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Processing of Transitivity Alternations and Frequency-Based Accounts in Greek Adult Language

Georgia Fotiadou

Department of Linguistics, School of Philology, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece; geofotia@lit.auth.gr

Abstract: The processing and resolution of syntactically ambiguous structures is accounted for by serial autonomous and multiple constraint satisfaction models differently. We investigated the extent to which frequency affects native speakers' processing and interpretation of 'voice (non)-alternating' anticausative Greek verbs which differ in the availability or lack of voice alternation on the verb when it appears in intransitive structures. The accessibility of interpretations was measured with an online self-paced reading (SPR) task and an offline acceptability judgment (AJ) task addressed to 45 monolingual Greek-speaking adults. In order to investigate whether processing load is affected by statistical records in the parser, we compared empirical data with the frequency of the available readings that these verbs receive in formal and informal registers (ILSP, Web-Based Corpus). The online processing study indicated that the parser is sensitive to morphological cues ((N)ACT voice marking), while semantic factors such as animacy are integrated in subsequent stages of processing. A frequency effect was found in accordance with 'coarse-grained' models of sentence processing, while more 'fine-grained' models could not be validated with respect to frequency alone. The majority of acceptability judgements attributed to the verbs investigated correlated with the most frequent interpretations of verb forms in intransitive structures in corpora.

Keywords: transitivity alternations; animacy of syntactic subject; anticausatives; sentence processing; frequency

1. Introduction

Theories of sentence processing try to explain the processing and resolution of syntactically ambiguous structures. The different accounts that have been proposed can be distinguished in two broad categories: serial autonomous models (e.g., Ferreira and Clifton 1986; Frazier 1990), which propose that the parser computes one analysis at a time, and multiple constraint satisfaction models (e.g., Garnsey et al. 1997; MacDonald et al. 1994; Trueswell et al. 1994), which suggest that the parser simultaneously computes multiple analyses. More specifically, serial autonomous models, as the Garden path, assume that the parser constructs an initial analysis to resolve ambiguity, based on syntactic information. When new elements are incrementally added to the sentence and prove that the initial analysis was incorrect, the parser revises it by reanalyzing the given structure. At this point, lexical, semantic, pragmatic or discourse information may affect processing. On the other hand, multiple constraint satisfaction models suggest that various types of information (e.g., lexicosemantic, discourse pragmatics or frequency) are available to the parser early in the processing and can be used unconditionally, with no architectural limitations (MacDonald et al. 1994). Lists of probabilistic constraints have been alternatively proposed (e.g., MacDonald and Seidenberg 2006) to facilitate the resolution of ambiguities as in the case of main/reduced relative clauses. Under this perspective, constraints such as the animacy of the preverbal NP, the frequency of the verb used in (in)transitive structures and the frequency of the syntactic structure, the thematic role of the preverbal NP (i.e., whether

it has an agent vs. a theme role) and other discourse-based constraints that incorporate ideas from referential theory (e.g., Steedman and Altmann 1989) are considered.

Researchers' interest in frequency-based parsing led to the rise in research juxtaposing corpus analyses to experimental data and to the formulation of approaches which posit that parsing decisions are determined on the basis of the frequency with which alternative analyses occur in natural language. For the coarse-grained Tuning Hypothesis (Cuetos et al. 1996), language-specific probabilities of statistical syntactic records are assumed to regulate early processing; more fine-grained 'lexicalist' approaches (e.g., MacDonald 1997) suggest that the parser is based on lexical records, i.e., on statistical records of individual lexical items within specific structures. Noticeably, the Tuning Hypothesis could be considered a variant of the Garden path model, their difference being that the latter is based on universal principles, while the former is based on exposure facts, though authors admit that there must exist some non-statistical influences in initial parsing (Mitchell and Brysbaert 1998, p. 324). Evidence in favor of more fine-grained approaches is provided by research matching the frequency of specific tokens in corpora to psycholinguistic data (e.g., Gibson et al. 1996).

Thus, the main question addressed in this paper concerns the evaluation of 'experience-based' models of sentence processing, which are based on the idea that the parser is affected by the frequency of alternative readings of ambiguous structures. The Greek verbal paradigm is a suitable candidate for this, given that morphological marking does not signal transitivity alternations unambiguously. Before proceeding with the formulation of specific research hypotheses, we outline some information on the Greek paradigm that is relevant to our research, though the literature on the topic is much richer.

Transitivity alternations in Greek may or may not involve morphological changes of Voice marking on the verb, while syncretism of voice morphology leads to temporal ambiguity resolved at the level of contextual integration. Voice morphology on the Greek verb has a binary value, active (ACT) and non-active (NACT), but does not signal transitivity alternations in a transparent way. Several theoretic explanations have been put forward in relation to the syntactic derivation of transitivity alternations (e.g., Alexiadou and Anagnostopoulou 2004; Alexiadou et al. 2015; Theophanopoulou-Kontou 2000; Tsimpli 2006; Zombolou 2004).

In the present paper, we focus on verbs which involve a CAUSE argument in the transitive version (see Dowty 1979; Alexiadou and Anagnostopoulou 2004; Tsimpli 2006 for Greek) and participate in the causative/anticausative (or inchoative) alternation, either marked as ACT (1), also referred to as ergatives/labile verbs (which we refer to as 'voice non-alternating' anticausatives), NACT (2)[1], or optionally as ACT/NACT with largely similar interpretation, labelled as *ditypias* (litt. of two types) in Greek, which we refer to as 'voice alternating' anticausatives (3). Noticeably, morphological marking does not affect the availability of anticausative interpretation among these 'voice alternating' anticausatives.

(1)   To potiri espase
        the-SING-NOM glass-SING-NOM broke-3SING-ACT
        'the glass broke'

(2)   I simea skistike
        the-SING-NOM flag-SING-NOM torn-3SING-NACT
        'the flag was torn'

(3)   Ta rucha lerosan/lerothikan
        the-PL-NOM clothes-PL-NOM spilled-3PL-ACT/NACT
        'the clothes spilled/were spilled'

The semantic feature of animacy of the surface syntactic subject is clearly indicated to block the alternating status of these anticausatives, i.e., substituting 'the clothes' by 'the kids' in a sentence such as (3), when combined with ACT, would give raise obligatorily to a transitive reading only and would need a continuation, including an object as in *ta pedhia lerosan ta rucha tus* (the kids spilled their clothes). NACT voice morphology can also receive a reflexive, a passive or a middle[2] interpretation. The choice of a reflexive over

the other available readings is also assumed to be affected by the [+/− animacy] of the syntactic subject (Tsimpli 2006): an animate subject favors the reflexive reading, whereas an inanimate subject favors the passive (or anticausative) one. Although unaccusativity has been a central topic on the debate between projectionist and constructionist models, it is beyond the scope of this paper to further discuss whether lexical entries project onto syntactic structures (e.g., Levin and Rapapport-Hovav 2005) or syntactic knowledge drives the verb interpretation (e.g., Borer 2004). Instead, we consider unaccusativity to be a sentence-level property (in line with Borer 2004) and follow Tsimpli (2006) for whom the anticausative interpretation of NACT verb forms is left underspecified in grammar, raising temporal structural ambiguity between passive and anticausative readings resolved by the semantics of the predicate among other discourse factors in later stages of processing (see, e.g., Alexiadou and Anagnostopoulou 2004; Alexiadou et al. 2015 for different proposals)[3].

Real-time processing is suggested to support a postverbal delay due to reactivation of a gap or trace left by the moved object in non-canonical constructions involving A-movement, i.e., structures where the syntactic subject is not the external argument (Perlmutter 1978). According to Manzini and Roussou (2000), θ-roles are features that can be attracted by DPs, clitics or affixes (as inflection). Tsimpli (2006, p. 18), following Alexiadou and Anagnostopoulou (2004), assumes that Voice projects as a feature of light v only in NACT. Accordingly, for NACT, morphological marking reflexes the Voice projection which attracts a θ-feature (external or internal), giving rise to a reflexive (4) or a non-reflexive reading (5). Voice lacking nominal features (case, person) leaves the attracted feature underspecified with respect to interpretation in spell-out position, which is actually regulated by other pragmatic information (naturalness, frequency), clausal information and the semantics of the predicate (Tsimpli 2006, pp. 23–25). Therefore, a single verb can receive various interpretations, equally acceptable by native speakers of Greek. The internal feature is attracted by the internal argument which moves to the subject position. For ACT, lack of Voice and external argument, the transitivity alternation is argued to represent differences in a transitivity or agentive feature borne by light v, independently of Voice, the single internal argument being either moved to [spec, TP] position (6a; Alexiadou and Anagnostopoulou 2004), or directly merged in its spell-out position attracting the internal θ-feature on the V head (6b; Manzini and Roussou 2000).

(4) $[_{v/VoiceP}$ DP $[_{v/Voice<\theta 1>}$ v/Voice $[_{VP}$ V $_{<\theta 2>}]]]$

(5) $[_{TP}$ DP $[_{v/VoiceP}$ v/Voice $_{<\theta 1>}$ $[_{VP}$ V$_{<\theta 2>}$]]]$

(6) a. $[_{TP}$ DP $[_{vP}$ V $[_{VP}$ $[_{DP}$ DP]]]]]$
     b. $[_{TP}$ DP $[_{vP}$ V $[_{VP}$ $[_{V <\theta>}]]]]]$

(adapted from Tsimpli 2006)

The overwhelming majority of previous research on the Greek verbal morphological system and the available readings examined L1 and 2L1 acquisition and suggested that, for NACT, passive is available in child grammar (Fotiadou and Tsimpli 2010), though not fully acquired even until the early school years (Nerantzini et al. 2022; Terzi et al. 2014; Zombolou et al. 2010), while reflexive is less vulnerable (Fotiadou and Tsimpli 2010; Nerantzini et al. 2022; Tsimpli 2006; Terzi et al. 2014). Anticausative exhibits variability due to the availability of both ACT and NACT, ACT revealing higher performance than NACT among bilingual children (Unsworth et al. 2011; Zombolou et al. 2010). Derivational differences have been suggested to account for earlier acquisition of reflexives over passives (Tsimpli 2006) and earlier acquisition of anticausatives over passives (Zombolou et al. 2010): reflexives are considered unergatives (where the agent θ-role in subject position is not a derived one), with animacy of the syntactic subject having a crucial role in comprehension; anticausatives are considered unaccusatives with a non-agent theme-role and therefore easier than passives (see also Terzi 2021 for a relevant discussion). Usage-based acquisition of transitivity alternations has been addressed by Fotiadou and Tsimpli (2010), who suggested that children lack sufficient exposure to form verb classes and regulate their preferences in line

with adults, but show abstract knowledge of syntactic structures and partial sensitivity to morphological marking (p. 2625).

To our knowledge, no prior research has investigated online processing of transitivity alternations in Greek among adult monolinguals in order to evaluate 'grammar-constrained' vs. 'experience-constrained' sentence processing. More specifically, we address the following questions:

i.   Is the parser driven by grammar in a serial autonomous way, or are multiple constraints unconditionally available during initial parsing?

ii.   At what level (syntactic or lexicosemantic) is processing regulated by statistical records, and at which point of processing are these experience-based constraints activated?

iii.   Is the judgment of native speakers conditioned by voice morphology, animacy of the syntactic subject, verb classes or previous experience?

To answer the above, we first report on a corpus study for specific verbs suggested to belong to voice (non-) alternating anticausatives in Greek (Section 2) and then we use a self-paced reading and acceptability judgment task to investigate the online processing and the degree of acceptability of sentences including these verbs among adult native speakers of Greek (Section 3). In Section 4 we discuss a comparison between empirical data and corpus evidence and in Section 5 we conclude with the main research findings.

