level. The aim of Experiment 2 was to delve to a deeper conceptual level, in order to assess if ETs are "pure linguistic" categorizations or if they rather apply also to non linguistic input. With this purpose, a key modification was applied to Experiment 1: picture primes were used instead of word primes.

Method

Participants 42 native Italian speakers from the University of Pisa and the Scuola Normale Superiore in Pisa volunteered to participate in the experiment and were paid for their participation. All had normal or corrected-to-normal vision.

Materials Targets from Experiment 1 were also used as targets for Experiment 2. Each target appeared in one of three prime contexts: after a neutral prime (a pattern of Xs), after a similar prime (a picture depicting an event of the same ET), after an opposite prime (a picture depicting an event of opposite ET). Picture primes were selected from the IPNP database (Bates et al., 2000, see examples in Figure 3) and their association with ET categories was assessed through pre-test 2. Each prime-target pair was assigned to one of three lists so that an equal number of pairs per each condition appeared on each list, so that exactly one version of each target appeared on each list and so that each participant saw not more than one version of each target.

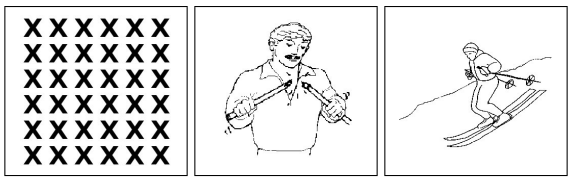

Figure 3: Picture primes: neutral prime, ACH picture (*to break*), ACT picture (*to ski*).

Pre-test 2 Non-ambiguous verb stimuli were selected through pre-test 1; a similar pre-test was conducted to select picture stimuli for Experiment 2. Materials for pre-test were 87 pictures from the IPNP database. Again, all four of Vendler's ET categories were used as possible answers. 20 native Italian-speaking students performed the test in a web-based format. Procedure was the same as in pre-test 1.

Results showed an inter-subject observed agreement of .42, inter-subject expected agreement of .26 and a kappa mean value of .21. 12 ACH pictures and 12 ACT pictures showing best agreement were chosen as primes for Experiment 2. Kappa mean value for chosen pictures was .42 (.41 for ACHs, .43 for ACTs).

Procedure Procedure was the same as in Experiment 1, with one difference: picture stimuli required longer times to be processed, and so SOA was set to a higher value (700 ms); SOA was assessed by asking 10 more participants from the same pool as in Experiment 1 and 2 to name the pictures. 700 ms was estimated as the shortest presentation time to allow the participants to identify the picture.

Design Design was the same as in Experiment 1.

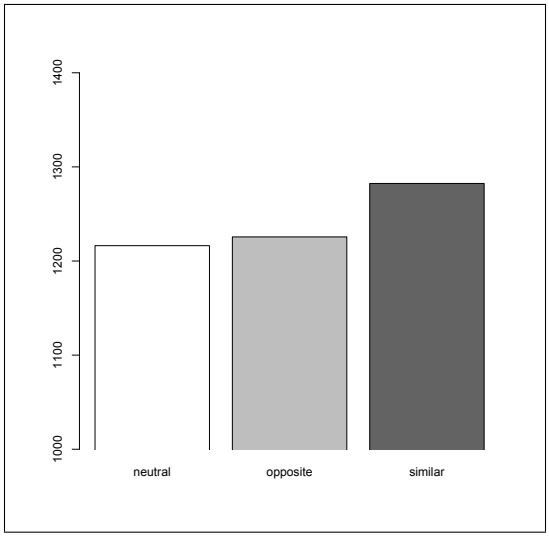

Figure 4: RT means for the different priming contexts in Experiment 2.

Results

In contrast with Experiment 1, in Experiment 2 picture primes showed longer mean DL than the neutral prime, suggesting a general inhibitory effect (see Figure 4, more detailed information on Table 5). A mixed effect model (see Table 6) of

Table 6: Experiment 2 - Mixed Effect Model: $log(dl) \sim prime + et + task + featval + (1|subj) + (1|verb) + (1|sem\_cl)$

	Estimate	MCMCmean	HPD95lower	HPD95upper	pMCMC	$Pr(>\|t\|)$	
(Intercept)	9.4	9.4	9.31	9.49	0	0	
primeopp	0.01	0.01	−0.02	0.03	0.68	0.69	
primesim	0.05	0.05	0.03	0.08	0.00	0.00	***
etACT	−0.08	−0.08	−0.14	−0.02	0.01	0.01	**
taskris	0.14	0.14	0.05	0.22	0.00	0.02	*
featval+	−0.05	−0.05	−0.08	−0.03	0.00	0.00	***

Table 7: Experiment 2 - Separate analyses: $log(dl) \sim prime + (1|subj) + (1|verb) + (1|sem\_cl)$

