Case, word order, and the incremental disambiguation of grammatical roles in Georgian

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Abstract: Comprehending a sentence involves identifying how event participants are mapped to syntactic arguments. Those grammatical mappings are often ambiguous, temporarily or even permanently, over the course of the clause. Given ambiguous cues, which mappings are easiest for the comprehender to process upon disambiguation, and why? The present study on Georgian, a split-ergative language with flexible word order, was designed to shed light on these questions. It tracked word-by-word reading times of sentences that, due to a complex morphosyntactic grammar, were incrementally ambiguous between a wide range of argument structures and word orders. Crucial disambiguating cues appeared at the verb, where tense/voice morphology unlocked the sentence's case–role mapping and thus word order. A few clear patterns emerge across the reading times of these disambiguating verbs. Given one noun that is incrementally ambiguous, cues that show its role to be an active transitive subject are not processed differently than cues to a nonactive intransitive subject. Given two role-ambiguous nouns, there is an interaction between word order and case mapping. It is relatively hard to process patient-first transitives that are morphologically/semantically noncanonical, but it is not hard to process either patient-first canonical transitives or agent-first noncanonical ones. It seems, then, that Georgian comprehenders do not prioritize identifying an event's agent above all else. Finally, affectee applicatives always cause processing difficulty, even for nonactives. This is notable because the temporarily ambiguous arguments were overwhelmingly high in animacy. If comprehenders sought to map high-animacy arguments to a role with as many prototypically agent-like properties as possible, then there should have been many contexts where indirect objects (which tend to least have some agent-like properties) were easier to process than direct objects (which tend to have few if any). Together, these results support a theory where prototypically transitive clauses, with two arguments highly distinct in thematic interpretation, are privileged during sentence comprehension.

1. Introduction

Verb-final word order is widespread in natural language: a remarkable fact, in light of the outsized contribution of a typical verb during real-time sentence comprehension. The verb root supplies a clause with its core lexical-semantic relations, and in many languages verbal inflection determines just how those relations are grammatically mapped to nominal arguments. The verb being the locus of so many thematic and morphosyntactic dependencies, withholding that word until the end of the clause may seem maladaptive for efficient communication of who did what to whom in what kind of event (Inoue & Fodor 1995).

But morphosyntactic grammars tend to throw the comprehender a bone. There has been a long-standing typological observation that verb finality correlates with rich case inflection (Greenberg 1963's Universal 41) and a long standing intuition that case morphology has an adaptive function for comprehension (Sapir 1917), signaling as it does grammatical role more or less directly. For example, take classical ergative case (Dixon 1979). Biuniquely associated with transitive subjecthood, ergative is an excellent cue to that syntactic role. In turn, transitive subjecthood is correlated with a cluster of lexical-semantic properties. After all, natural language lexicons are overwhelmingly organized so that grammatical roles are quite semantically coherent (e.g. Dowty 1991). Thus, ergative is a reliable cue not just to a narrow syntactic relation (transitive subjecthood, external argumenthood) — it also reliably cues a cluster of entailments about the event participant's relative agency, causality, animacy, and so on. Encountering ergative morphology on a preverbal noun, then, allows the comprehender to reliably predict quite a bit about the clause's morphosyntactic and thematic dependencies, totally independent of the verb.

This paper focuses on a verb-final language where case cues are often much less reliable than classical ergative is. In Georgian, the so-called nominative and dative cases have wide distributions, marking grammatical roles differently across tenses and argument structures. Consequently, sequences of preverbal nominative and dative arguments are highly ambiguous. The NOM<DAT sequence in 1, for example, is temporarily compatible with many parses: subject- or object-initial, active or nonactive, with or without an indirect object. Generally, tense/voice inflection on the verb is what disambiguates the correct parse of the clause (2).

(1) *Ambiguous preamble*
ekʰim-i msaχiob-s…[1]
doctor-NOM actor-DAT

(2) *Possible continuations*

a. …gaaʧʰerebs.
stop:ACT:FUT
"The doctor will stop the actor" — *Monotransitive SOV parse*

b. …gauʧʰerebia.
stop:ACT:PERF
"The doctor must have stopped the actor" — *Monotransitive OSV parse*

c. …gauʧʰerebs…
stop:ACT:APPL:FUT
"The doctor will stop the actor […for 3RD]"
or "The doctor will stop […3RD] for the actor" — *Ditransitive SO$_1$V parse, anticipated O$_2$*

d. …gavuʧʰere.
stop:ACT:APPL:AOR
"I stopped doctor for the actor" — *Ditransitive DO-IO-V parse, null S triggering Agr*

e. …gauʧʰerda.
stop:NACT:APPL:AOR
"The doctor stopped for the actor" — *Applied nonactive S-IO-V parse*

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[1] Georgian data are provided in IPA transcription, which is also a faithful transliteration of the orthography. Glosses and text use the following abbreviations: ACC "accusative"; ACT "active"; AOR "aorist"; APPL "applicative"; CAUS "causative"; COP "copular agreement"; DAT "dative"; DITR "ditransitive"; F "feminine"; FUT "future"; GEN "genitive"; INCH "inchoative"; NMLZ "deverbal nominalization"; NPST "nonpast" NOM "nominative"; PASS "passive"; PERF "perfect"; PPTC "past participle"; PL "plural"; PST "past"; PSYCH "psych verb"; PVB "preverb"; SG "singular"; THM "thematic suffix [stem formant]"; UNERG "unergative"; VVA/E/H/I/U "version vowel /a-, e-, h-, i-, u-/ [i.e. inflection related to voice and tense]"; 1/2/3 "first/second/third person"; X>Y "category X outranks Y on some hierarchy"; X<Y "word X precedes word Y"; X|Y$_{\not Z}$ "role X disambiguated by cues on word Y, eliminating parses involving role Z".

For expository purposes full morpheme-by-morpheme breakdowns are sometimes avoided, given the complexity of Georgian verbal morphology. Undecomposed verbs are glossed for argument structure, tense, and phi-agreement for 1st or 2nd person arguments, separated by colons; decomposed verbs (in Section 2.1) are accompanied with bracketed feature-bundles conveying those same inflectional dimensions.

How do Georgian comprehenders navigate such ambiguities? To what degree do they entertain each grammatically available parse, and why? Novel behavioral data from three sentence-processing experiments address these questions, tracking reading times across out-of-the-blue sentences using an incremental lexical-decision task (the Lexicality Maze: Freedman & Forster 1985, Boyce et al. 2020). This study, building on Skopeteas et al. (2011) and Foley (2020), leverages Georgian's unique grammar to isolate the contribution of certain linguistic cues that have been argued to guide the processing of verb–argument dependencies crosslinguistically (e.g. in the eADM theory; Bornkessel-Schlesewsky & Schlesewsky 2006, et seq). Effects emerge at disambiguating verb regions. Nuanced generalizations emerge about word order, agreement, tense, and particular case–role mappings — but in sum, we find that prominence scales are not implemented symmetrically during real-time sentence processing.

Consider the scales for animacy (human > inanimate) and thematic role (agent > goal/affectee > patient). Suppose that parsers are biased to assign to an ambiguous high-animacy argument the most prominent unclaimed role allowed by the grammar. After all, comprehenders do seem inclined to give low-animacy arguments the least prominent possible role, in Georgian (Foley 2020, ch. 2) and beyond (Bornkessel-Schlesewsky & Schlesewsky 2014). However, results do not support a general advantage to harmonic combinations of animacy and role scales (contra Foley 2020). In this study, almost all preverbal nouns referred to humans. In Georgian, any regular verb can take a dative-case transitive subject or dative applied indirect-object, given the right inflection. Yet comprehenders are unphased to discover high-animacy datives parsed as direct objects: a disharmonic combination of animacy and role. In other words, animacy–role harmony per se is not a heuristic for parsing, even though animacy clearly helps identify transitive subjects (Bornkessel-Schlesewsky & Schlesewsky 2009b).