2. The Corpus Study

2.1. Materials and Methods

We compiled a corpus with samples of (a) authentic written and (b) quasi-oral speech including verbs that have been classified (i) as 'voice non-alternating' anticausatives, suggested to undergo the causative/inchoative alternation appearing only in ACT (ergative/labile verbs), and (ii) as 'voice alternating' anticausatives, optionally marked with (N)ACT morphology. The samples of authentic written speech are records drawn from the ILSP Corpus (http://hnc.ilsp.gr/ accessed on 20 February 2010), which contains texts from various genres, i.e., books, newspapers, magazines and other sources of informal language such as leaflets, flyers and reports, among others (hence 'ILSP' samples). Although this is a quite large corpus, sparseness among verbs belonging in the class of anticausatives that are highly frequent in everyday life put forward the quest for oral data. Therefore, we additionally compiled a dataset with what we consider samples of 'quasi'-oral speech, in line with supporters of linguistic research based on the web (e.g., Hundt et al. 2007). The web-based samples of quasi-oral speech were retrieved from documents produced by non-professional writers, i.e., chat pages, fora, mails, blogs and other informal written material (hence 'Web' samples). This compilation was created via automatic searches on the Internet with the Google Web APIs technology in Active Server Pages and then manually trimmed to eliminate repetition of sentences and reduce noise (for more, see Fotiadou 2010). The compiled samples were then annotated in terms of semantic and syntactic features in MS Access and are accessible at https://www.enl.auth.gr/langlab/projects/google_corpus.htm, accessed on 5 February 2022.

The morpho-syntactic strings under examination included the following verbs: seven voice non-alternating anticausatives, i.e., *jerni* (lean), *lijizi* (bend), *lioni* (melt), *sapizi* (rot), *vrazi* (boil), *stegnoni* (dry) and *klini* (close); and seven voice alternating anticausatives, i.e., *leroni* (spill), *katharizi* (clean), *tripai* (pierce), *htipai* (hit), *tendoni* (stretch), *berdevi* (mingle) and *tsalakoni* (crumple). For the annotation, we adopted a coding scheme including information relevant to voice morphology, person, number and aspect of the verb used, animacy of the syntactic subject and, when applicable, the prepositional phrases (PPs) that participated in the structures. For the evaluation of the reading specific verb tokens received, we considered contextual information: for ACT, evaluative decisions were taken based on whether the subject initiated the event described by the verb's semantics (transitive) or was acted upon (anticausative), as in (7)-(8), respectively; for NACT, the various interpretations were diagnosed based on argument structure, i.e., whether the subject was acted upon and

a cause or an instrument was also included in the structure (anticausative), as in (9), or an agent was implicitly or explicitly present (passive), as in (10), and whether the subject was a true agent (reflexive), as prompted by cues such as the existence of a purpose clause or other relevant context information, as in (11).

(7)   [. . .] apo ta mpaza pu eklisan to dromo.
from the-SING-NOM debris-SING-NOM that close-3SING-PAST-ACT
the-SING-ACC road-SING-ACC
'[. . .] because of the debris that closed the road'
http://www.hri.org/news/grpapers/eleytherotypia/1995/95-08-23.eley.html
(accessed on 15 May 2021)

(8)   I zelatina echi tetia kataskevi pu na klini apo moni tis.
the-SING-NOM gelatin-SING-NOM has that construction that
close-3SING-PRES-ACT by its own
'Gelatin has that kind of making that it closes by itself'
http://www.moto.gr/forums/showthread.php?s=a90a27e326114307492b108ea117
1155&threadid=11499&perpage=15&pagenumber=2 (accessed on 15 May 2021)

(9)   [. . .] otan grafun se tetradio leronete me melani to aristero maniki tus
when write-3PL-PRES-ACT in notebook, stain-3SING-PRES-NACT the-SING-ACC
left-SING-ACC sleeve-SING-ACC their
'[. . .] when they write in the notebook, their left sleeve is stained with ink'
http://www.tex.unipi.gr/undergraduate/notes/ergonomia/lefthand.pdf
(accessed on 15 May 2021)

(10)   [. . .] to teren itan jemato chioni to opio katharistike apo ethelontes filathlus
the-SING-ACC pitch-SING-ACC be-3SING-PAST full-SING-ACC snow-SING-ACC
which-SING-ACC clear-3SING-PAST-NACT by volunteer-PL-ACC fans-PL-ACC
'[. . .] the pitch was full of snow which was cleared by volunteer fans'
http://www.surfbet.net/Default.asp?article=134 (accessed on 15 May 2021)

(11)   I skorpii [. . .] strefun to dilitiriodes kentri tus pros ton eafto tus ke tripiunte
the-PL-NOM scorpion-PL-NOM [. . .] direct-3PL-PRES-ACT the-SING-ACC
poisonous-SING-ACC sting-SING-ACC towards the-PL-ACC self-PL-ACC their and
pierce-3PL-PRES-NACT
'Scorpions direct their venom at themselves and sting themselves'
http://www.focusmag.gr/fora/view-message.rx?oid=268549 (accessed on
15 May 2021)

For example, with respect to ACT verb forms, *close* is attributed a transitive reading in (7), as the inanimate syntactic subject is the external causer argument and a postverbal direct object (internal argument) is included in the clause, while an anticausative reading is acquired in (8) as the inanimate syntactic subject is affected and a *by-itself* phrase is licensed. For NACT verb forms, (9) receives an anticausative reading as the inanimate syntactic subject *sleeve* is acted upon and a *me* (litt. 'with') instrument-PP is also included; (10) is diagnosed as passive as the inanimate subject ('pitch') is an internal argument deliberately acted upon by animate agents ('fans'), while in (11), the verb is reflexive as the subject is an external argument acting upon -self, a volitional agent. Ambiguous instances of the verbs under examination were excluded from the reported corpus.

Potential PPs were specified with respect to the preposition they were construed with (*apo-* ('by'/'from') or other), the status they had (verb complement or modifier of the verb or the predicate) and the meaning they denoted (agent, instrument, cause, time, location). We report on the PPs no further as they are not included in the experimental design of the empirical study that follows in Section 3.

2.2. Frequencies

Coarse-grained vs. fine-grained level analyses of frequency counts are measured with respect to verb types (ACT-NACT voice morphology), distinct verb classes ('voice

alternating'—'voice non-alternating' anticausatives) and specific verb tokens (i.e., particular ACT-NACT verb forms and particular co-occurrences of these verbs with animate or inanimate subjects), in the sense of Bybee (1995).

We first consider verb types: In a total of 28,904 occurrences of the fourteen verbs under examination, the majority of them are used in ACT verb forms (21,371; 73.93%), while NACT appears mostly in the samples of quasi-oral speech retrieved from the web (ILSP: 876; 0.3% vs. Web: 6657; 23.03%). The distribution of the interpretations that (N)ACT verb forms receive in the corpus is also considered (Figure 1): ACT verb forms are shown to equally receive transitive and anticausative readings (42.40% and 57.60% respectively), a conclusion that is reversed when verb classes are considered, since 'voice non-alternating' anticausatives favor an anticausative reading (66.14% in a total of 13,343 ACT utterances), while 'voice alternating' anticausatives are preferably used as transitives instead (82.31% in a total of 9773 ACT utterances). On the other hand, the few instances of NACT verb forms found are shared among passive (40.23%), anticausative (38.97%) and some reflexive readings (20.79%), a picture that is not fully conserved when verb classes are considered: NACT 'voice alternating' anticausatives receive mostly an anticausative reading (49.62%), while passive and reflexive readings are favored among 'voice non-alternating' anticausatives (50.99% and 42.78% respectively). Thus, 'voice alternating' anticausatives do not freely alternate after all, since different syntactic environments are met with (N)ACT verb forms; 'voice non-alternating' anticausatives, on the other hand, are allowed and used in NACT forms, as well. In these counts, we identify a high percentage of non-literal (metaphorical) uses (37.34%)[4] allowing for odd readings that should not be neglected since probably activated during sentence processing and taken into account when judging the acceptability of a given sentence.
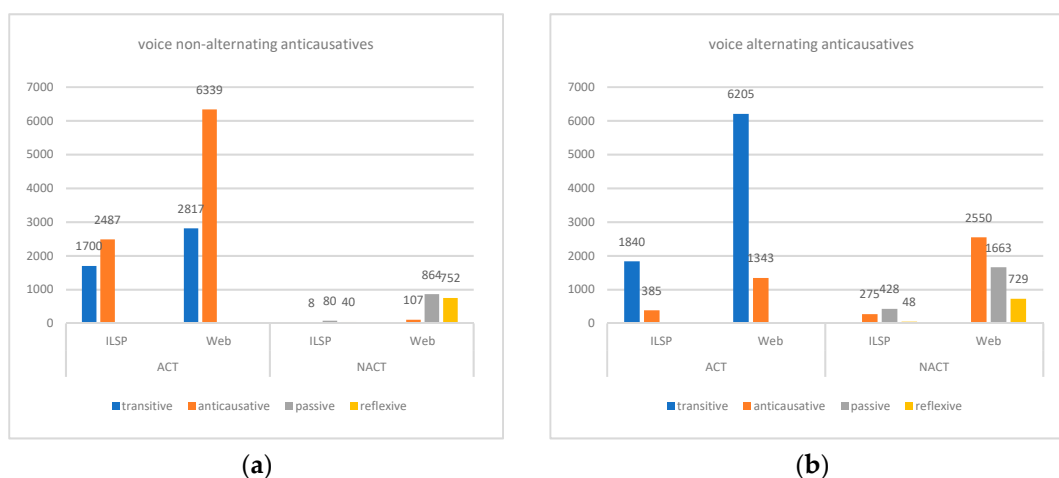

(**a**)   (**b**)

Figure 1. The distribution of verb readings in (N)ACT voice morphology per verb class in written (ILSP) and quasi-oral speech (Web): (**a**) 'voice non-alternating' anticausatives; (**b**) 'voice alternating' anticausatives.

The semantic feature of animacy of the syntactic subject is also relevant, as suggested in the literature: ACT verb forms with animate subjects favor transitive uses of both verb classes (94.61% for 'voice alternating' anticausatives and 69.32% for 'voice non-alternating' anticausatives); inanimate subjects renders the anticausative reading the most frequent one for 'voice non-alternating' anticausatives (84.82%), while for 'voice alternating' anticausatives, transitive uses remain the most frequent ones (67.82%). NACT verb forms with animate subjects favor the reflexive reading instead: among 1141 utterances of 'voice non-alternating' anticausatives, 68.62% are reflexive, while among 2406 'voice alternating' anticausatives, anticausative uses are the most frequent ones (50.29%), though reflexive remain highly available (31.29%). When inanimate subjects are involved, passive and anticausative readings are both available: 50.13% passive and 49.13% anticausative uses

are identified among 'voice alternating' anticausatives, while passive structures (86.05%) are the most common ones for 'voice non-alternating' anticausatives.

Turning to a more fine-grained analysis, we consider specific verb tokens, i.e., (N)ACT instances of each verb in contexts with a [+/− animate] syntactic subject and the interpretations they receive. Noticeably, not all the verbs examined in each verb class yield a similar pattern of behavior: Among 'voice non-alternating' anticausative verbs (Table 1), *klini* (close) is the only verb that alternates between ACT and NACT forms, both in formal and informal registers (samples from the ILSP and the Web, respectively), though more frequently in the informal (quasi-oral) speech (Web), especially in the presence of animate subjects. Another case worth mentioning is *lioni* (melt), which is mostly used as an anticausative with an inanimate syntactic subject in formal registers (ILSP), while its uses in colloquial (quasi-oral) speech (Web) prioritize the transitive structure when the syntactic subject is inanimate and the anticausative when it is animate; NACT occurrences are also allowed with inanimate subjects, giving rise to a passive reading. Finally, *vrazi* (boil) is clearly used as anticausative with inanimate subject in formal registers (ILSP), while in quasi-oral speech (Web), it is furthermore often used transitively with animate or inanimate subjects and allowed in NACT with inanimate subjects as passive. For the remaining verbs, the general pattern followed is that utterances with inanimate syntactic subjects outnumber the ones with animate ones, while the most frequent reading they receive is the anticausative one for the former and the transitive one for the latter.