	Estimate	MCMCmean	HPD95lower	HPD95upper	pMCMC	$Pr(>\|t\|)$	
DUR, ACH targets							
(Intercept)	9.38	9.37	9.24	9.53	0	0	
opp	0.02	0.01	−0.04	0.07	0.59	0.55	
sim	0.08	0.08	0.02	0.13	0.00	0.00	**
DUR, ACT targets							
(Intercept)	9.26	9.26	9.18	9.33	0	0	
opp	0.03	0.03	−0.02	0.08	0.22	0.21	
sim	0.02	0.02	−0.02	0.07	0.36	0.34	
RES, ACH targets							
(Intercept)	9.52	9.51	9.35	9.68	0	0	
opp	−0.02	−0.02	−0.08	0.03	0.52	0.48	
sim	0.07	0.07	0.01	0.12	0.01	0.01	*
RES, ACT targets							
(Intercept)	9.46	9.46	9.39	9.53	0	0	
opp	−0.01	−0.01	−0.06	0.04	0.71	0.7	
sim	0.03	0.03	−0.02	0.09	0.21	0.19	

DLs[4] showed that the difference between the neutral prime and the similar prime was the only one to reach significancy; furthermore, it yielded a significant effect of the target's ET, of the task and of the featural value ([+/−dur], [+/−res]) of the target.

General accuracy was .92 (.94 for DUR, .90 for RES). A logistic regression analysis performed on errors did not yield any effect of the priming context or of any other factor.

Separate analyses Four separate analyses were conducted, one for each ET (ACH and ACT) within each task (DUR and RES), using four smaller-scale mixed effect models (see Table 7). A significant difference between the neutral prime level and the similar prime level was found on ACH targets for both DUR and RES tasks.

A striking difference with respect to Experiment 1 is the absence of priming effects with ACTs, both as target or prime. This fact might be due to the inherently "static" character of picture stimuli, which makes the [+dur] of ACTs less salient.

General Discussion and Conclusions

In line with both our expectations and the study in Bonnotte (2008), our experiments yielded significant priming effects of ET, thus providing evidence to the idea that ETs are indeed relevant for the mental lexicon. This conclusion is further supported by the crucial innovation we introduced in the experiments, i.e. controlling the semantic class of prime and target verbs. The priming effects can thus be related to the more abstract event structure shared by verbs that greatly differ for other dimensions of their meaning.

In addition to this, two different modalities were explored and contrasted: word primes and picture primes. Using picture stimuli is a first but significant attempt to place the study of ETs within a broader frame of study of event meaning in cognition. The Embodied Cognition Framework (Evans & Green, 2006; Haggard et al., 2007; Barsalou, 2008) suggests that semantic representations are not purely amodal, but rather grounded in our sensorimotor perception, and it has been suggested that processing a verb might involve "covertly recapitulating" the event it refers to (Kemmerer & Gonzales-Castillo, 2010).

The effect of facilitation given by the word primes is not surprising; the negative priming which we report for the picture primes is usually explained with a combination of inhibition (an effort of selective attention to avoid a previous stimulus) and memory retrieval (see Tipper, 2001, for a review). Picture primes seem to act at a deeper level than word primes, and it is crucial that the negative priming is found in the similar prime condition: similar primes seem to be more difficult for subjects to ignore.

Moreover, the pattern of results offered by this study suggests a different explanation of such priming effects than the one offered by Bonnotte (2008) (see Table 8). Bonnotte (2008) suggests a crucial difference between processing of

[4]Fixed effects were prime, task, ET of the target, featural value ([+/−dur], [+/−res]) of the target; random effects were subject, target verb, semantic class of the target.

Table 8: Comparison with results in Bonnotte (2008).

	DUR		RES	
	ACH	**ACT**	**ACH**	**ACT**
Bonnotte 2008	–	sim and opp	sim	sim
Exp 1	opp	sim	opp	–
Exp 2	sim	–	sim	–

durativity and resultativity: "facilitation was shown on the former with similar and opposite priming, whereas it was shown on the latter only with similar priming". Nevertheless, the pattern emerging from our experiments does not show great differences between processing of durativity and resultativity, but rather suggests a difference at the level of ET categories, which seem to differ with respect to their behavior in both tasks. Differences in priming effects across ET categories can be ascribed to different lexical encodings of their ET features: the [+dur] and [−res] of ACTs is more ductile and subject to contextual adaption, whereas ACHs are more "inherently" [−dur] [+res]. Moreover, ACTs do not seem to be affected by priming with picture stimuli, which might be problematic in conveying the [+dur] [−res] nature of ACTs. In the near future a comparison will be carried out with a similar study of Russian (Batiukova et al., 2010).

The use of videos was also contemplated for this study, but pictures were preferred for a first exploration of the visual modality because the IPNP database provided a convenient standard of stimuli and because picture primes allowed for shorter SOAs. This would not have been the case for video stimuli. Nevertheless, videos have been used in the investigation of event representations (e.g. Gennari et al., 2002) and, since they could provide a better depiction of both DUR and RES, this modality would definitely be of some interest for further work, in order to more thoroughly investigate ET representations in the mental lexicon.

ET categories were found to give rise to semantic priming effects, at both word and picture levels, which, albeit with crucial cross-modal differences, provide empirical correlates for ET categories in the mental lexicon and suggest that ETs are not only a linguistic phenomenon, but relate with our way of conceptualizing events in the world.

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