In morphosyntactic typology, special marking is often associated with high-animacy objects (Aissen 1991). From various perspectives this is a related to their unexpectedness (Haspelmath 2021), their abstract featural representation (Kalin 2018), or their non-canonicity/non-prototypicality (Primus 1999, Van Valin 2005). Insofar as any of these concepts translate to processing difficulty, the comprehender might seek to avoid positing them absent top-down evidence. With its relative wealth of indirect objects and dative subjects, Georgian grammar makes it very easy to avoid parses that involve a human patient. Indeed, in the Georgian Reference Corpus (Gippert & Tandashvili 2015), verbs which morphologically license a dative-case indirect object outnumber verbs with a dative direct object (Foley 2022). Yet, overall, a dative noun is easiest to process when parsed as a direct object, in line with Skopeteas et al.'s (2011) generalizations.

Another perspective on high-animacy objects is that they increase a clause's abstract Transitivity (Hopper & Thompson 1980). In the context of real-time sentence processing, a highly Transitive predicate can be conceived as one whose arguments are held in sharper focus in the mind's eye: it is an event with highly distinct participants, which are easier to distinguish in memory (cf. Bornkessel-Schlesewsky & Schlesewsky 2006's principle of Distinctness). Even holding lexeme and valence constant (as in 2a,e), Georgian shows that dative indirect objects are harder to process than dative direct objects. This follows if the comprehenders are biased towards parses that are more Transitive, or Distinct — rather than more optimal/harmonic (Hoeks & Hendriks 2011, Skopeteas et al. 2011, Foley 2020), or less surprising given linguistic experience (Hale 2001, Levy 2008).

In what sense is Georgian a maladaptive verb-final language? Why doesn't it throw the comprehender a few more bones, by making word order stricter, or pronouns obligatorily overt? How has such an entropic morphosyntax evaded the forces of grammaticization so long? In fact, a case–role mapping system nearly identical to Modern Georgian's is reconstructable to Proto South Caucasian (Harris 1985). And, across many centuries of written attestation, certain dative arguments in Georgian have if anything gained syntactic subjecthood properties (Tuite 1998). Clearly, the comprehender can tolerate a certain degree of morphosyntactic ambiguity before encountering the verb.

The rest of this paper explores this observation and weighs its theoretical consequences. Section 2 gives key background about Georgian grammar and about crosslinguistic sentence processing. Section 3 lays out some predictions for the processing of certain case–role ambiguities in Georgian. Section 4 turns to the reading-time study, describing the design of three subexperiments and reporting their results. Section 5 summarizes and discusses findings in light of predictions. Section 6 concludes.

2. Background

This section describes important grammatical properties of Georgian (Section 2.1), digests crosslinguistic findings on case–role findings (Section 2.2), and summarizes previous sentence-processing research (Section 2.3) and corpus studies (Section 2.4) on Georgian.

2.1 Case and grammatical roles in Georgian

Georgian (Shanidze 1980 [1953]; Harris 1981; Aronson 1990; Hewitt 1995; Tuite 1998; Lomashvili 2011) is a member of the South Caucasian language family (Harris 1991, Boeder 2005, Testelets 2021). It has weakly head-final syntax, null pronouns, flexible word order, and rich verbal agreement. Morphologically signaled argument-structure alternations can productively increase or decrease a verb's valence. Case assignment of core clausal arguments depends on grammatical role and tense (Harris 1985, Nash 2017). Together, these facts render many nouns preceding a verb temporarily ambiguous for role. Cues from verbal inflection will often be the key disambiguators.

Take a regular verb like /gaʧʰereba/ "stop:NMLZ". Its finite forms, inflected for tense and argument structure, can be categorized as active or nonactive. Active forms have a transitive subject ('A') and a direct object ('P'); see 3. Nonactive forms, like 4, have an intransitive subject ('U')[2] that corresponds thematically to the active direct object (Harris 1981, Gérardin 2016; compare e.g. Greek anticausatives, Alexiadou et al. 2015).

(3) ekʰim-ma msaχiob-i ga= a- ʧʰer -a.
doctor-ERG actor-NOM PVB= VVA- stop -PST [ACT:AOR]
"The doctor$_{[A]}$ stopped the actor$_{[P]}$."

(4) msaχiob-i ga= ʧʰer -d -a.
actor-NOM PVB= stop -INCH -PST [NACT:AOR]
"The actor$_{[U]}$ stopped."

Both active and nonactive verbs have applicative forms (Lomashvili 2011). Applicativization is an alternation in verbal morphology that signals the addition of an indirect object ('G'). Applied indirect objects will be translated as benefactees here (i.e., "for NP"), though interpretations involving malefactees, accidental causers, or possessors of the internal argument might also possible (compare Bosse et al. 2012).

(5) ekʰim-ma mʦ'eral-s msaχiob-i ga= u- ʧʰer -a.
doctor-ERG writer-DAT actor-NOM PVB= VVU- stop -PST [ACT:APPL:AOR]
"The doctor$_{[A]}$ stopped the actor$_{[P]}$ for the writer$_{[G]}$."

[2] Departing from standard conventions in typology (e.g. Dixon 1979), I reserve 'S' and 'O' as symbols for "any subject [i.e. transitive or intransitive, agentive or non-agentive]" and "any object [i.e. direct or indirect]", respectively.

(6) msaχiob-i mʦ’eral-s ga= u- ʧʰer -d -a.
actor-NOM writer-DAT PVB= VVU- stop -INCH -PST [NACT:APPL:AOR]
“The actor$_{[U]}$ stopped for the writer$_{[G]}$.”

So far, morphological case tracks thematic interpretation quite well. Indeed, case marking in 3–6 seems streamlined for comprehension. Ergative marks A, which reliably corresponds to event participants with many Proto-Agent properties (Dowty 1991). Nominative marks P and anticausative U, which reliably have many Proto-Patient properties. Dative marks G, which tends to have few of either.

But this pattern is found only in certain contexts: in ‘Series-II’ tense categories. Across other tenses, two other case–role mappings are found. In Series-I tenses (present, imperfective past, future, conditional, and two subjunctives), transitive and intransitive subjects are all nominative; direct and indirect objects are all dative. Consequently, active ditransitives (8) are globally ambiguous here, and applied nonactives (10) are distinguishable from active transitives (7) only by voice cues from verbal morphology. (Compare case marking across 3 and 6.)

(7) ekʰim-i msaχiob-s ga= a- ʧʰer -eb -s.
doctor-NOM actor-DAT PVB= VVA- stop -THM -NPST.ACT [ACT:FUT]
“The doctor$_{[A]}$ will stop the actor$_{[P]}$.”

(8) ekʰim-i mʦ’eral-s msaχiob-s ga= u- ʧʰer -eb -s
doctor-NOM writer-DAT actor-DAT PVB= VVU- stop -THM -NPST.ACT [ACT:APPL:FUT]
“The doctor$_{[A]}$ will stop the writer$_{[P]}$ for the actor$_{[G]}$.” (AGVP reading)
or “The doctor$_{[A]}$ will stop the actor$_{[P]}$ for the writer$_{[G]}$.” (APVG reading)

(9) msaχiob-i ga= ʧʰer -d -eb -a.
actor-NOM PVB= stop -INCH -THM -NPST.NACT [NACT:FUT]
“The actor$_{[U]}$ will stop.”

(10) msaχiob-i mʦ’eral-s ga= u- ʧʰer -d -eb -a
actor-NOM writer-DAT PVB= VVU- stop -INCH -THM -NPST.NACT [NACT:APPL:FUT]
“The actor$_{[U]}$ will stop for the writer$_{[G]}$.”

As for Series-III tenses (the perfect, which has past-evidential readings; and the pluperfect, with past-counterfactual readings), these are characterized by “inverse” morphosyntax (Harris 1981). Active subjects are dative, and agree with the verb like erstwhile indirect objects. Direct objects and nonactive subjects are nominative, as in Series II. Only nonactive verbs have applicative forms in Series III (11–12). Indirect objects of nonactive verbs are dative; for active verbs, would-be indirect objects must be expressed as postpositional phrases (13–14).

(11) msaχiob-i ga= ʧʰer -eb -ul -a.
actor-NOM PVB= stop -THM -PPTC -COP [NACT:PERF]
“The actor$_{[U]}$ must have stopped.”