Table 1. Distribution of readings (%) among 'voice non-alternating' anticausatives by voice morphology and [+/− animacy] of the syntactic subject.

| VERB | N | ACT | | | | NACT | | | | | |
| | | Trans. | | Anticaus. | | Pass. | | Anticaus. | | Refl. | |
		Anim	Inan	Anim	Inan	Anim	Inan	Anim	Inan	Anim	Inan
klini (close)	ILSP n = 3317	36.15	8.05	0.18	52.07	0.60	1.60		0.18	1.15	0.03
	Web n = 2937	27.41	5.01		28.50	9.67	2.01	0.72	2.38	24.04	0.27
lijizi (bend)	ILSP n = 275	33.45	6.91	45.09	14.55						
	Web n = 1552	13.21	15.53	31.25	38.66		0.58		0.13	0.64	
jerni (lean)	ILSP n = 155	16.13	11.61	5.81	66.45						
	Web n = 1075	22.42	12.93	5.77	58.14		0.19	0.28	0.09	0.19	
stegnoni (dry)	ILSP n = 48	10.42	10.42	4.17	68.75				4.17	2.08	
	Web n = 1818	6.22	9.08	1.98	73.65		7.54		0.17	1.38	
ljoni (melt)	ILSP n = 106	16.04	10.38	13.21	60.38						
	Web n = 699	21.32	32.05	27.32	11.16	0.29	7.15			0.57	0.14
vrazi (boil)	ILSP n = 231	12.99	0.87	14.72	68.40		3.03				
	Web n = 1042	12.09	1.06	10.56	46.26	1.63	28.12	0.10	0.19		
sapizi (rot)	ILSP n = 183	1.09	4.37	27.87	66.67						
	Web n = 1756	10.36	3.93	16.40	68.68	0.57	0.06				

Among 'voice alternating' anticausative verbs (Table 2), the majority of ACT instances are used transitively, irrespective of the subject animacy. Anticausative structures differ by verb: *berdevi* (mingle), *tsalakoni* (crumble), *leroni* (spill) are mostly met in NACT, *tendoni* (stretch) is equally used in ACT and NACT (with inanimate subjects), *tripai* (pierce) and *katharizi* (clean) are anticausatives in ACT but passives in NACT (with inanimate subjects in both cases). *Htipai* (hit) is anticausative when in ACT with an inanimate subject, while when in NACT, all available readings, i.e., passive, anticausative, reflexive, are used with both animate and inanimate subjects, only the latter being mostly restricted to a combination with animate subjects.

Table 2. Distribution of readings (%) among 'voice alternating' anticausatives by voice morphology and [+/− animacy] of the syntactic subject.

VERB	N	ACT						NACT			
		Trans.		Anticaus.		Pass.		Anticaus.		Refl.	
		Anim	Inan	Anim	Inan	Anim	Inan	Anim	Inan	Anim	Inan
berdevi (mingle)	ILSP n = 443	37.70	13.54		0.45		0.23	19.19	24.60	3.84	
	Web n = 3021	28.17	25.19		0.63			25.06	20.03	0.86	0.07
tsalakoni (crumple)	ILSP n = 26	53.85	7.69			3.85	15.38	7.69	7.69	3.85	
	Web n = 268	26.49	16.79		13.81	0.37	2.61	4.85	34.70	0.37	
leroni (spill)	ILSP n = 46	54.35	19.57		2.17			15.22	8.70		
	Web n = 735	36.60	30.88	0.27	4.35			5.71	21.77	0.41	
tendoni (stretch)	ILSP n = 71	59.15	12.68		1.41		4.23		12.68	9.86	
	Web n = 1346	34.92	8.54		12.63		6.24	0.07	24.00	13.60	
tripai (pierce)	ILSP n = 128	40.63	45.31		4.69	2.34	3.91	0.78	0.78	1.56	
	Web n = 1260	28.49	44.76		12.62	0.63	7.14	1.35	1.11	3.89	
katharizi (clean)	ILSP n = 435	77.01	5.06	0.23	4.60	0.46	12.58		0.23	0.23	
	Web n = 1600	11.00	14.69	0.06	12.13	0.75	53.63	2.88	4.00	0.81	0.06
htipai (hit)	ILSP n = 1829	42.10	15.04	2.62	16.73	4.65	14.82	1.31	1.64	0.98	0.11
	Web n = 4260	32.96	15.45	1.46	15.66	7.77	6.38	5.05	4.69	10.14	0.45

Furthermore, some register differences are observed (as was also the case for 'voice non-alternating' anticausatives). For example, a rise in inanimate subjects participating in transitive structures is attested in the samples of colloquial speech (Web) when compared to formal registers (ILSP), as is the case for *leroni* (spill) and *tripai* (pierce); across NACT forms, reflexive uses appear more frequently in informal (quasi-oral) than formal speech (Web vs. ILSP), particularly in the case of *tendoni* (stretch) and *htipai* (hit), verbs that are indeed considered quite frequent in everyday speech, and similarly, *katharizi* (clean) is more frequent in the Web than the ILSP when construed with inanimate subject expressing a passive reading. In the same vein, some metaphorical uses (already commented), as is the case of reflexives with inanimate subjects (e.g., *berdevi* (mingle), *katharizi* (clean), *htipai* (hit)), are mostly indexed in the Web.

Overall, although anticausative readings are frequently identified for all the verbs under examination—as expected, since they belong to the so-called anticausative classes— animacy of the syntactic subject is also proved to influence the distribution of readings across (N)ACT verb morphological markings. Next, we present empirical data and report online and offline results in a coarse-grained- and a fine-grained-level analysis.

3. The Empirical Study

We designed an online self-paced reading and acceptability judgment task where we manipulated (ACT/NACT) voice morphology and syntactic subject animacy for two verb classes of Greek ('non-alternating' anticausatives/alternating anticausatives). Online RTs are used to evaluate whether the parser is driven by grammar, i.e., it is based on syntactic information or, alternatively, by frequency of use considerations. Moreover, offline acceptability judgment is used to examine whether the degree of acceptability of these unaccusative structures is regulated by previous language experience among native speakers of Greek or not.

More specifically, based on previous research, morphological cues have been suggested to play an important role in Greek native speakers' processing (e.g., Papadopoulou and Tsimpli 2005), while animacy of the syntactic subject has also been found to affect disambiguation of the preferred readings in transitivity alternations in Greek (Fotiadou and Tsimpli 2010; Fotiadou and Peristeri 2012; Peristeri et al. 2013; Tsimpli 2006). Thus, if

the parser is driven by grammar, in a serial autonomous way, we anticipate that processing of the verb is affected by voice morphology, while other (semantic) information becomes relevant at later stages ([+/− animacy] of the syntactic subject, verb classes). On the contrary, if multiple constraints are activated in parallel, an interaction of the above factors should be available very early, on the processing of the verb.

On the other hand, if the parser is frequency-based, we anticipate that processing matches statistical records in a more or less detailed way. To answer this, we need to determine whether processing is regulated by coarse-grained records (of syntactic environments). Verb classes are also to be considered, although not explicitly included in experience-based approaches of language processing, because we assume that they draw on semantic generalizations on the basis of specific verbs use, allowing speakers to predict their interpretation. Corpus data suggest the following decreasing order of frequency among anticausatives: 'voice non-alternating'-ACT > 'voice alternating'-ACT > 'voice alternating'-NACT > 'voice non-alternating'-ACT. Thus, ACT forms are expected to yield shorter reaction times (RTs) than NACT for the verb class of 'voice non-alternating' anticausatives, while a reverse pattern is expected for 'voice-alternating' anticausatives. In other words, we anticipate a significant interaction of voice by verb class on verb processing. Moreover, a significant interaction of animacy by voice by verb class is expected. For ACT forms of both verb classes, we expect an animacy effect, because the readers are supposed to rapidly analyze the verb as anticausative when construed with inanimate subjects, but when combined with animate subjects, ambiguity between transitive and anticausative interpretations should slow down verb processing. For NACT, we expect different patterns for the two verb classes: a grammaticality effect is expected for 'voice non-alternating' anticausatives due to violation of morphological marking; thus, no animacy effect should be found, as short RTs are expected for both structures. For 'voice-alternating' anticausatives, we expect shorter RTs for their combination with inanimate than with animate subjects, given the higher frequency of appearance for the former than the latter combination.

If the hypothesis that the processor keeps fine-grained records is valid, we expect that RTs vary depending on the frequency of an anticausative reading for specific tokens (DP(subject)$_{+/-\text{anim}}$ +V$_{\text{ACT}}$ and DP(subject)$_{+/-\text{anim}}$ + V$_{\text{NACT}}$ structures) of individual verbs. More specifically, *klini* (close) and *vrazi* (boil) should differ from the remaining voice 'non-alternating' anticausatives and yield no voice effect, since both morphological markings are met in the corpus. Among 'voice alternating' anticausatives, instead, we anticipate a significant voice effect for *berdevi* (mingle), *tsalakoni* (crumble), *leroni* (spill) and *tendoni* (stretch), indicating an activation of speakers' expectation that only NACT types involve intransitive (thus more complex than transitive) structures. No voice effect should be manifested for the remaining three verbs, *tripai* (pierce), *katharizi* (clean) and *htipai* (hit), as participants would perceive syntactic ambiguity for both ACT and NACT forms at initial stages of processing, since equally used in ACT and NACT with anticausative readings in the corpus. Animacy is also expected to yield a significant effect for all 'voice non-alternating' anticausatives for reasons already outlined under the coarse-grained analysis expectations, especially because corpus data show a similar pattern across the members of the verb class. For 'voice alternating' anticausatives, however, animacy is expected to interact with voice only among verbs whose NACT types mostly denote an anticausative reading (combined with inanimate subjects), i.e. in *tsalakoni* (crumble) and *tendoni* (stretch).

In the offline judgment task, we anticipate that the degree of acceptability depends on speakers' metalinguistic knowledge; thus, morphology or animacy (the study variables) alone should not suffice to regulate speakers' intuition. Instead, verb classes are relevant as they draw on semantic similarities between verbs leading to predict their behavior, and participants are expected to regulate their judgment accordingly. If previous experience is what regulates the degree of acceptability of the verbs examined in specific contexts, we anticipate that, in a coarse-grained-level analysis, speakers will rate positively unaccusative structures including the verb types that are mostly used as anticausatives in the corpus, i.e., ACT verb types for 'voice non-alternating' anticausatives, both (N)ACT types for 'voice

alternating' ones. Moreover, ACT combined with animate subjects should not be accepted as highly as when combined with inanimate ones. In a fine-grained-level analysis, judgment of this kind of sentences is expected to correlate positively with the most frequent reading of specific verb tokens (utterances of individual verbs in combination to (N)ACT morphology and [+/− animate] subjects): high acceptability is expected for morpho-syntactic strings that native speakers register as anticausative based on prior language experiences. Thus, the presence of inanimate subjects should be highly accepted for both voice markings, given that the experimental sentences include unaccusative structures. Animate subjects combined with ACT 'voice non-alternating' anticausatives should be judged negatively but for *lijizi* (bend), which is highly indexed to receive an anticausative reading in the corpus, while *lioni* (melt), *vrazi* (boil) and *sapizi* (rot) should be moderately accepted, since they occur as such to a small extent in colloquial register. ACT 'voice-alternating' anticausatives are expected to be completely rejected when with animate subjects, since the verbs across the experimental sentences could not be interpreted as transitives lack a postverbal object and due to contextual information of the subordinate clauses following them.

3.1. Participants

A total of 45 adult native speakers of Greek (mean age: 30, age range: 17–43), 24 females, completed the online self-paced reading and acceptability judgment tasks. All participants were living in urban areas of northern Greece and had followed higher education; none of them had studied linguistics and they were all naïve with respect to the research questions of the study.

3.2. Materials

The verbs used in the experimental sentences belong to the class of anticausatives (or ergatives) and anticausatives with optional voice alternation (in Greek *ditypias*), but their interpretation can vary across different verb classes of Greek (reflexive, passive and ergative/anticausative in NACT morphology, ergative and transitive in ACT morphology). The fourteen verbs we used in the empirical study are the same as the ones examined in the corpus study; here, experimental sentences presented unaccusative structures (no object included) comprising the verbs in the third singular (past perfective or present tense)[5]. We manipulated voice, ACT and NACT morphology and animacy; each form was included in sentences with an animate and an inanimate syntactic subject, making a total of four experimental conditions: act-anim, act-inanim, nact-anim, nact-inanim (example sentences per condition in Table 3). The verb segment followed a conjunction introducing a subordinate clause. As a result, for NACT conditions, all possible readings (passive, reflexive, anticausative) were available until the end of the sentences; for ACT conditions, only the anticausative reading was plausible for the verb used, although a null object is allowed for some of the verbs when in transitive structures. However, the continuation of the sentences did not favor such a reading.