(12) msaχiob-i mʦ’eral-s ga= s- ʧʰer -eb -i -a
actor-NOM writer-DAT PVB= VVH- stop -THM -PERF -COP [NACT:APPL:PERF]
“The actors$_{[U]}$ must have stopped for the actor$_{[G]}$.” (Applicative form distinct)

(13) ekʰim-s msaχiob-i ga= u- ʧʰer -eb -i -a.
doctor-DAT actor-NOM PVB= VVU- stop -THM -PERF -COP [ACT:PERF]
“The doctor$_{[A]}$ must have stopped the actor$_{[P]}$.”

(14) ekʰim-s msaχiob-i mʦ’erl-is=tʰvis ga= u- ʧʰer -eb -i -a.
doctor-DAT actor-NOM writer-GEN=for PVB= VVU- stop -THM -PERF -COP [ACT:PERF]
“The doctor$_{[A]}$ must have stopped the actor$_{[P]}$ for the actor$_{[G]}$.” (No applicative available)

This demonstrates the behavior of verbs derivable from a regular telic transitive verb. There are also atelic intransitive active verbs — i.e. unergatives (Holisky 1981, Nash 2022). With respect to case marking, unergative subjects (A_{INTR}) have the same behavior as active transitive subjects (A_{TR}). However, unergatives mostly resist applicativization (Nash 2022), and there are no impersonal passives of unergatives (as in some languages; Perlmutter & Postal 1984, Legate et al. 2020).

(15) a. ekʰim-i i- mʁer -eb -s.
doctor-NOM VVI- sing -THM -NPST.ACT [UNERG:FUT]
“The doctor$_{[A]}$ will sing.”

b. ekʰim-ma i- mʁer -a.
doctor-ERG VVI- sing -PST [UNERG:AOR]
“The doctor$_{[A]}$ sang.”

c. ekʰim-s u- mʁer -i -a.
doctor-DAT VVU- sing -PERF -COP [UNERG:AOR]
“The doctor$_{[A]}$ must have sung.”

Finally, there are psych verbs (Harris 1981, Cherchi 1997). In all tenses, their experiencer subjects (‘Ex’) are dative, and stimuli objects (‘St’) are nominative. Morphologically, they mostly behave like applied nonactives. They do not participate in the applicative or anticausative alternations. This makes them quite amenable to the ‘passive ditransitive’ analysis of psych verbs (Belletti & Rizzi’s 1988 *piacere*-class): essentially reducing the Ex role to G, and St to U. (Compare Harris’s 1981 analysis, where Ex is essentially G derived from A.)

(16) a. mʦ’eral-s msaχiob-i mo= e- ʦ’on -eb -a.
writer-DAT actor-NOM PVB= VVE- like -THM -NPST.NACT [PSYCH:FUT]
“The writer$_{[Ex]}$ will like the actor$_{[St]}$.”

b. mʦ’eral-s msaχiob-i mo= e- ʦ’on -a.
writer-DAT actor-NOM PVB= VVE- like -PST [PSYCH:AOR]
“The writer$_{[Ex]}$ liked the actor$_{[St]}$.”

c. mʦ’eral-s msaχiob-i mo= s- ʦ’on -eb -i -a.
writer-DAT actor-NOM PVB= 3DAT- like -THM -PERF -COP [PSYCH:PERF]
“The writer$_{[Ex]}$ must have liked the actor$_{[St]}$.”

The patterns here define about six grammatical roles — i.e. clusters of syntactic, morphological, and thematic properties (17). Table 1 summarizes these roles’ case-marking behavior, across tense series.

(17) a. <u>Active subject (A)</u>: a.k.a. ‘A’ and ‘S_A’ (cf. Comrie 1978; Dixon 1978, 1994; Bickel & Nichols 2009; Haspelmath 2011); External argument, in Spec-VoiceP (Lomashvili 2011, Nash 2017; after Kratzer 1996 et seq); Initial-1 (i.e. in Relational Grammar terms; Harris 1981); The event-participant with more Proto-Agent properties (Dowty 1991); Agents, actors, initiators; Includes unergative / atelic intransitive subjects (Nash 2022)

c. Direct object (P): Internal argument, the verb’s complement; Initial-2; More Proto-Patient properties; Undergoer, patient, theme, etc.

b. Nonactive subject (U): a.k.a. ‘S_P’, ‘S_O’; Internal argument, the verb’s complement; Initial-2; Passive, anticausative, unaccusative, telic intransitive subject; Theme, undergoer; Reduceable to P given the Unaccusative Hypothesis (Perlmutter 1978, et seq).

d. Indirect object (G): a.k.a. ‘R’; Applied argument, in Spec-ApplP; Initial-3; Few Proto-Agent or Proto-Patient properties; Goal/recipient, affectee, benefactee, malefactee, external possessor, miscellaneous ‘oblique’.

e. Psych subject (Ex): Applied argument, in Spec-ApplP; Initial-1, inverted to 3-hood (Harris 1981); Few Proto-Agent or Proto-Patient properties; Experiencer; Arguably reduceable to A, or to G (Belletti & Rizzi 1989, Marantz 1989, Lomashvili & Harley 2011).

f. Psych object (St): Internal argument, the verb’s complement; Initial-2 (Harris 1981); Few Proto-Agent or Proto-Patient properties; Stimulus, theme; Arguably reduceable to U/P (Belletti & Rizzi 1989).

<table>
<tr><th></th><th>Active Subject ($A_{TR/INTR}$)</th><th>Nonactive Subject (U)</th><th>Direct Object (P)</th><th>Indirect Object (G)</th><th>Psych Subject (Ex)</th><th>Psych Object (St)</th></tr>
<tr><td>Series I (FUT…)</td><td colspan="2">NOM</td><td colspan="2">DAT</td><td rowspan="3">DAT</td><td rowspan="3">NOM</td></tr>
<tr><td>Series II (AOR…)</td><td>ERG</td><td colspan="2">NOM</td><td>DAT</td></tr>
<tr><td>Series III (PERF…)</td><td>DAT</td><td colspan="2">NOM</td><td>DAT / PP_{for}</td></tr>
</table>

Table 1: Summary of case marking of core arguments across three ‘Series’ of morphological tenses categories. In Series III, indirect objects are dative in nonactive clauses, but PPs in active clauses (i.e., when there is a dative subject).

2.2 Crosslinguistic processing of case–role ambiguities

The processing of argument–verb dependencies within a clause is being studied in more and more languages, testing the typological generality of sentence-processing theories (see Bornkessel-Schlesewsky & Schlesewsky 2009a, 2009b, 2014 for surveys). This section summarizes some key generalizations, mostly setting aside the vast literature on filler–gap dependencies like relative clauses (e.g. Lau & Tanaka 2021).

A common theme is that subject-initial parses, or perhaps agent-initial ones, tend to have a processing advantage. To illustrate, consider the well-studied case of German (Hemforth et al. 1993, Bader & Meng 1999, Frisch & Schlesewsky 2001, Bornkessel et al. 2004, Knoeferle et al. 2005, Henry et al. 2017, Dröge et al. 2020, a.o.), a language with rich case morphology, argument scrambling, and verb-final word order in embedded clauses. These features are leveraged by Bader & Meng (1999), in a design illustrated by the following sentences (18). Feminine and plural noun phrases are syncretic between nominative and accusative cases, but only nominatives will control phi-agreement on the clause-final auxiliary verb. So, given one feminine and one plural noun, the crucial disambiguator will be that auxiliary, its agreement morphology disambiguating to either the SOV or OSV parse. In a speeded acceptability task, Bader &

Meng find that the OSV sentences (18b) are judged as grammatical less frequently, and correct responses took longer. The authors interpret this as evidence that German comprehenders are biased to parse the first argument as a nominative subject (as 18a), given the ambiguous cues.

(18) a. Die Direktorin hat erzählt, [daß **die** neue Lehrerin
the:F.SG.NOM director has:3SG said C **the:F.SG.NOM** new teacher
einige **der** Kollegen angerufen **hat**.]
some **the:PL.ACC** colleague phoned **has:3SG**
"The director said that the new teacher phoned some of the colleagues." [embedded **SOV**]

b. Die Direktorin hat erzählt, [daß **die** neue Lehrerin
the:F.SG.NOM director has:3SG said C **the:F.SG.ACC** new teacher
einige **der** Kollegen angerufen **haben**.]
some **the:PL.NOM** colleague phoned **has:3PL**
"The director said that some of the colleagues phoned the new teacher." [embedded **OSV**]
German (Bader and Meng 1999:127; glosses adapted)

Subject/agent-initial processing advantages have been observed for many languages, including Italian (de Vincenzi 1991), Finnish (Kaiser & Trueswell 2004), Turkish (Demiral et al. 2008), Chinese (Philipp et al. 2008, Wang et al. 2009), Tamil (Muralikrishnan et al. 2008), Hindi (Choudhary et al. 2010, Bickel et al. 2015), Estonian (Miljan et al. 2017), and Austrian Sign Language (Krebs et al. 2018). The preference has been hypothesized to reflect a general cognitive principle guiding event cognition, a plausibly pre-linguistic one that might have a role shaping grammatical typology (Kemmerer 2012, Bickel et al. 2015).

However, there is reason to believe subject-initial preference is not universal. In Kaqchikel (Mayan), VOS is the base word order, but derived SVO and VSO orders are also very frequent. Evidence from a plausibility-judgement study (Koizumi et al. 2014) and an ERP experiment (Yasunaga et al. 2015) show that VOS is the easiest word order to process in Kaqchikel. This suggest that subject-initial parsing preference in other languages might not be the reflection of a universal S<O advantage, but rather a learned adaptation to frequent or derivationally simple word orders within a particular language.

In another O<S language, Äiwoo (Oceanic Austronesian), evidence is more nuanced (Sauppe et al. 2023). OVS and SVO orders are both possible in this language, disambiguated by voice morphology on the verb; OVS sentences are much more frequent, though. Sauppe et al.'s ERP study finds differential effects depending on animacy: there is an SVO advantage when the first constituent refers to a human, but an OVS advantage elsewhere. Canonical agents are of course high in animacy (e.g. Comrie 1989, Dowty 1991, Primus 1999). This agency–animacy correlation seems to compel Äiwoo comprehenders towards a subject-initial parse when faced with a high-animacy noun with ambiguous role, away from the object-initial preference rooted in experience with their language.

Beyond Äiwoo, there is much evidence that animacy modulates how roles are processed — but in ways that interact with language-specific properties (e.g. MacWhinney et al. 1984, Li et al. 1993; see Bornkessel-Schlesewsky & Schlesewky 2009a, 2009b, 2014 for reviews). In particular, parses involving inanimate agents reliably cause processing difficulty. Consider again German. Reanalyzing Frisch & Schlesewky's (2001) ERP data, Roehm et al. (2004) find an N400 effect at an inanimate subject following an unambiguous accusative object (19a) compared to an animate subject (19b), registering violated expectations about the agent's animacy. Note that clause-initial inanimate arguments in the nominative case do not elicit similar effects (Schlesewsky & Bornkessel 2004; see also Tamil, Muralikrishnan et al. 2008), since they are still parsable as non-agentive (e.g. passive or unaccusatives) subjects.

(19) a. Paul fragt sich, welchen Angler **der** **Zweig** gestreift hat.
Paul asks self which:ACC Angler **the:NOM** **twig** brushed has:3SG
"Paul asks himself which angler the twig brushed."

b. Paul fragt sich, welchen Angler **der** **Jäger** gelobt hat.
Paul asks self which:ACC Angler **the:NOM** **hunter** praised has:3SG
"Paul asks himself which angler the hunter praised."

German (adapting Frisch & Schlesewsky 2001)

There are multiple theoretical interpretations of the inanimate-agent penalty. It might be that inanimate agents are difficult to process because that combination of linguistic properties is inherently noncanonical (e.g. Dowty 1991, Primus 1999), and/or infrequent. Or, perhaps noncanonicity is not an inherent vice; rather, in the context of a bivalent clause, an inanimate subject has fewer Proto-Agent properties that distinguish it thematically from the coargument direct object. Bornkessel-Schlesewsky & Schlesewsky (2009b, 2009c) term this relative constraint on role-processing *Distinctness*, proposing that events whose participants are less distinct are harder to process. Note that there is less evidence for the inverse of this inanimate-agent penalty — i.e. an animate-patient penalty. Bornkessel-Schlesewsky & Schlesewsky (2009b) suggest that this is because undergoers (P or U arguments) have no defining prototypical features of their own, but are defined simply in opposition to agents. (Though compare e.g. Dowty 1991's Patient Proto-Role.)

The extended Argument Dependency Model (eADM; Bornkessel-Schlesewsky & Schlesewsky 2006, 2009a, 2009b, 2016) synthesizes crosslinguistic findings like these at the intersection of case, word order, and animacy. eADM is neurolinguistic theory of sentence comprehension which posits a cascade of cognitive processes involved in the identification syntactic arguments and their mapping to event participants. Various cues (semantic and morphosyntactic) can influence the computation of prominence and role-mapping, which might be weighted differently across languages. For instance, word order is weighted much higher in identifying agents in English than in a scrambling language like German. The extent of this crosslinguistic variation and its precise causes remain an open question in sentence processing.

2.3 Previous sentence-processing work on Georgian

With a complex split-ergative case system and flexible verb-final word order, Georgian is language rich in incremental case–role ambiguities. These ambiguities are not due to morphological syncretisms (as in German above; 18); nouns' nominative and dative case forms are always distinct in Georgian. Rather, what is ambiguous is how those case categories are mapped to grammatical ones: a factor that shifts across tense in this language.

A few previous studies have investigated how comprehenders navigate Georgian's temporary role ambiguities. Skopeteas et al. (2011) designed an acceptability-judgement study comparing case mappings and word orders. Their stimuli were all bivalent verb-final sentences, varying in tense and argument structure. The two nominal arguments, one nominative and one dative, were presented together on a screen; then the verb appeared, along with a binary acceptability prompt. Critical stimuli belonged to two experiments, each with a 2×2 factorial design. (These stimuli were all grammatical; fillers included various morphosyntactic errors.) The first experiment focused on active transitives, manipulating word order (SOV vs. OSV) and tense/case alignment ($A_{nom}/P_{dat}/V_{series\text{-}I}$ vs. $A_{dat}/P_{nom}/V_{series\text{-}III}$) while holding lexical items constant across itemsets. SOV versions of the stimuli are given in 20. Analyzing response latency, the authors found a significant effect of tense / case mapping: future-tense sentences were endorsed as grammatical significantly faster than perfect ones, indicating a processing penalty for the A_{dat}/P_{nom} mapping.

(20) a. ʤarisk’atsʰ-i monadire-s daʧ’ris.
soldier-NOM hunter-DAT wound:ACT:FUT
“The soldier will wound the hunter.”

b. ʤarisk’atsʰ-s monadire dauʧ’ria.
soldier-DAT hunter:NOM wound:ACT:PERF
“The soldier must have wounded the hunter.” (adapted from Skopeteas et al. 2011)

Their second experiment focused on nonactive clauses, with itemsets comparing pairs of applied nonactives and psych verbs ($U_{nom}/G_{dat}/V_{nact.appl}$ vs. $Ex_{dat}/St_{nom}/V_{psych}$) in either word order (SOV versions are in 21). The authors found main effects of verb type, word order, and a significant interaction of those factors: OSV order was endorsed more slowly than SOV order, but only in clauses with psych verbs.