The sentences were divided into seven segments (as illustrated by slashes (/) in Table 3) and the verb appeared always in the third segment. The sentences across the four conditions were minimal pairs, in the sense that they included the same words and they differed only in the syntactic subject (animate vs. inanimate) and the verb morphology (ACT vs. NACT). In order to avoid any repetition effects in the RTs of the SPR and AJ task, as well as in the degree of acceptability of the sentences, two quartets were designed for each verb: these quartets were equally distributed across four lists in a Latin-square design. Thus, participants saw a total of fourteen experimental sentences with seven different verbs, but never saw the same context. The experimental sentences were intermixed with 63 filler sentences of various syntactic structures, 30 grammatical and 33 ungrammatical ones, also divided into seven segments and followed by an acceptability judgment task with a nine-point grading scale[6] and a '?' for the case that readers could not decide upon the grammaticality of the sentence they had read due to lack of attention or other extra-linguistics reasons.

Table 3. Example sentences of the SPR task[7].

Voice Non-Alternating Anticausatives	**ACT (n = 14)**	anim (n = 7)	*To/aghori/stegnose/an ke/itan/poli/vreghmeno.* the/boy $_{NOM}$/dried $_{ACT}$/even if/it was/very/wet
		inanim (n = 7)	*To/panteloni/stegnose/an ke/itan/poli/vreghmeno.* the/trousers $_{NOM}$/dried $_{ACT}$/even if/they were/very/wet
	NACT (n = 14)	anim (n = 7)	*To/aghori/stegnothike/an ke/itan/poli/vreghmeno.* the/boy $_{NOM}$/dried $_{NACT}$/even if/it was/very/wet
		inanim (n = 7)	*To/panteloni/stegnothike/an ke/itan/poli/vreghmeno.* the/trousers $_{NOM}$/dried $_{NACT}$/even if/they were/very/wet
Voice Alternating Anticausatives	**ACT (n = 14)**	anim (n = 7)	*To/aghori/katharise/an ke/itan/poli/vromiko.* the/boy $_{NOM}$/cleaned $_{ACT}$/even if/it was/very/dirty
		inanim (n = 7)	*To/pukamiso/katharise/an ke/itan/poli/vromiko.* the/shirt $_{NOM}$/cleaned $_{ACT}$/even if/it was/very/dirty
	NACT (n = 14)	anim (n = 7)	*To/aghori/katharistike/an ke/itan/poli/vromiko.* the/boy $_{NOM}$/cleaned $_{NACT}$/even if/it was/very/dirty
		inanim (n = 7)	*To/pukamiso/katharistike/an ke/itan/poli/vromiko.* the/shirt $_{NOM}$/cleaned $_{NACT}$/even if/it was/very/dirty

3.3. Procedure

All sessions were administered individually. Participants were seated in front of a computer installed with E-Prime 2.0 software to collect data. They were first presented with a fixed set of instructions according to which they were encouraged to read the segments of the sentences displayed on the screen as fast as possible, but at their own pace, and press the space bar in order to read the next segment. The display of a nine-point rating scale and the '?' which followed each sentence (experimental and filler ones) invited the participants to judge each of them based on their intuition and was meant to ensure that they paid attention to the task and processed the sentences. The nine-point scale was chosen because the sentences under investigation may not be categorically considered grammatical or not, while the '?' was available for the cases where the reader was distracted and could not evaluate a given sentence. The session started with 10 practice sentences to help participants familiarize themselves with the procedure, followed by the main experiment. All the sentences were presented in a non-cumulative word-by-word fashion, supposed to reflect initial parsing choices since the reader cannot go back to what (s)he has previously read and is encouraged to keep-up-to-date with sentence processing (see Marinis 2010 for a discussion on techniques used to assess sentence processing). The sentences were divided into seven segments, as shown in Table 3, and ended with a full stop. All RTs per segment (the times between button presses) as well as the RTs for the acceptability judgments were recorded and provided the crucial experimental measure. For the offline measure, we considered participants' degree of acceptability of the experimental sentences. The administration of the task lasted approximately 15 min.

3.4. Results

Two subjects were eliminated from further analyses because their reading times (RTs) were two standard deviations (2SDs) above the mean for each experimental conditions in many cases, they scored high many ungrammatical fillers and did not provide an answer for several critical items. Thus, the analyses that follow present data from 43 participants. RTs that were 2SDs above or below the mean for each condition were replaced with the mean for each condition (e.g., Chondrogianni et al. 2014), resulting in the replacement of 3.67% (354/9640) values, both in per subject (F_1, t_1) and per item (F_2, t_2) analyses.

3.4.1. Online Data

In a coarse-grained-level analysis, we consider verb types, i.e., the (N)ACT morphological marking of the verbs used. As shown in Figure 2, RTs from the third (critical) segment onwards indicate divergent processing preferences depending on the experimental manipulations. A reactivation of a trace at the NACT verb segment is evidenced by a significant voice effect ($F_1(1,42) = 26.527$, $p < 0.001$; $F_2(1,26) = 18.510$, $p < 0.001$): participants needed more time to process NACT verbs with both animate (ACT vs. NACT: $t_1(42) = 3.976$, $p < 0.001$ and $t_2(26) = -2.589$, $p < 0.016$) and inanimate subjects (ACT vs. NACT: $t_1(42) = 3.966$, $p < 0.001$ and $t_2(26) = -3.402$, $p < 0.001$). Animacy did not have an effect on the critical verb segment, in line with models suggesting the priority of syntax over semantics in the course of sentence processing.
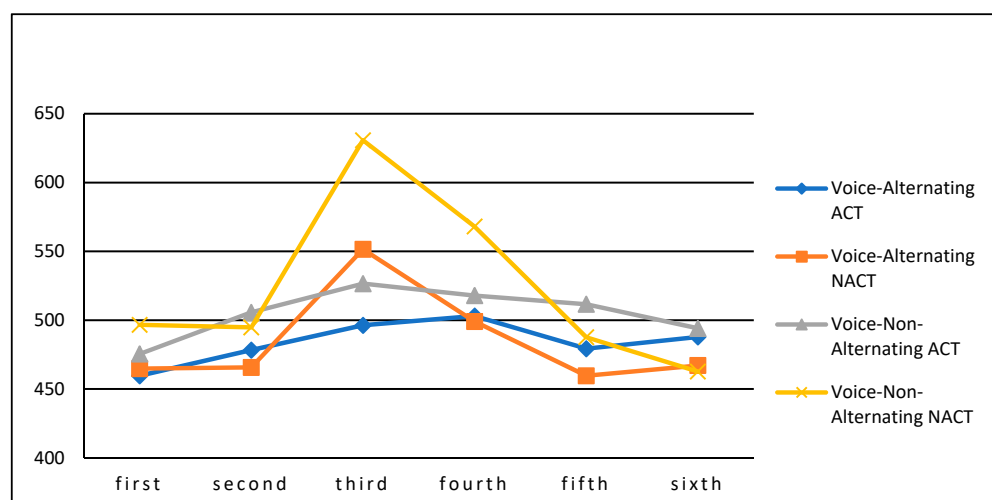

Figure 2. Verb class by voice morphological marking during sentence processing.

Segments that followed the verb segment are also of special interest, since the verb's interpretation was not disambiguated by the end of the sentence. No significant effects were found on the fourth segment. On the fifth segment, data showed a significant voice effect ($F_1(1,42) = 4.945$, $p = 0.032$; $F_2(1,26) = 7.508$, $p = 0.011$) and a significant interaction between voice and animacy ($F_1(1,42) = 4.879$, $p = 0.033$; $F_2(1,26) = 7.054$, $p = 0.013$). At this point, participants understand that the sentences they read do not affect the verb interpretation; when an animate subject is involved, clauses with NACT verb forms are read faster than those with ACT ones ($t_1(42) = 3.148$, $p = 0.003$ and $t_2(26) = 3.337$, $p = 0.003$), showing that both (non)-reflexive readings are still available, while lack of a postverbal object renders the transitive/causative reading problematic for ACT. Inanimate subjects entailed no significant effects. The interaction between voice and animacy remained significant for RTs received on the sixth segment ($F_1(1,42) = 4.365$, $p = 0.043$; $F_2(1,26) = 4.919$, $p = 0.036$), along with a main voice effect ($F_1(1,42) = 4.677$, $p = 0.036$; $F_2(1,26) = 6.223$, $p = 0.019$): readers followed the sequences with NACT verbs involving animate subjects faster than the ones with inanimate ones ($t_1(42) = 2.110$, $p = 0.041$ and $t_2(26) = 1.354$, $p = 0.187$), while no such effect was found for sequences with ACT verbs. Noticeably, individual verb differences arose, as revealed by the n.s. per item analysis (see t_2).

Narrowing down the scope of analysis, we consider verb classes in relation to experimental variables, i.e., voice morphology and animacy of the syntactic subject (Figure 3). In the course of sentence processing, a verb class effect was evidenced only on the fourth segment. More specifically, an ANOVA with voice as the within-subject factor and verb class and animacy of the syntactic subject as the between-subjects factors revealed a significant voice effect ($F(1,598) = 4.939$, $p = 0.027$) and a significant interaction between voice and verb class ($F(1,598) = 6.731$, $p = 0.01$): NACT verb forms received shorter RTs than

ACT ones in the case of voice alternating anticausatives, and longer RTs in the case of voice non-alternating anticausatives.
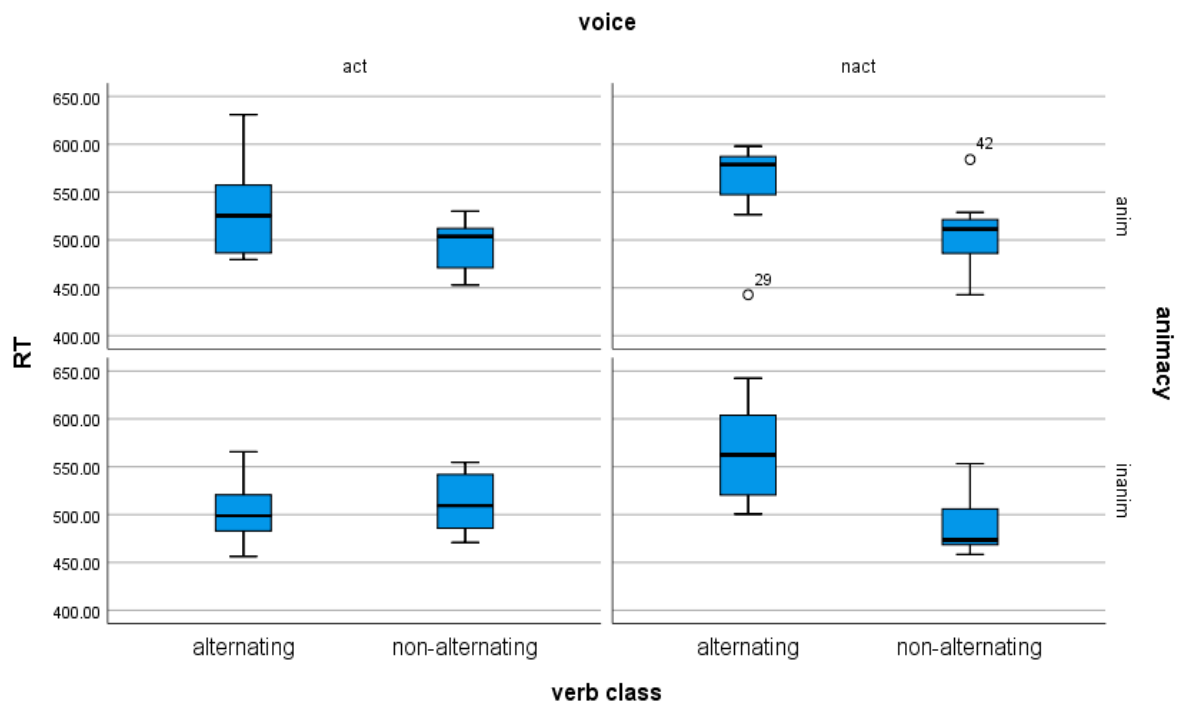

Figure 3. Hi-low RTs on the fourth segment (by voice, animacy and verb class).

Turning to a more fine-grained-level analysis, we examine the processing of individual verbs (considering subject animacy in the two available ACT-NACT markings). Verbs revealed different patterns: Among 'voice non-alternating' anticausatives (Figure 4a), for *stegnoni* (dry), the main effects of voice or animacy were not significant across segments, though on the verb (third) segment a significant interaction of voice by animacy ($F(1,41) = 4.087$, $p = 0.05$) is attributed to shorter time needed to read NACT types when preceded by inanimate than animate subjects ($t(41) = 2.099$, $p = 0.042$), but no such difference arose for ACT types. The verb *vrazi* (boil) revealed no significant effects throughout sentence processing. In *sapizi* (rot), a significant voice effect was found on the third ($F(1,41) = 10.080$, $p = 0.003$) and fourth segments ($F(1,41) = 5.212$, $p = 0.028$), while a significant interaction of voice by animacy was found on the seventh segment ($F(1,41) = 6.788$, $p = 0.013$), which owes its manifestation to faster reading times for NACT types with animate than inanimate subjects ($t(41) = 2.390$, $p = 0.022$), but no such difference was attested for ACT types. In *lioni* (melt), the voice effect was not significant on the critical third verb segment but on the following one, i.e., on the fourth segment ($F(1,41) = 9.393$, $p = 0.004$) only. In *lijizi* (bend), we also found a significant voice effect on the third ($F(1,41) = 5.628$, $p = 0.022$) and fourth segments ($F(1,41) = 10.080$, $p = 0.003$), while a significant interaction of voice by animacy was registered on the following segments, i.e., on the fifth ($F(1,41) = 5.548$, $p = 0.023$) and sixth ($F(1,41) = 10.196$, $p = 0.003$): sentences with NACT types were read faster when preceded by animate than inanimate subjects on both the fifth ($t(41) = 2.739$, $p = 0.023$) and sixth segments ($t(41) = 2.037$, $p = 0.048$), while no such differences were found for sentences with ACT types. In *klini* (close) no significant effects were found throughout the whole sentence. Finally, in *jerni* (lean), a significant voice effect was first evidenced on the third segment ($F(1,41) = 4.072$, $p = 0.05$) and remained significant on the fourth ($F(1,41) = 5.718$, $p = 0.021$), marginal on the fifth ($F(1,41) = 3.914$, $p = 0.055$) and regained strength on the seventh segment ($F(1,41) = 4.728$, $p = 0.036$).

Figure 4. Mean RT lines for individual verbs: (**a**) 'voice non-alternating' anticausatives; (**b**) 'voice alternating' anticausatives.

Among 'voice alternating' anticausatives (Figure 4b), *berdevi* (mingle) revealed no significant effects during processing. In *katharizi* (clean), a significant voice effect was found on the third segment ($F(1,41) = 6.582$, $p = 0.014$) only; processing of sentences including *leroni* (spill) revealed no significant effects either. In *tendoni* (stretch), we found a significant voice effect only on the third verb segment ($F(1,41) = 6.040$, $p = 0.018$). In *tripai* (pierce), main effects were not significant across sentences, but an interaction of voice by animacy was marginally significant during later stages of processing, on the sixth segment ($F(1,41) = 3.923$, $p = 0.054$), though no significant differences were identified by independent samples t-tests. *Tsalakoni* (crumble) yielded a significant voice effect long after processing the critical verb segment, i.e., on the fifth segment ($F(1,41) = 5.325$, $p = 0.026$), and it reappeared on the seventh segment ($F(1,41) = 6.646$, $p = 0.014$), the end of the sentence. Finally, *htipai* (hit) revealed no significant effects during sentence processing.

3.4.2. Acceptability Judgment

Participants were asked to determine the acceptability of the sentences they read on a rating scale from 1 (totally unacceptable) to 9 (totally acceptable). We received 1204 answers, while 22 sentences were not evaluated and the '?' was used instead. Overall, in a coarse-grained-level analysis, both main effects (voice: ACT vs. NACT $F_1(1,42) = 29.944$, $p < 0.001$ but $F_2(1,26) = 1.733$, $p = 0.199$ and animacy: anim. vs. inan. $F_1(1,42) = 115.500$, $p < 0.001$; $F_2(1,26) = 20.279$, $p < 0.001$) and their interaction ($F_1(1,42) = 46.232$, $p < 0.001$; $F_2(1,26) = 21.306$, $p < 0.001$) were found significant. Sentences including verbs in ACT presented extreme tendencies depending on the subject animacy in that sentences with inanimate subjects were highly accepted, while sentences with animate subjects were not ($t_1(42) = -10.313$, $p < 0.001$; $t_2(26) = -5.796$, $p < 0.001$); similarly, sentences including verbs in NACT were better accepted with inanimate than animate subjects ($t_1(42) = -2.465$, $p < 0.01$; but $t_2(26) = -1.126$, $p = 0.270$).

We next analyzed data adding the notion of 'verb classes'; the violin plot in Figure 5 illustrates the distribution of the received responses. Speakers accepted better ACT to NACT forms of 'voice non-alternating' (high vs. low: $\chi^2 = 176.138$, $p < 0.001$) and NACT to ACT forms of 'voice alternating' anticausative verbs (high vs. low: $\chi^2 = 19.931$, $p < 0.001$), although they are supposed to freely alternate.
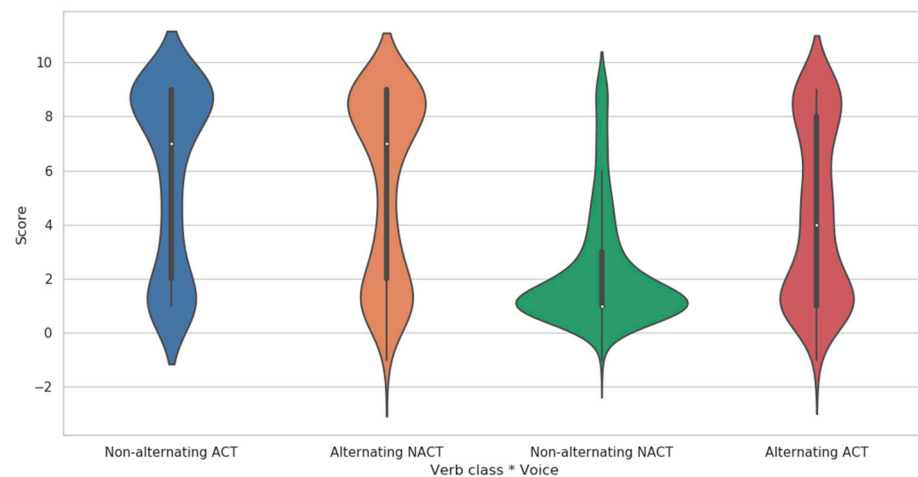
Figure 5. Violin plot: distribution of the degree of acceptability (by voice morphology, verb class).

Deviant cases of low acceptability of 'voice non-alternating' anticausatives in ACT (92/602; 15.28%) and 'voice alternating' anticausative verbs in ACT (150/602; 24.92%) and NACT (90/602; 14.95%) come from specific verbs, animacy of the syntactic subject considered, and are to be examined in a per verb analysis (Table 4).

Table 4. Individual verbs mean acceptability rates and RTs across the experimental conditions (voice, animacy).

Verb class	Verb	Act-Anim	RTs	Act-Inanim	RTs	Nact-Anim	RTs	Nact-Inanim	RTs
Voice non-alternating anticausatives	*klini*	3.50	1713.34	**7.73**	1639.68	3.76	1359.33	4.23	1776.91
	lijizi	**6.00**	2131.68	**7.48**	1492.86	*1.73*	1353.41	3.24	1295.16
	jerni	**6.18**	1774.38	**7.10**	1783.52	*1.63*	1039.27	*1.67*	1238.86
	stegnoni	5.25	2201.14	**7.86**	1286.59	*1.86*	1176.29	2.73	1198.05
	lioni	3.30	1949.38	**7.91**	1787.95	*1.43*	1117.25	2.68	1524.33
	vrazi	*1.71*	1368.10	**7.91**	1845.56	*1.24*	1183.71	*2.00*	1265.55
	sapizi	*2.57*	1619.09	**7.55**	1600.88	*1.73*	1299.68	*2.00*	1504.67
Voice alternating anticausatives	*tsalakoni*	*1.76*	1549.73	3.62	1452.10	*2.18*	1957.09	**6.33**	2135.86
	berdevi	*1.48*	1205.91	3.33	1819.10	5.81	1923.32	**7.50**	1770.22
	leroni	*2.70*	1711.05	3.68	1867.49	**7.67**	1791.24	**6.68**	1148.12
	tendoni	*2.58*	1609.86	4.71	1688.32	**7.10**	1320.83	5.67	1872.14
	tripai	3.82	1888.41	5.62	2350.29	**6.27**	2287.67	4.05	2354.39
	katharizi	3.45	2017.14	**6.90**	1861.67	5.23	1672.41	**6.55**	1365.86
	htipai	**7.48**	1458.69	5.29	1639.63	5.95	1880.88	4.14	1856.97

Note: High scores are marked with bold and low scores are italicized.

In a fine-grained-level analysis, individual verbs' degree of acceptability varied even within each verb class. Starting with 'voice non-alternating' anticausatives (Tables 4 and 5), statistical analyses performed show that for *klini* (close), *lioni* (melt), *vrazi* (boil) and *sapizi* (rot), both main (voice and animacy) effects were significant, as well as their interaction; these verbs (but *klini* (close)) are classified as anticausatives, denoting an internally caused change-of-state, and are primarily accepted in ACT with inanimate subjects. The verb *klini* (close) presents a similar pattern, although not completely rejected across the other conditions: independent samples t-tests show that inanimate subjects were preferred over animate ones with the verb in ACT (t(19) = −5.571, $p < 0.001$), but no significant differences are found for NACT. Lack of a significant interaction of the main effects in *lijizi* (lean) and *stegnoni* (dry) may be also attributed to the fact that animate subjects with ACT were not rejected, while for *jerni* (lean), participants accepted both animate and inanimate subjects co-occurring with ACT, hence no significant animacy effect, nor its interaction with voice.

Table 5. Main effects (voice, animacy) and their interaction, across verbs' degree of acceptability.

Verb Class	Verb	Voice	Animacy	Interaction (Voice × Animacy)
Voice non-alternating anticausatives	*klini*	F(1,19) = 8.717 p = 0.008	F(1,19) = 16.471 p = 0.001,	F(1,19) = 13.330 p = 0.002
	lijizi	F(1,20) = 47.817 p < 0.001	F(1,20) = 10.807 p = 0.004	n.s.
	jerni	F(1,17) = 68.338 p < 0.001	n.s.	n.s.
	stegnoni	F(1,19) = 118.686 p < 0.001	F(1,19) = 15.804 p = 0.001	n.s.
	lioni	F(1,19) = 97.675 p < 0.001;	F(1,19) = 39.457 p < 0.001	F(1,19) = 6.370 p = 0.021
	vrazi	F(1,20) = 141.386 p < 0.001	F(1,20) = 83.478 p < 0.001	F(1,20) = 69.871 p < 0.001
	sapizi	F(1,18) = 57.564 p < 0.001	F(1,18) = 33.999 p < 0.001	F(1,18) = 47.509 p < 0.001
Voice alternating anticausatives	*tsalakoni*	F(1,20) = 141.386 p < 0.001	F(1,20) = 83.478 p < 0.001	F(1,20) = 69.871 p =< 0.001
	berdevi	F(1,18) = 47.509 p < 0.001	F(1,17) = 11.552 p = 0.003	n.s.
	leroni	F(1,19) = 43.413 p < 0.001	n.s.	F(1,19) = 6.714 p = 0.018
	tendoni	F(1,17) = 471.133 p < 0.003	n.s.	F(1,17) = 9.912 p = 0.006
	tripai	n.s.	n.s.	F(1,18) = 14. 653 p = 0.001
	katharizi	F(1,19) = 5.894 p = 0.025	F(1,19) = 10.074 p = 0.005	n.s.
	htipai	n.s.	F(1,19) = 10.100 p = 0.005	n.s.

Among 'voice alternating' anticausatives (Tables 4 and 5), *berdevi* (mingle) and *katharizi* (clean) yielded significant main effects of voice and animacy, as for both verbs, NACT forms were preferred over ACT ones and inanimate subjects over animate ones, although for the former, positive evaluation is clear-cut to acceptance of NACT combinations, while for the latter, all combinations are highly accepted. In *tsalakoni* (crumble), not only NACT forms were better accepted than ACT ones, but co-occurrence with animate subjects was judged ungrammatical for either forms, as supported by both main effects and their interaction being significant. In *leroni* (spill) and *tendoni* (stretch), NACT forms were significantly more preferred over ACT forms, as evidenced by a significant voice effect, while a significant interaction of voice by animacy for *leroni* (spill) is attributed to the significantly more accepted co-occurrence of NACT to ACT for both inanimate (t(21) = −3.711, p = 0.001) and animate subjects (t(19) = −8.128, p < 0.001) and, similarly, for *tendoni* (stretch), it is attributed to NACT being preferred over ACT for animate subjects (t(21) = −6.332, p < 0.001) and animate to inanimate subjects (t(18) = −2.655, p = 0.016) for NACT occurrences. A significant interaction of voice by subject animacy in *tripai* (pierce) shows that when animate subjects were involved, participants preferred NACT to ACT (t(21) = −3.395, p = 0.003), while when inanimate subjects were used in the sentences under examination, only a marginally significant preference of ACT over NACT was attested instead (t(18) = 2.036, p = 0.57), these latter ones being the most positively evaluated structures. Finally, participants judged *htipai* (hit) only according to subject animacy; that is, they better accepted animate to inanimate subjects for both (N)ACT forms, though acceptability rates were high across conditions.