(21) a. datʰo nino-s elodeba.[3]
Dato:NOM Nino:DAT wait:NACT:APPL:PRES
“Dato is waiting for Nino.”

b. datʰo-s nino sʣuls.
Dato-DAT Nino:NOM hate:PSYCH:PRES
“Dato hates Nino.” (adapted from Skopeteas et al. 2011)

In light of these results, Skopeteas et al. theorize the following: the Georgian comprehender’s preference to parse a nominative argument as S and dative as O is stronger than their preference for S<O order. This explains why future-tense active clauses and applied nonactives are relatively easy to process, whatever their word order. Dative-subject clauses ($A_{dat}/P_{nom}/V_{series\text{-}III}$ or $Ex_{dat}/St_{nom}/V_{psych}$) violate the hypothesized case–role preference. The $St_{nom}<Ex_{dat}<V_{psych}$ condition of their Experiment 2 additionally violates the weaker preference for S<O, hence its slow RTs. Given Experiment 1’s sole main effect of case marking, the S<O preference seems to operate differently for Series-III active verbs. The authors speculate that this is related to semantic and discourse–pragmatic properties of the Georgian perfect tense, a past evidential that is particularly felicitous when A is less relevant to or identifiable in a context of utterance than P. So, perhaps in perfect clauses P_{nom} is interpreted by default with higher discourse prominence than A_{dat} is. The $A_{dat}<P_{nom}<V_{series\text{-}III}$ condition violates this secondary preference for initial high-prominence P, but it still satisfies the general S<O preference; the $P_{nom}<A_{dat}<V_{series\text{-}III}$ condition does the opposite. If the two costs related to linear order cancel out here, this explains the lack of main effect of word order in Experiment 1.

Building on Skopeteas et al. 2011, Foley (2020, chapter 2) ran two self-paced reading experiments. Both had a 2×2 design, manipulating word order (SOV vs. OSV) and tense/case-mapping ($A_{nom}/P_{dat}/V_{series\text{-}I}$ vs. $A_{erg}/P_{nom}/V_{series\text{-}II}$) of simple active transitive clauses. Arguments both referred to humans in Experiment 1 (22), and both to inanimate objects in Experiment 2 (23).

(22) a. ianvar=ʃi **pʰeχburtʰel-i** q’ru **dedopʰal-s** **gaitsʰnobs** it’aliur op’era=ʃi.
January=in **footballer-NOM** deaf **queen-DAT** **meet:ACT:FUT** Italian opera=in
“In January the footballer will meet the deaf queen at the Italian opera.”

b. ianvar=ʃi **pʰeχburtʰel-s** q’ru **dedopʰal-i** **gaitsʰnobs** it’aliur op’era=ʃi.
January=in **footballer-DAT** deaf **queen-NOM** **meet:ACT:FUT** Italian opera=in
“In January the deaf queen will meet the footballer at the Italian opera.”

[3] This verb is formally an applied nonactive verb, but it is obligatorily bivalent, and it not derived via anti-causativization from an active transitive (cf. 9, 10). There are many ‘deponent’ verbs like this in Georgian: their subjects are always nominative (hence ‘U’) and their objects dative (hence ‘G’).

c. ianvar=ʃi **pʰeχburtʰel-ma** q'ru **dedopʰal-i** **gaitsʰno** it'aliur op'era=ʃi.
January=in **footballer-ERG** deaf **queen-NOM** **meet:ACT:AOR** Italian opera=in
"In January the footballer met the deaf queen at the Italian opera."

d. ianvar=ʃi **pʰeχburtʰel-i** q'ru **dedopʰal-ma** **gaitsʰno** it'aliur op'era=ʃi.
January=in **footballer-NOM** deaf **queen-ERG** **meet:ACT:AOR** Italian opera=in
"In January the deaf queen met the footballer at the Italian opera."

(Foley 2020:42, glosses adapted)

For all-human sentences, RTs for the verb were fast in the $A_{erg}<P_{nom}<V_{series\text{-}II}$ condition (22c), and about equally slow in the three other conditions. In the $P_{nom}<A_{erg}<V_{series\text{-}II}$ condition (22d), Foley interprets the slowdown as a garden-path effect. A high-animacy nominative in initial position is preferentially mapped to A, but ergative at the next noun region forces a revision to P. As for the Series I conditions (22a,b), there is no effect of word order, contrasting with the findings of Skopeteas et al. 2011. Foley offers the following explanation. The $P_{dat}<A_{nom}<V_{series\text{-}I}$ sentence (22b) suffers from a similar garden path to (22d): there are dative A arguments in Series III, so high-animacy initial dative can always be parsed as A; this is disconfirmed by Series I tense morphology at the verb. In the $A_{nom}<P_{dat}<V_{series\text{-}I}$ condition (22a), what causes a garden path is the availability of a G parse for $N2_{dat}$. A crucial assumption is that the G role is more prominent than P.[4] If high-animacy arguments are parsed by default in Georgian with the most prominent role available, then a ditransitive $A_{nom}<G_{dat}<V_{series\text{-}I}$ parse will be the most optimal way to process an ambiguous $N1_{hu.nom}<N2_{hu.dat}$ string. The observed future-tense monotransitive verb would necessitate a reparse of N2 to P.

Foley calls this parsing strategy *Incremental Harmonic Alignment*. It involves parsing each role-ambiguous noun encountered with the unclaimed grammatical role most canonically aligned with its array of inherent prominence features. So, all else equal, the best parse possible for a high-animacy noun is A; if that role is already claimed, or if the mapping is ungrammatical, the next best parse is G; the worst would be high-animacy P. For inanimate nouns, the mirror image obtains. The most harmonic parse for a low-animacy noun would be P; next best would be G; worst would be A.

Results of Experiment 2, involving two inanimate nouns (23), bear out some of these predictions. Given the A_{nom}/P_{dat} mapping, verbs disambiguating to the SOV order (23a) are read slower than OSV (23b). The $\text{NOM}_{inan}<\text{DAT}_{inan}$ preamble would be most harmonically aligned as $P_{nom}<G_{dat}$, so the observed monotransitive Series-I verb forces both arguments to be reparsed, to $A_{nom}<P_{dat}$. Compare $\text{DAT}_{inan}<\text{NOM}_{inan}$ (23b); the first noun can be parsed P, but with that role already claimed, the only role left compatible with the second noun is A. The verb confirms this $P_{dat}<A_{nom}$ parse, hence no slow-down. In the other two conditions, there is a processing cost to inanimate ergatives in both initial (23c) and medial (23d) position. Incremental Harmonic Alignment predicts garden path effects, but not inherent costs to misaligned prominence scales. So Foley posits an independent cost to certain scale misalignments, as eADM does. Evidence of an inanimate agent, perhaps an ergative one specifically (cf. the quickly-processed verb in 23b), always causes processing difficulty.

[4]This is not an uncontroversial assumption. On the one hand, indirect objects tend to have more Proto-Agent properties than direct objects do (Dowty 1991), and across languages G tends to asymmetrically c-command P (though there is much variation in the syntax of ditransitives, between and within languages: e.g. Boneh & Nash 2017, Harley & Miyagawa 2017). On the other hand, G tends to be less frequent and more morphosyntactically marked, and is perhaps in some informal sense less centrally connected to the event. Thus many role hierarchies rank direct objects higher than indirect objects (e.g. Jackendoff 1971, Moravcsik 1972, Keenan & Comrie 1977, Larson 1988).

(23)

a.

agarak'=ze	**sark'e**	paʰrtʰo	**pʰandʒara-s**	**gat'eχs**	mits'isdzvr-is	dro-s.
dacha=on	**mirror:NOM**	wide	**window-DAT**	**break:ACT:FUT**	earthquake-GEN	time-DAT

"At the summer home, the mirror will break the wide window during the earthquake."

b.

agarak'=ze	**sark'e-s**	paʰrtʰo	**pʰandʒara**	**gat'eχs**	mits'isdzvr-is	dro-s
dacha=on	**mirror-DAT**	wide	**window:NOM**	**break:ACT:FUT**	earthquake-GEN	time-DAT

"At the summer home, the wide window will break the mirror during the earthquake."

c.

agarak'=ze	**sark'e-m**	paʰrtʰo	**pʰandʒara**	**gat'eχa**	mits'isdzvr-is	dro-s
dacha=on	**mirror-ERG**	wide	**window:NOM**	**break:ACT:AOR**	earthquake-GEN	time-DAT

"At the summer home, the mirror broke the wide window during the earthquake."

d.

agarak'=ze	**sark'e**	paʰrtʰo	**pʰandʒara-m**	**gat'eχa**	mits'isdzvr-is	dro-s
dacha=on	**mirror:NOM**	wide	**window-ERG**	**break:ACT:AOR**	earthquake-GEN	time-DAT

"At the summer home, the wide window broke the mirror during the earthquake."

(Foley 2020:55, glosses adapted)

2.4 Corpus findings and conditional entropy

Clearly, case is not always a reliable cue to grammatical role in Georgian. Ergative morphology is only found on active subjects in particular tenses, but even then an ergative subject is not guaranteed to be a transitive one, coargument to a direct object (i.e. Georgian is not 'classically ergative'; Harris 1990, Van Valin 1990). The other two case categories are much less reliable: nominative might be A, U, P, or St; dative might be A, P, G, or Ex.

The unreliability of case for Georgian comprehenders can be quantified with the information-theoretic metric of conditional entropy (cf. Ackerman & Malouf 2013 on conditional entropy of morphological paradigms). Using corpus data, Foley (2022) estimates *H*(role|case) — the conditional entropy of an out-of-the-blue noun's grammatical role, given cues to its case morphology. Foley queried the morphologically parsed Georgian Reference Corpus (Gippert & Tandashvili 2015) for verbs tagged in every combination of tense and argument-structure morphology, and from these inferred the maximum number of overt third-person arguments in that corpus.[5] Counts are reproduced in the following tables. For example, there were enough verbs a Series II tense to license 61,928 transitive subjects (Series II × A_{TR}, Table 2). That figure corresponds to all the possible ergative transitive subjects in the corpus, or about 13% (ERG × A_{TR}, Table 3) of the 475,805 total licensed arguments.

[5] This must be an overestimate, since all Georgian permits null pronouns in all argument positions. Future corpus research, perhaps using a treebank, might yield a more accurate estimate the proportion of each case–role combination. These counts also abstract away from word order, which likely to be an important factor too.

	A_{TR}	A_{INTR}	U	P	G	Ex	St	
Series I	37,474	15,235	38,467	43,143	26,148	14,639	26,516	201,622
Series II	61,928	6,572	48,717	75,825	36,980	3,596	5,356	238,974
Series III	9,607	574	7,947	12,101	3,013	786	1,181	35,209
	109,009	22,381	95,131	131,069	66,141	19,021	33,053	

Table 2: Corpus counts adapted from Foley 2022. Figures give the maximum number of third-person arguments across tense categories licensed by verbs of various argument structures in the GRC. Shading indicates case (white for nominative, grey for dative, black for ergative; cf. Table 1).

	A_{TR}	A_{INTR}	U	P	G	Ex	St	
NOM	7.9%	3.2%	20.0%	18.5%	0	0	7.0%	56.6%
DAT	2.0%	0.1%	0	9.1%	13.9%	4.0%	0	28.1%
ERG	13.0%	1.4%	0	0	0	0	0	14.4%
	22.9%	4.7%	20.0%	27.6%	13.9%	4.0%	7.0%	

Table 3: Corpus proportions adapted from Foley 2022. Figures give the percentage of total arguments across case categories licensed by verbs of various argument structures in the GRC.

Qualitatively, these counts suggest the following about the Georgian. First, nominative case is highly correlated with subjecthood (A, U), but also highly correlated with roles that tend to have proto-patient properties (U, P, St). Second, ergative is exclusively associated with Proto-Agent subjects (A), and more often than not with transitive agents specifically (A_{TR}). Third, Georgian is a language rich in indirect objects (G), and dative case is a good predictor of indirect objecthood.

Quantitatively, this corpus data lets us be precise about challenges comprehenders face in navigating Georgian. Conditional entropy values of role given case in Georgian are given in 23a. (Each bit of entropy corresponds to the amount of uncertainty associated predicting the outcome of one fair coin flip.) To contextualize these figures, 23b recalculates conditional entropy for a hypothetical version of the language with a less complex case system. In this 'Georgian′', ergative is found on A_{TR} in all tenses; dative is found on all G and Ex arguments; absolutive is on all other arguments — that amounts to something like the system of, say, Lezgian (Northeast Caucasian; Haspelmath 1993). See Foley 2022 for estimated values of other case-alignment systems.

(24) a. Georgian
H(role|case) = 1.73 bits
H(role|NOM) = 1.16 bits
H(role|DAT) = 0.50 bits
H(role|ERG) = 0.06 bits

b. Georgian′ (classically ergative, no tense-splits)
H(role|case) = 1.14 bits
H(role|ABS) = 1.00 bits
H(role|DAT) = 0.13 bits
H(role|ERG) = 0 bits

3. Predictions

Synthesizing discussion in the previous section, we identify a set of constraints that might guide how comprehenders of Georgian navigate the incrementally ambiguous grammatical roles of preverbal arguments in the nominative or dative case. First is a constraint that prioritizes the identification of the clause's subject (25): transitive or intransitive, with any thematic role. Unlike Kaqchikel or Äiwoo, Georgian is not a language where O<S orders dominate; word order is flexible, but S<O is most common (Skopeteas et al. 2009). Following eADM, it may be that comprehenders in fact prioritize identifying the event's agent (26), in which case nonactive and psych-verb parses would not be highly ranked. Or, following expectation-based theories (e.g. Hale 2001, Levy 2008), it might be that Georgian comprehenders will go for the most frequent case–role mapping (27): which, for both nominative and dative (Tables 2–3), might not be a subject at all, much less an agentive one.

(25) *Prioritize Subject:* Given a role-ambiguous noun, parse it as a subject (A, U, or Ex) if possible.

(26) *Prioritize Agent:* Given a role-ambiguous noun, parse it as an agent (A_{TR} or A_{INTR}) if possible.

(27) *Prioritize Frequency:* Given a role-ambiguous noun, parse it as the most likely role combination of cues given previous linguistic experience.

Two more constraints are relevant upon encountering a second role-ambiguous noun. Following Foley (2020), the comprehender might seek to maximize the role-prototypicality of each noun, given inherent cues like animacy (28). Assuming a Dowtyan hierarchy of roles, there will be many contexts where Incremental Harmonic Alignment will lead the comprehender to parse a second ambiguous noun as an indirect object. This contrasts with the predictions of eADM's Distinctness constraint (29), which always penalizes parses with indirect objects. That is precisely because G is of intermediate prominence: it is less distinct from either A or U/P, than A and P are from each other.

(28) *Incremental Harmonic Alignment:* Given a high-animacy role-ambiguous noun, parse it as the most prominent role allowed by the grammar; given a low-animacy role-ambiguous noun, parse it as the least prominent role. Assumed role hierarchy: A > G/Ex > U/P/St (extending Dowty 1991).

(29) *Distinctness:* Parse arguments such that they are as distinct as possible across all dimensions of linguistic prominence (i.e. hierarchies for thematic role, syntactic role, animacy, definiteness, etc.)

To illustrate the interplay of these constraints, and to prime the present study's experimental design (Section 4), consider the following sets of sentences. First, 30 gives some of the possible parses of a nominative argument immediately preceding a verb. Recall that preverbal nominative is ambiguous between the grammatical roles A (active subject), U (nonactive subject), P (direct object of an active transitive), and St (stimulus object of a bivalent psych verb), and that the intended case–role mapping will be disambiguated by the verb's tense–voice morphology. In 30a, for instance, the verb /gaaʧʰerebs/ "will stop" is an active monotransitive, in a Series-I tense. The notation $\mathbf{V}_{[\mathrm{A=NOM,\ P=DAT}]}$ indicates that it therefore licenses an A argument in the nominative case, and a P argument in the dative case. So, the previously ambiguous nominative noun must be a transitive subject. The notation $\mathbf{A|V}_{\cancel{\mathrm{UPSt}}}$ indicates this disambiguation: it reads "this must be an A, given cues delayed until the verb, which eliminate alternative parses as U, P, or St". The grammatical role of the postverbal dative noun, on the other hand, is unambiguously P. The notation **AVP** will be used to refer to this type of parse as a whole. Finally, note that postverbal nouns in the genitive case (30b,d) are unambiguously not arguments of the verb, but rather the first word of a clausal adjunct; that is notated **X**.

(30) a.

A|V~~UPSt~~	**V**$_{[A=NOM,\ P=DAT]}$	**P**		**(AVP)**
msaχiob-i	gaatʃʰerebs	mts’eral-s	ezo=ʃi	
actor-NOM	stop:ACT:FUT	writer-DAT	garden=in	

“The actor$_{[A]}$ will stop the writer$_{[P]}$ in the garden.”

b.