We now turn in the analysis of the RTs in the AJ task, first in a 'coarse-grained' and next in a more fine-grained-level analysis, for verb types and for specific verb tokens, accordingly. Very elevated response latencies are indicative of the complexity of the task our participants were administered: they were instructed to evaluate how acceptable they consider the sentences they just read, which is a lot different than judging if a sentence is grammatical or not. Thus, mean response times are two to three times higher than the time they needed to process each segment through sentence reading. Deciding whether to accept as grammatical

or not sentences was harder when they included ACT than NACT verb forms, as suggested by a significant voice effect ($F_{(1,170)}$ = 4.770, p = 0.03) in response latencies. Animacy gave no significant effects. When we added verb classes in the within-subject factors, we found the following significant effects: voice effect ($F_{(1,84)}$ = 10.834, p = 0.001), verb class ($F_{(1,84)}$ = 4.805, p = 0.031), interaction of verb class by voice ($F_{(1,84)}$ = 9.303, p = 0.003) and interaction between voice, verb class and animacy ($F_{(1,84)}$ = 3.918, p = 0.051). The significant interaction of verb class by voice is further supported by a significant voice effect among 'voice non-alternating' anticausatives only ($F_{(1,84)}$ = 10.834, p < 0.001). In fact, we expected that 'odd' sentences (as the case of ACT forms with animate subjects) would yield short RTs, but, since ACT does not show unaccusativity in a transparent way, participants may have tried to reanalyze them as transitive/causative ones, assigning a non-literal meaning; similarly, delay evinced in highly accepted cases of ACT forms with inanimate subjects may be attributed to increased processing load due to the complexity of the syntactic derivation (i.e., unergative, anticausative). On the other hand, participants judged NACT forms relatively quickly: short RTs can be an effect of low acceptability attributed to this morphology for several verbs used in the task. Participants needed longer time to decide on the acceptability of sentences with 'voice-alternating' than 'voice non-alternating' anticausatives, overall. Mean RTs (and SDs) are illustrated in Figure 6.
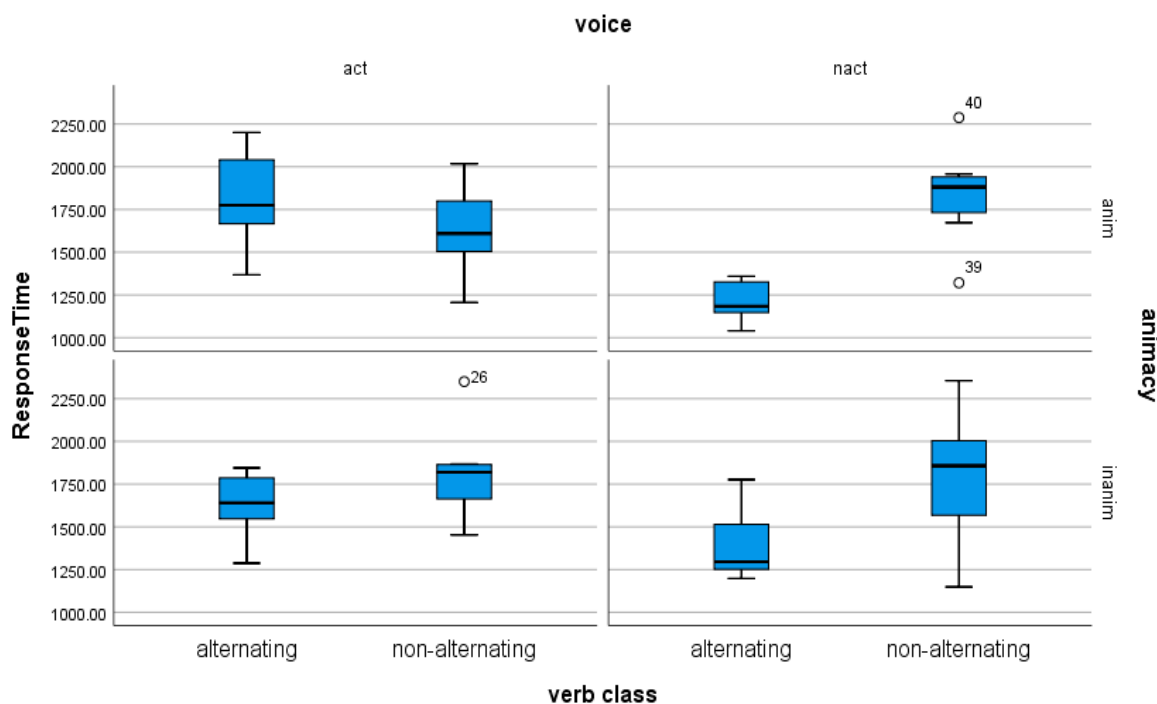

Figure 6. RTs per verb class across conditions in the AJ task.

To untangle the triple significant interaction found (voice by animacy by verb class), we next consider response latencies in individual verbs, i.e., in a fine-grained-level analysis (Table 4), in which we note significant effects mostly among 'voice non-alternating' anticausatives. More specifically, animacy had a significant impact on delay in the decision making for *jerni* (lean) ($F_{(1,20)}$ = 7.491, p = 0.013), *lioni* (melt) ($F_{(1,20)}$ = 8.214, p = 0.009), *vrazi* (boil) ($F_{(1,20)}$ = 4.618, p = 0.044) and *sapizi* (rot) ($F_{(1,20)}$ = 9.751, p = 0.005). Response latencies varied according to a significant animacy effect ($F_{(1,20)}$ = 4.500, p = 0.047) and its interaction with voice in *stegnoni* (dry) ($F_{(1,20)}$ = 6.739, p = 0.017): participants needed more time to decide upon sentences with NACT than ACT verb forms in the presence of animate subjects ($t_{(20)}$ = 2.655, p = 0.015) and sentences with ACT verb forms and inanimate rather than animate subjects ($t_{(20)}$ = 2.118, p = 0.047). No significant effects are attested in *klini* (close) or *lijizi* (lean) despite their inclusion in this verb class, suggesting that these

verbs may actually be truly alternating. On the other hand, among 'voice-alternating' anti-causatives, a significant voice effect is revealed only in *tsalakoni* (crumble) ($F(1,20) = 5.002$, $p = 0.037$), which does not justify its inclusion in this verb class. Crucially, very large standard deviation (SD) and slow reaction for instances of the verbs with low evaluation suggest increased complexity of the phenomenon and point to other extralinguistic factors that may affect individual verbs' behavior.

4. Discussion

In order to account for the validity of 'experience-based' models of sentence processing in adult populations and define the degree of importance (or lack thereof) of exposure facts in the judgment of sentences including temporarily ambiguous information, we need to revisit the research questions addressed in Section 1 and evaluate the hypotheses stated in Section 3.

We begin with the first question, i.e., whether the parser is driven by grammar in a serial autonomous way or if multiple constraints are unconditionally available during initial parsing. Empirical evidence support theories that propose the priority of syntax over semantics in that a voice effect was registered during initial parsing (i.e., on the verb), while when animacy, being a semantic feature, was examined, a significant effect was also registered, though located in later stages of processing, i.e., after reading the verb. Thus, the processor is suggested to rely on morphological cues, in line with previous research on Greek (e.g., Papadopoulou and Tsimpli 2005) which prioritize inflectional morphology overshadowing 'universal' parsing strategies in decision making tasks in which native speakers of Greek resolve ambiguities arising on the verb. Animacy distinctions on the surface syntactic subject are also proved to play an important role in processing transitivity alternations, as previously suggested (Tsimpli 2006) and supported by research in different populations (Fotiadou and Peristeri 2012; Fotiadou and Tsimpli 2010; Peristeri et al. 2013).

Next, we revisit the second question that examines at what level is processing regulated by statistical records, i.e., whether the parser keeps coarse-grained syntactic statistical records or fine-grained lexicosemantic records of previous experience. For this, we compare online processing data of 'voice (non-)alternating' anticausative verbs to the most frequent readings in the compiled corpus based on the following formulated prediction. Building on a coarse-grained level of analysis, verb processing was expected to be facilitated across ACT types (more frequent than NACT in the corpus). RTs on the verb (third) segment supported coarse-grained models (e.g., Cuetos et al. 1996), as a significant voice effect was registered: ACT verb types were read significantly faster than NACT ones. However, this finding does not contradict alternative proposals which postulate a grammar-driven parser, as already suggested. Similarly, the notion of verb class has also been found to be relevant as a side effect of discourse/pragmatics properties interacting with grammar after processing the verb (on the segment where a subordinate clause begun, i.e., the fourth segment). Recall that the two verb classes examined differ only in the availability of voice morphological marking alternation: 'voice non-alternating' anticausatives surface only in ACT denoting an anticausative reading, while for 'voice alternating' anticausatives, ACT and NACT alternation does not affect the accessibility to the anticausative reading. Thus, the registered verb class effect could be actually narrowed down to an effect of morphology.

Admitting that processing is somehow affected by previous language experience, we also examined whether probabilistic constraints are activated at a fine-grained level (e.g., MacDonald et al. 1994) based on input frequency measurable in natural language. For this, we evaluated predictions formulated in relation to frequent verb tokens (DP(subject)$_{+/-\text{anim}}$ + V$_{\text{ACT}}$ and DP(subject)$_{+/-\text{anim}}$ + V$_{\text{NACT}}$ structures with anticausative reading) in the corpus and compared them to empirical data of individual verbs. We expected a voice effect for 'voice non-alternating' anticausative verbs but for *klini* (close), which alternated between ACT and NACT in corpus data. Empirical data gave no such straightforward results: A significant voice effect was indeed registered for *lijizi* (bend), *jerni* (lean), *lioni* (melt) and *sapizi* (rot), but mostly on segments other than the critical (third) verb segment

and it patterned in a very singular way throughout the sentences, while a significant interaction of voice by animacy was also registered for some of them. Recall that processing of the verb segment was faster in ACT than NACT for the cases of *lijizi* (bend) and *sapizi* (rot), in agreement with our expectations, while this experience-based effect was somehow evidenced in later stages for the remaining cases. We suggest that this result is evidence for a late integration of speakers' previous language experience: participants processed faster segments of sentences that included unusual combinations, as they quickly rejected them (as in 'the man was rotten', and 'the woman was bent' i.e., DP$_{(anim)}$ rot-$_{NACT}$). For *stegnoni* (dry), this frequency effect was evidenced early, on the verb segment, probably due to the mostly restricted contexts the verb occurs in natural language and its unambiguously anticausative use, as suggested by frequency counts. On the other hand, *klini* (close) (as expected) and *vrazi* (boil) (not predicted) were not affected by voice, animacy or its interaction, though due to different reasons. In the corpus *klini* (close) was highly frequent (6254 tokens retrieved) and highly ambiguous (between transitive and anticausative for ACT, and passive, anticausative and reflexive for NACT); thus, a lack of effects in this case should suggest equal processing load across experimental conditions and point towards an overall hesitant behavior of our participants. *Vrazi* (boil) was used in limited contexts (1273 tokens retrieved), rather unambiguously (it mostly received an anticausative reading), and surfaced in the combination DP(subject) + V$_{ACT}$; thus, a lack of any effect could be attributed to its instantly recognizable status.