U|V~~APSt~~	**V**$_{[U=NOM]}$	**X**		**(UVX)**
msaχiob-i	gatʃʰerdeba	mts’erl-is	ezo=ʃi	
actor-NOM	stop:NACT:FUT	writer-GEN	garden=in	

“The actor$_{[U]}$ will stop in the writer’s$_{[X]}$ garden.”

c.

U|V~~APSt~~	**V**$_{[U=NOM,\ G=DAT]}$	**G**		**(UVG)**
msaχiob-i	gautʃʰerdeba	mts’eral-s	ezo=ʃi	
actor-NOM	stop:NACT:APPL:FUT	writer-DAT	garden=in	

“The actor$_{[U]}$ will stop for the writer$_{[G]}$ in the garden.”

d.

P|V~~AU~~	**V**$_{[A=1SG.ERG,\ P=NOM]}$	**X**		**(PVX; null 1st/2nd A)**
msaχiob-i	gavatʃʰere	mts’erl-is	ezo=ʃi	
actor-NOM	stop:ACT:AOR:1SGS	writer-GEN	garden=in	

“I$_{[A]}$ stopped the actor$_{[P]}$ in the writer’s$_{[X]}$ garden.”

How difficult will it be to process these disambiguating verbal cues? Prioritize Subject (25) will penalize the PVX parse (30d), since it requires interpreting the initially ambiguous argument as an object. Prioritize Agent (26) will penalize the UVX (30b), UVG (30c), and PVX (30d) parses, since these do not have an initial agent. Incremental Harmonic Alignment (28) makes the same prediction, since the first argument is high in animacy. As for Prioritize Frequency (27), the UVX and UVG parses are best, since the most common type of nominative argument in Georgian is U. Finally, Distinctness: best for this constraint will be the monovalent UVX parse, since intransitive subjects are vacuously distinct (Bornkessel-Schlesewsky & Schlesewsky 2009c). Next best will be the active transitive parses AVP and PVX, since A and P are maximally distinct. Worst will be UVG, since U and G are not as distinct as A and P are.

Now consider sentences that have two role-ambiguous nouns: first a nominative one, then dative (31). Recall that dative might be mapped to the roles A, P, G, or Ex, and that ditransitives in Series-I tenses have two dative objects. Thus sentences like (31b) are globally ambiguous: either argument could be the P or G argument. That is represented by the notation **PG|V**~~AEx~~ and **PG**.

(31) a.

A|V~~UPSt~~	**P|V**~~AGEx~~	**V**$_{[A=NOM,\ P=DAT]}$	**X**		**(APVX)**
ekʰim-i	msaχiob-s	gaatʃʰerebs	mts’erl-is	ezo=ʃi	
doctor-NOM	actor-DAT	stop:ACT:FUT	writer-GEN	garden=in	

“The doctor$_{[A]}$ will stop the actor$_{[P]}$ in the writer’s$_{[X]}$ garden.”

b.

A|V~~UPSt~~	**PG|V**~~AEx~~	**V**$_{[A=NOM,\ G=DAT,\ P=DAT]}$	**PG**		**(AOVO)**
ekʰim-i	msaχiob-s	gautʃʰerebs	mts’eral-s	ezo=ʃi	
doctor-NOM	actor-DAT	stop:ACT:APPL:FUT	writer-DAT	garden=in	

“The doctor$_{[A]}$ will stop the actor$_{[P]}$ for the writer$_{[G]}$ in the garden.” (**APVG** reading)
or “The doctor$_{[A]}$ will stop the writer$_{[P]}$ for the actor$_{[G]}$ in the garden.” (**AGVP** reading)

c.

P|V~~AUSt~~	**A|V**~~PGEx~~	**V**$_{[A=DAT,\ P=NOM]}$	**X**		**(PAVX)**
ekʰim-i	msaχiob-s	gautʃʰerebia	mts’erl-is	ezo=ʃi	
doctor-NOM	actor-DAT	stop:ACT:PERF	writer-GEN	garden=in	

“The actor$_{[A]}$ must have stopped the doctor$_{[P]}$ in the writer’s$_{[X]}$ garden.”

	d.	**P|V**~~$_{\text{AUSt}}$~~	**G|V**~~$_{\text{APEx}}$~~	**V**$_{\text{[A=1SG.ERG, G=DAT, P=NOM]}}$	**X**		**(PGVX; null A)**
		ekʰim-i	msaχiob-s	gavuʧʰere	mʦ'erl-is	ezo=ʃi	
		doctor-NOM	actor-DAT	stop:ACT:APPL:AOR:1SGS	writer-GEN	garden=in	
		"I$_{[A]}$ stopped the doctor$_{[P]}$ for the actor$_{[G]}$ in the writer's$_{[X]}$ garden."					

Given a NOM<DAT preamble like this, the APVX parse (31a) is optimal according to the constraints Prioritize Subject, Prioritize Agent, and Distinctness. But, since the second ambiguous noun is high in animacy, Incremental Harmonic Alignment prefers an AGVP parse (i.e. one of the readings available for 31b). The first noun is parsed A, the most prominent role; the next most prominent role available to the second noun is thus G. As for Prioritize Frequency, the PGVX parse is probably best, since the NOM=A, DAT=A, and DAT=P mappings are less common than NOM=P and DAT=G.

Finally, consider a DAT<NOM preamble (32). The predictions here are mostly the same, except that Incremental Harmonic Alignment prefers parsing the initial high-animacy dative noun as A (32a), rather than G (32b,c).

(32)	a.	**A|V**~~$_{\text{PGEx}}$~~	**P|V**~~$_{\text{AUSt}}$~~	**V**$_{\text{[A=DAT, P=NOM]}}$	**X**		**(APVX)**
		ekʰim-s	msaχiob-i	gauʧʰerebia	mʦ'erl-is	ezo=ʃi	
		doctor-DAT	actor-NOM	stop:ACT:PERF	writer-GEN	garden=in	
		"The doctor$_{[A]}$ must have stopped the actor$_{[P]}$ in the writer's$_{[X]}$ garden."					
	b.	**PG|V**~~$_{\text{AEx}}$~~	**A|V**~~$_{\text{UPSt}}$~~	**V**$_{\text{[A=NOM, G=DAT, P=DAT]}}$	**PG**		**(OAVO)**
		ekʰim-s	msaχiob-i	gauʧʰerebs	mʦ'eral-s	ezo=ʃi	
		doctor-DAT	actor-NOM	stop:ACT:APPL:FUT	writer-DAT	garden=in	
		"The actor$_{[A]}$ will stop the doctor$_{[P]}$ for the writer$_{[G]}$ in the garden." (**PAVG** reading)					
		or "The actor$_{[A]}$ will stop the writer$_{[P]}$ for the doctor$_{[G]}$ in the garden." (**GAVP** reading)					
	c.	**G|V**~~$_{\text{APEx}}$~~	**P|V**~~$_{\text{AUSt}}$~~	**V**$_{\text{[A=1SG.ERG, G=DAT, P=NOM]}}$	**X**		**(GPVX)**
		ekʰim-s	msaχiob-i	gavuʧʰere	mʦ'erl-is	ezo=ʃi	
		doctor-DAT	actor-NOM	stop:ACT:APPL:AOR:1SG>3	writer-GEN	garden=in	
		"I$_{[A]}$ stopped the actor$_{[P]}$ for the doctor$_{[G]}$ in the writer's$_{[X]}$ garden."					
	d.	**P|V**~~$_{\text{AGEx}}$~~	**A|V**~~$_{\text{UPSt}}$~~	**V**$_{\text{[A=NOM, P=DAT]}}$	**X**		**(PAVX)**
		ekʰim-s	msaχiob-i	gaaʧʰerebs	mʦ'erl-is	ezo=ʃi	
		doctor-DAT	actor-NOM	stop:ACT:PERF	writer-GEN	garden=in	
		"The actor$_{[A]}$ will stop the doctor$_{[P]}$ in the writer's$_{[X]}$ garden."					

The following table summarizes predicted processing difficulty of the disambiguating verbs across the previous sentences (30–32). Note that the parses discussed here do not exhaust the grammatical possibilities, but they are the ones tested in the reading-time experiment.