Turning to 'voice alternating' anticausatives, although both (N)ACT morphology can receive an anticausative interpretation, corpus data showed that *berdevi* (mingle), *tsalakoni* (crumble) and *leroni* (spill) were mostly used in anticausative structures when in NACT, while ACT forms were mostly found in transitive ones. *Tendoni* (stretch) presented a somehow similar pattern, though competition with the other available readings was high (NACT was highly ambiguous in that passive and reflexive were also very common, and ACT, was additionally (but less frequently) interpreted as anticausative). Based on the above, voice effect was expected to signal speakers' expectation that only NACT types involve intransitive (thus more complex than transitive) structures. For *tripai* (pierce), *katharizi* (clean) and *htipai* (hit), ACT was preferred over NACT for the anticausative reading, while NACT forms received more frequently passive or reflexive interpretations than anticausative. Thus, no voice effect should be manifested, as participants would perceive syntactic ambiguity for both ACT and NACT forms at initial stages of processing, transitive and intransitive structures being available for ACT, derived and non-derived ones for NACT. Processing data verified a voice effect on the verb only for *tendoni* (stretch) (as expected) and *katharizi* (clean) (though not expected), while for *tsalakoni* (crumble), the expected effect was significantly long after verb processing.

Overall, empirical evidence did not support our predictions of a fine-grained lexical processing. However, different patterns of processing registered in the online SPR task should not be neglected, as sensitivity to lexical biases may offer support to assumptions that pertain to the richness of information included in the lexical entry of verbs participating in transitivity alternations which are activated during later stages of processing (MacDonald and Seidenberg 2006). Thus, lexically included information in verb entries are shown to interact with previous experience and grammar-based information during a stage of reanalysis which, however, we cannot conceptualize in a unified way for all members of 'voice (non)-alternating' anticausatives. As ambiguities were never resolved in the utterances we used, probabilistic constraints (in the sense of MacDonald and Seidenberg 2006) are shown to enter at a second stage. These suggestions should be considered with cautiousness as premature remarks and behavior of individual verbs should be further examined in future research.

Moving finally to our research question which addressed the possible effect of exposure facts on the offline (metalinguistic) responses that our participants gave in the AJ task, we consider the acceptability ratings in comparison with frequency data, while response latencies are used to evaluate the difficulty of the performed task. Starting with a coarse-

grained level of analysis, given that corpus data showed a highly frequent use of ACT formations, we expected ACT forms to be highly accepted in the AJ task. However, morphology alone was not enough to verify participants' judgments. Instead, the semantic notion of verb classes was crucial to the completion of the task; in the literature (e.g., Theophanopoulou-Kontou 2000), the verb classes under examination are suggested to differ in the availability of (N)ACT morphological marking to express an anticausative reading. In our SPR and AJ task, the sentences with ACT verb types could not receive a transitive reading (no DP in postverbal position was included, a null object was not favored either), while for the sentences with NACT verb types, all intransitive available readings were possible (no disambiguation was included). Thus, in line with frequencies drawn from the corpus, acceptability of 'voice non-alternating' anticausatives should be high only when used in ACT, a hypothesis which was verified only when co-occurring with inanimate subjects. For 'voice-alternating' anticausatives, ACT verb types were mostly used transitively, while NACT verb types were distributed across anticausative, passive and reflexive structures. Accordingly, participants accepted better sentences including NACT to ACT verb types.

If we are to answer whether lexical information registered in a fine-grained level motivated construing of the examined verbs, we must juxtapose the degree of acceptability each verb was accredited to the frequency data. Verb tokens' frequency matched acceptability in most of the cases. Among 'voice non-alternating' anticausatives, *klini* (close) was the only verb that alternated between ACT and NACT forms and, accordingly, in the AJ task, it was highly accepted in ACT co-occurring with inanimate subject, but not rejected in the other combinations; noticeably, it was the only verb in this class that was highly frequent in the corpus (6000 instances approx.). ACT types of *stegnoni* (dry), *lioni* (melt), *vrazi* (boil) and *sapizi* (rot) co-occurring with inanimate subjects outnumbered any other combination in the corpus; thus, these were the only combinations that were also accepted by our participants. For *lijizi* (bend) and *jerni* (lean), participants accepted ACT forms combined either with inanimate or with animate subjects, finding that matches frequency data only for the former, in that *lijizi* (bend) was frequently found in unergative structures with animate subjects, while *jerni* (bend) was mostly used transitively when combined with animate subjects, a structure that was not included in the task.

Among 'voice alternating' anticausatives, *berdevi* (mingle) was mostly used in structures with DP(subject)$_{inanimate}$ + V$_{NACT}$ in the corpus, and this was also the most positively evaluated combination in the AJ task. When in ACT, in the corpus it was used transitively, a structure not included in the task. A similar pattern was found in the corpus for *tsalakoni* (crumble) and *leroni* (spill), verbs that our participants evaluated positively in equivalent combinations (i.e., in DP(subject)$_{inanimate}$ + V$_{NACT}$ structures), the only difference being that *leroni* (spill) was also highly accepted in DP(subject)$_{animate}$ + V$_{NACT}$ structures, which were not frequent in the corpus and appeared only in colloquial speech (Web). The distribution of interpretations *katharizi* (clean) received in the corpus was somehow different, in that it was equally found in transitive and anticausative structures when in ACT (with inanimate subjects in the latter case), while when in NACT, it was mostly passive. Our participants did accept relatively highly all combinations, even the sentences with DP(subject)$_{animate}$ + V$_{ACT}$, which was not found in the corpus, probably attributing to it an unergative interpretation or supposing a null object (though not inferred by the context). For *tendoni* (stretch) and *tripai* (pierce), results of our AJ task differed from frequency data in that the best accepted sentences were the ones that included DP(subject)$_{animate}$ + V$_{NACT}$, a structure which was not frequent in the corpus; nonetheless, the remaining combinations that were also positively accepted appeared in some degree in the corpus, while the only combination participants accurately rejected was DP(subject)$_{anim}$ + V$_{ACT}$, favoring a transitive use, but ill-formed in the experimental material (since there was no object included). Finally, *htipai* (hit), the most common verb in this verb class (6000 instances approx.), was largely ambiguous in both (N)ACT and, subsequently, highly accepted across conditions in the experiment.

Latencies in the acceptability judgements are indicative of the complexity of transitivity alternations, given the fact that overall reaction times were very elevated. In fact, the time participants needed to decide on the degree of acceptability of the sentences they just read is two or even three times higher than the time participants needed to react while reading, as revealed by RTs obtained across segments during processing. Recall that a voice effect was attested, suggesting difficulty in deciding over the acceptability of ACT when compared to NACT types and narrowed down among verbs belonging to the 'voice non-alternating' anticausatives' class—this result may actually show speakers' tendency to initially opt for the structurally simplest (transitive) analysis even when it was implausible and thus need additional time to reinterpret the sentences in accordance to the most suitable use of specific verb tokens based on prior experience. Moreover, this finding points towards a need of examining the compatibility of the verbs with a (null) object. This behavior may be also relevant to previous language experience in relation to individual verbs: looking back to the degree of acceptability and the time needed to reach a final decision (Table 4), we notice that a voice effect appeared only in *tsalakoni* (wrinkle), a relatively rare verb (only 294 utterances found in the corpus), which, although suggested to freely alternate, was rather mostly found in DP(subject)$_{inanimate}$ + V$_{NACT}$ structures receiving an anticausative interpretation; still, the highest latency for decision making originated from the only highly accepted combination and could be attributed to a grammaticality effect. The same counts for latencies for decision making among labile (voice non-alternating anticausative) verbs, for which an animacy effect (and an interaction of voice by animacy for *stegnoni* (dry)) is explained by longer time needed for the (DP(subject)$_{inanimate}$ + V$_{ACT}$) combinations that were both highly frequent in the corpus and highly accepted in the acceptability judgment task when compared to the remaining constructions tested. Thus, prior experience is suggested to be mostly relevant to a level of semantic (re)analysis.

After all, the differences in effects attested during online processing and final decisions may actually be indicative of supporting the idea that unaccusativity is a sentence-level property (in the sense of Borer 2004), where the lexical meaning of verbs is 'bare' (with only unordered lists of arguments) and serves as a modifier rather than determinant of structural properties. Moreover, the syntactic structure and lexical specification follow different developmental timetables in language acquisition, as demonstrated in research (such as Fotiadou and Tsimpli 2010) where children are suggested to show sensitivity in cues provided by morphological marking (see also Papadopoulou 2006), but deviate adults' interpretational preferences due to lack of sufficient language exposure.

Large deviations in RTs during online processing (and offline decision making) may be indicative of methodological limitations of the study that need to be considered. In order to improve the validity of the task, we plan to further research, with modifications on the methodology used, the stimuli and the population examined. Evidence from the visual–world paradigm will be of primary importance to reveal whether participants rapidly use prior language experience to interpret specific verb types and verb tokens or they rely online on purely grammatical cues during processing to resolve the ambiguous verb. For the experimental stimuli, we envisage to control for the tense used, as it may contribute to a deeper understanding of the different nature of modality and unaccusativity. We also intend to investigate the potential effect of the verbs' compatibility with a (null) object in psycholinguistic data and compare it to previous experience by calculating its frequency of occurrence in corpora. Finally, for the population, as age was not considered in the present research, we will further examine the potential effect of an age factor and investigate whether older monolinguals are less flexible in accepting syntactic combinations (neologisms) found mostly in the samples of colloquial speech (Web) than younger ones.

5. Conclusions

The present research provides evidence in favor of a parser guided by morphological cues which provide language-specific constraints (for Greek, a morphologically rich language), while semantic cues such as animacy of the syntactic subject and the semantic

notion of verb classes are also important during later stages of (re)analysis in the course of disambiguating the verb's meaning. The above finding is also relevant to prior knowledge of syntactic structures in a coarse-grained level of analysis, while fine-grained lexical records are not fully supported by parsing of individual verbs examined. Still, different parsing patterns in individual verbs participating in the transitivity alternations may be attributed to other (extra)linguistic factors, such as age or the compatibility of verbs with a (null) object, affecting processing. The concurrent acceptability judgment provided demonstrated that adult native speakers of Greek accepted morpho-syntactic combinations they are familiar with, based on their prior language experience, as a fraction of this may be illustrated in the compiled corpus. Divergent results between online processing and metalinguistic judgment are not really contradictory but rather indicative of the different level of activation of usage experience in language comprehension (and use). In other words, our research is supportive of the hypothesis that the initial parsing is grammar-driven but provides evidence in favor of a rapid integration of frequency-based information which, together with semantic and other pragmatic cues (animacy included), drive final analysis and decision making. Increased complexity of transitivity alternations is also suggested by extreme latencies across experimental conditions in the decision making offline task. Further research is still needed to shed light on the exploration of the VP domain, the nature of unaccusativity and its relation to interfaces.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki. Ethical review and approval were waived for this study, due to the fact that data collection was completed at a time prior to the 2013 revision, thus not mandatory.

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: Data supporting reported results can be found in the IRIS database (https://www.iris-database.org/iris/app/home/detail?id=york%3a940211&ref=search).

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Notes

[1]　Verbs that fall into this category are not examined in the present paper, as their ACT forms are unambiguously transitive; instead, we are interested in cases that voice alternate (more or less) in natural speech to express unaccusativity, something that speakers tend to do with verbs of the first and third category.

[2]　Middle readings are beyond the scope of this paper, because contextual factors such as generic interpretation are difficult to test in parallel to passive/anticausative readings (but see, e.g., Manney 2000; Manzini et al. 2016; Lekakou 2005; Papastathi 2006; Sioupi 2005, for Greek).

[3]　The presence of an *apo*-phrase (as an equivalent of the *by*-phrase in English) as a criterion for passsivization is not used in our study as it has been challenged by the underspecification of the prepositional phrase (e.g., Kallulli 2019; Lavidas 2010), by its marked (very rare) use to express agentivity (e.g., Angelopoulos et al. 2020; Laskaratou and Philippaki-Warburton 1984; Joseph and Philippaki-Warburton 1987) and by empirical data (e.g., Fotiadou 2007; Plakouda 2020).

[4]　Non-literal uses are drawn from both (N)ACT, as in *sapistike sto ksilo* (litt. He was rotten to beat, 'he was beaten to death'), or in *lionun sto djavazma* (litt. They melt in studying, 'they burnout from studying').

5   The tense used in the experimental sentences correlated with the most frequent uses in corpora, i.e., present tense appeared with neologisms (e.g., Fotiadou 2014) and was not considered in the experimental manipulation.

6   We chose to include such a large grading scale because of the nature of the sentences under examination which may not be categorically considered grammatical or not, thus allowing the best possible illustration of participants' preferences.

7   The total of experimental sentences are accessible in Fotiadou (2010, pp. 372–83), Appendix I.

References

Alexiadou, Artemis, and Elena Anagnostopoulou. 2004. Voice morphology in the causative-inchoative alternation: Evidence for a non-unified structural analysis of unaccusatives. In *The Unaccusativity Puzzle: Explorations of the Syntax-Lexicon Interface*. Edited by Artemis Alexiadou, Elena Anagnostopoulou and Martin Everaert. Oxford: Oxford University Press, pp. 114–36.

Alexiadou, Artemis, Elena Anagnostopoulou, and Florian Schäfer. 2015. *External Arguments in Transitivity Alternations: A Layering Approach*. Oxford: Oxford University Press.

Angelopoulos, Nikos, Chris Collins, and Arhonto Terzi. 2020. Greek and English passives, and the role of by-phrases. *Glossa: A Journal of General Linguistics* 5: 90. [CrossRef]

Borer, Hagit. 2004. The grammar machine. In *The Unaccusativity Puzzle: Explorations of the Syntax-Lexicon Interface*. Edited by Artemis Alexiadou, Elena Anagnostopoulou and Martin Everaert. Oxford: Oxford University Press, pp. 288–331.

Bybee, Joan L. 1995. Regular morphology and the lexicon. *Language and Cognitive Processes* 10: 425–55. [CrossRef]

Chondrogianni, Vasiliki, Theodoros Marinis, Susan Edwards, and Elma Blom. 2014. Production and on-line comprehension of definite articles and clitic pronouns by Greek sequential bilingual children and monolingual children with specific language impairment. *Applied Psycholinguistics* 36: 1155–91. [CrossRef]

Cuetos, Fernando, Don C. Mitchell, and Martin Corley. 1996. Parsing in different languages. In *Language Processing in Spanish*. Edited by Manuel Carreiras, Jose Garcia-Albea and Nuria Sebastian-Galles. Hillsdale: Lawrence Erlbaum, pp. 145–187.

Dowty, David. 1979. *Word Meaning and Montague Grammar*. Dordrecht: Reidel.

Ferreira, Fernanda, and Charles Clifton. 1986. The independence of syntactic processing. *Journal of Memory and Language* 25: 348–68. [CrossRef]

Fotiadou, Georgia. 2007. Voice morphology and the *apo*-phrase. *Selected Papers on Theoretical and Applied Linguistics* 17: 378–87. [CrossRef]

Fotiadou, Georgia. 2010. Voice Morphology and Transitivity Alternations in Greek: Evidence from Corpora and Psycholinguistic Experiments. Unpublished doctoral dissertation, Aristotle University of Thessaloniki, Thessaloniki, Greece. [CrossRef]

Fotiadou, Georgia. 2014. Productivity and interpretations of Greek voice morphology: A corpus based analysis. Paper presented at Actes du 30e Colloque International de Linguistique Fonctionnelle, Cyprus, October 18–21; Edited by Marilena Karyolemou, Fabienne Baider and Marianne Katsoyannou. Fernelmont: E.M.E. (Editions Modulaires Européennes) & InterCommunications s.p.r.l., pp. 79–84.

Fotiadou, Georgia, and Eleni Peristeri. 2012. The Lexicon-Syntax-Morphology Interface in Language Unimpaired and Broca's Aphasic Populations: When Unaccusative Verb Processing Meets Animacy and Voice Alterations. *Studies in Greek Linguistics* 32: 77–88.

Fotiadou, Georgia, and Ianthi Maria Tsimpli. 2010. The acquisition of transitivity alternations in Greek: Does frequency count? *Lingua* 120: 2605–26. [CrossRef]

Frazier, Lyn. 1990. Parsing modifiers: Special purpose routines in the human sentence processing mechanism. In *Comprehension Processes in Reading*. Edited by David A. Balota, G.B. Flores D'Arcais and Keith Rayner. Hillsdale: Lawrence Erlbaum Associates Incorporation, pp. 301–31.

Garnsey, Suzan M., Neal J. Pearlmutter, Elizabeth Myers, and Melanie A. Lotocky. 1997. The contribution of verb bias and plausibility to the comprehension of temporally ambiguous sentence. *Journal of Memory and Language* 37: 58–93. [CrossRef]

Gibson, Edward, Carson T. Schütze, and Ariel Salomon. 1996. The relationship between the frequency and the complexity of linguistic structure. *Journal of Psycholinguistic Research* 25: 59–92. [CrossRef]

Hundt, Marianne, Nadja Nesselhauf, and Carolin Biewer. 2007. *Corpus Linguistics and the Web (Language and Computers, 59)*. Amsterdam: Rodopi, Brill.

Joseph, Brian, and Irene Philippaki-Warburton. 1987. *Modern Greek*. London, Sydney, and Wolfeboro: Croom Helm.

Kallulli, Dalina. 2019. A unified analysis of passives and anticausatives. *Proceedings of Sinn Und Bedeutung* 10: 171–82. [CrossRef]

Laskaratou, Chryssoula, and Irene Philippaki-Warburton. 1984. Lexical vs. transformational passives in M.G. *Glossologia* 2–3: 99–109.

Lavidas, Nikolaos. 2010. *Transitivity Alternations in Diachrony: Changes in Argument Structure and Voice Morphology*. Newcastle: Cambridge Scholars Publishing.

Lekakou, Marika. 2005. In the Middle Somewhat Elevated. The Semantics of Middles and Its Cross-Linguistic Realization. Unpublished doctoral dissertation, University of London, London, UK. Available online: https://discovery.ucl.ac.uk/id/eprint/1444931/3/Lekakou_lekakouEtAl_05_In-the-Mid.pdf (accessed on 5 February 2022).

Levin, Beth, and Malka Rapapport-Hovav. 2005. *Argument Realization (Research Survays in Linguistics)*. Cambridge: Cambridge University Press.

MacDonald, Maryellen C. 1997. Lexical representations and sentence processing: An Introduction. *Language and Cognitive Processes* 9: 195–201. [CrossRef]

MacDonald, Maryellen C., and Mark Seidenberg. 2006. Constraint satisfaction accounts of lexical and sentence comprehension. In *Handbook of Psycholinguistics*, 2nd ed. Edited by Matthew Traxler and Morton Gernsbacher. London: Elsevier, pp. 581–611.

MacDonald, Maryellen C., Neal J. Pearlmutter, and Mark Seidenberg. 1994. Syntactic ambiguity resolution as lexical ambiguity resolution. In *Perspectives on Sentence Processing*. Edited by Charles Clifton Jr., Lyn Frazier, Keith Rayner and Charles Clifton. Hillsdale: Lawrence Erlbaum, pp. 178–269.

Manney, Linda Joyce. 2000. *Middle Voice in Modern Greek*. Amsterdam and Philadelphia: John Benjamins.

Manzini, M. Rita, and Anna Roussou. 2000. A minimalist theory of A-movement and control. *Lingua* 110: 409–47. [CrossRef]

Manzini, M. Rita, Anna Roussou, and Leonardo M. Savoia. 2016. Middle-passive voice in Albanian and Greek. *Journal of Linguistics* 52: 111–50. [CrossRef]

Marinis, Theodoros. 2010. On line sentence processing methods in typical and atypical populations. In *Experimental Methods in Language Acquisition Research*. Edited by Sharon Unsworth and Elma Blom. Amsterdam and Philadelphia: John Benjamins, pp. 139–62.

Mitchell, Don, and Marc Brysbaert. 1998. Challenges to recent theories of crosslinguistic variation in parsing: Evidence from Dutch. In *Sentence Processing: A Crosslinguistic Perspective*. Edited by Dieter Hillert. San Diego: Academic Press, pp. 313–35.

Nerantzini, Michaela, Maria Mastropavlou, Theofano Christou, Marika Lekakou, and Victoria Zakopoulou. 2022. Processing voice morphology and argument structure by Greek beginner readers and children with reading difficulties. *Applied Psycholinguistics* 43: 125–55. [CrossRef]

Papadopoulou, Despoina. 2006. *Cross-Linguistic Variation in Sentence Processing: Evidence from RC Attachment Preferences in Greek*. Amsterdam: Springer.

Papadopoulou, Despina, and Ianthi Maria Tsimpli. 2005. Morphological cues in children's processing of ambiguous sentences: A study of subject/object ambiguities in Greek. In *Proceedings of the 29th annual Boston University Conference on Language Development*. Edited by Alejna Brugos, Manuella R. Clark-Cotton and Seungwan Ha. Somerville: Cascadilla Press, pp. 471–81.

Papastathi, Maria. 2006. The Syntax and Semantics of Middle Constructions in English and Greek. Unpublished doctoral dissertation, Aristotle University of Thessaloniki, Thessaloniki, Greece.

Peristeri, Eleni, Ianthi Maria Tsimpli, and Kyranna Tsapkini. 2013. The on-line processing of unaccusativity in Greek agrammatism. *Applied Psycholinguistics* 34: 233–76. [CrossRef]

Perlmutter, David. 1978. Impersonal passives and the Unaccusativity Hypothesis. *Berkeley Linguistics Society: Proceeding of the Annual Meeting* 38: 157–89. [CrossRef]

Plakouda, Aikaterini. 2020. Sentence Processing of Greek Anticausative Structures. Unpublished doctoral dissertation, National and Kapodistrian University of Athens, Athens, Greece. Available online: https://pergamos.lib.uoa.gr/uoa/dl/object/2875714 (accessed on 5 February 2022).

Sioupi, Athina. 2005. Morphological and telicity aspect with accomplishment VPs in Greek. In *Crosslinguistic Views on Tense, Aspect and Modality*. Edited by Bart Hollebrandse, Angeliek Van Hout and Co Vet. [Cahiers Chronos 13]. Amsterdam and New York: Rodopi, pp. 131–44.

Steedman, Mark, and Gerry Altmann. 1989. Ambiguity in context: A reply. *Language, Cognitive and Neuroscience* 4: 105–22. [CrossRef]

Terzi, Arhonto. 2021. Synthetic passives in early and impaired grammar: The view from Greek reflexive verbs. In *Passives Crosslinguistically: Theoretical and Experimental Approaches*. Edited by Kleanthes K. Grohmann, Akemi Matsuya and Eva-Maria Remberger. Leiden: Brill Academic Publishers, pp. 394–418.

Terzi, Arhonto, Theodoros Marinis, Angeliki Kotsopoulou, and Konstantinos Francis. 2014. Grammatical abilities of Greek-speaking children with autism. *Language Acquisition* 21: 4–44. [CrossRef]

Theophanopoulou-Kontou, Dimitra. 2000. -O/-me alternations in MG patient oriented constructions: Anticausatives and passives [Domes tis NE me prooptiki tu dekti ke i katanomi –o/-ome: Ta antimetavivastika ke pathitika]. *Studies in Greek Linguistics* 20: 146–57.

Trueswell, John C., Michael K. Tanenhaus, and Susan M. Garnsey. 1994. Semantic influences on parsing: Use of thematic role information in syntactic disambiguation. *Journal of Memory and Language* 33: 285–318. [CrossRef]

Tsimpli, Ianthi Maria. 2006. The acquisition of voice and transitivity alternations in Greek as native and second language. In *Paths of Development in L1 and L2 acquisition: In honor of Bonnie D. Scwartz. Language Acquisition and Language Disorders*. Edited by Sharon Unsworth, Teresa Parodi, Antonella Sorace and Martha Young-Scholten. New York and Philadelphia: John Benjamins, vol. 39, pp. 15–55.

Unsworth, Sharon, Frosso Argyri, Leonie Cornips, Aafke Hulk, Antonella Sorace, and Ianthi Maria Tsimpli. 2011. Bilingual acquisition of Greek voice morphology and Dutch gender: What do they have in common? In *Proceedings of the 35th annual Boston University Conference on Language Development*. Edited by Nick Danis, Kate Mesh and Hyunsuk Sung. Somerville: Cascadilla Press, pp. 590–602.

Zombolou, Katerina. 2004. Verbal Alternation in Greek: A Semantic Analysis. Unpublished doctoral dissertation, University of Reading, Reading, UK.

Zombolou, Katerina, Spyridoula Varlokosta, Artemis Alexiadou, and Elena Anagnostopoulou. 2010. Acquiring anticausatives vs. passives in Greek. In *Proceedings of the 34th Boston University Conference on Language Development*. Edited by Katie Franich, Kate M. Iserman and Lauren L. Keil. Somerville: Cascadilla Press, pp. 515–24.