		Pr-Subj	*Pr-Agent*	*Pr-Freq*$_{N1}$	*Pr-Freq*$_{N2}$	*IHA*	*Dist*
NOM<V	**AVP** (29a)			**	n/a		
	UVX (29b)		*		n/a	*	
	UVG (29c)		*		n/a	*	*
	PVX (29d)	*	*	*	n/a	*	
NOM<DAT<V	**APVX** (30a)			*	*	*	
	APVG (30b)			*	*	*	*
	AGVP (30b)			*			*
	PAVX (30c)	*	*		**	*	
	PGVX (30d)	**	**			**	*
DAT<NOM<V	**APVX** (31a)			**			
	PAVG (31b)	*	*	*	*	**	*
	GAVP (31b)	*	*		*	*	*
	GPVX (31c)	**	**			***	*
	PAVX (31d)	*	*	*	*	**	

Table 4: Summary of predictions. Asterisks indicate degrees to which various parses violate hypothesized comprehension constraints (24–28), relative to other parses for the same preamble. Prioritize Frequency violations are given for the first and second noun separately.

4. L-Maze study

The present study tests the predictions laid out above (Table 4) about the processing of role-ambiguous nouns in Georgian. It consisted of three co-presented subexperiments, each corresponding to the quartets of parses illustrated above (30–32). 208 total itemsets were constructed: 24 for Subexperiment 1; 32 each for Subexperiments 2 and 3; and 120 additional fillers of comparable length and complexity. These were divided evenly into two lists, serving as the stimuli for two experimental sessions of 104 trials each. Experimental items were distributed in the Latin Square manner, such that each participant saw only one version of each itemset.[6]

The experimental methodology used was the Lexicality Maze (L-Maze; Freedman & Forster 1985, Boyce et al. 2020), a variant of self-paced reading that has participants make a series of incremental forced-choice lexicality decisions. Each word of each itemset was paired with a nonce word of equal orthographic length. The real and nonce words appeared side by side on screen, in a random order. Participants were instructed to choose the real Georgian word of the pair, and that together the real words would form a coherent sentence. They used the [e] and [i] keys to input their lexicality decisions. A correct judgement would lead automatically to the next pair of words. A feedback message would appear after an incorrect judgement; participants would remake the lexicality decision and continue on through the rest of the item. Figure 1 shows a mock-up of a simple L-Maze trial, illustrated in English.

[6] Materials, anonymized data, and analysis files are available in an OSF repository: https://osf.io/4j958/

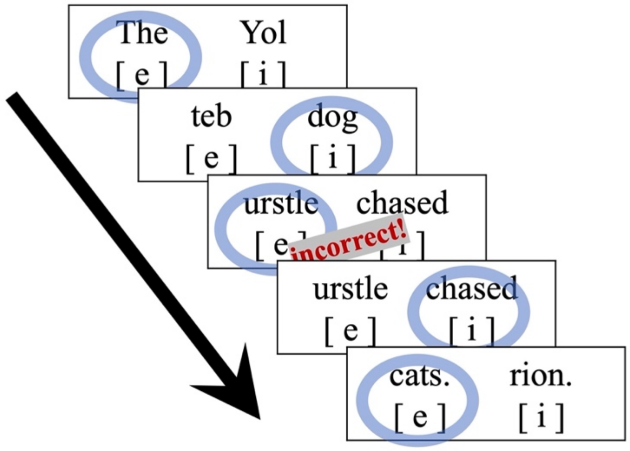

Figure 1: Illustration of the L-Maze methodology in English. The participant's selections, input with the keyboard, are indicated with blue circles.

Hosted on PCIbex (Zehr & Schwartz 2018), the study was conducted entirely remotely, via the internet. Each experimental session began with a demographic form, instructions, and three practice items. The 104 target items of each session were presented in a random order, with two breaks built in. Each session ended with optional debriefing questions.

56 native speakers of Georgian residing in Georgia were recruited to participate in the study. 44 participants took both experimental sessions. Among them, 38 took Session A first and 6 took Session B first. Another 8 participants took only Session A, and 4 took only Session B. All participants were paid 30 GEL for each experimental session they participated in.

Data from two participants with lexical decision accuracies lower than 60% were excluded from analysis. (Average accuracy for the other 54 participants was 97%.) Typos were found in six items across Subexperiments 1–3; observations at or after misspelled words were excluded. Finally, assuming that the error feedback message was likely to impede participants' comprehension of the whole sentence, we also excluded within a given trial all correct lexicality decisions made after an error. These exclusion decisions left 88% of all collected critical data for analysis.

There were no comprehension questions, a design decision that decreased the length and difficulty of the task. However, it is somewhat unusual for a real-time processing experiment not to include a direct measure of whole-sentence understanding. Comprehension questions incentivize participants to pay closer attention to stimuli (see Stewart et al. (2007) on the effect comprehension questions have on participants' depth of processing). Without comprehension checks, it is likely that some trials included in our analyses were in fact miscomprehended. It may even be that some participants made lexicality decisions without attending closely to the linguistic relations between the words they chose. However, the clear and coherent results of this study, presented in the next sections, give us confidence that the L-Maze task on its own was a good measure of incremental syntactic processing. That said, future research should include a comprehension task to explicitly encourage deeper attention and to filter out data from misunderstood trials.

4.1 Subexperiment 1 (NOM<V)

Subexperiment 1 was designed to compare the processing-times of verbs whose tense–voice morphology disambiguates the role of one preceding noun phrase, in the nominative case.

4.1.1 Materials

Twenty-four itemsets were constructed in a four-condition design, similar to the quartet of examples above (30a–d). Key regions were a preverbal noun (N1), the verb, and a postverbal noun (N2). N1 was always in the nominative case, but functioned as a transitive subject (in the AVP condition), nonactive subject (UVX or UVG), or direct object (PVX). In the AVP and UVG conditions, N2 was a dative argument of the verb; in the UVX and PVX conditions, it was the first word of a postverbal adjunct constituent (usually a possessor, inflected genitive). Both N1 and N2 always referred to humans.

N1 was preceded by a single word (WD1), either an adjective or adverb. After N2 were two words (WD5 and WD6) that formed an adjunct constituent (usually a PP). In some conditions of some itemsets, the verb was immediately preceded by a grammatical particle (PART). This was either the modal particle /unda/ "must, should" or the ordinary negation marker /ar/ "NEG". The particles were included to increase an item's global plausibility/acceptability, generally by facilitating particular readings of the various tenses used. Of the 96 items (24 itemsets with 4 conditions each), 9 had one of these preverbal particles.

Table 5 summarizes the syntactic template for target stimuli in Subexperiment 1.

	WD1	**NOUN1**	**(PART)**	**VERB**	**NOUN2**	**WD6**	**WD7**
AVP (Exp1,a)		Case: NOM Role: A|V~~$_{\text{UPSt}}$~~		Mapping: A_{nom}/P_{dat}	Case: DAT Role: P	*Adjunct continuation*	
UVX (Exp1,a)	*Mod-ifier*	Case: NOM Role: U|V~~$_{\text{APSt}}$~~	(NEG, MOD)	Mapping: U_{nom}	Case: GEN Role: ¬V-arg.	*Adjunct*	
UVG (Exp1,a)		Case: NOM Role: U|V~~$_{\text{APSt}}$~~		Mapping: U_{nom}/G_{dat}	Case: DAT Role: G	*Adjunct continuation*	
PVX (Exp1,a)		Case: NOM Role: P|V~~$_{\text{AUSt}}$~~		Mapping, Agr.: $A_{1/2erg}/P_{nom}$	Case: GEN Role: ¬V-arg.	*Adjunct continuation*	

Table 5: Syntactic template the four conditions of Subexperiment 1 (compare 30a–d). For critical verbs, various features/cues disambiguate the case–role mapping of the clause. For key nouns, case morphology is always unambiguous, but role is incrementally ambiguous. See Section 3 for notational conventions.

4.1.2 Analysis

Mixed linear effects models were run on log-transformed RTs, using the R package *lme4* (Bates et al. 2015); interaction effects were investigated with *emmeans* (Lenth et al. 2020). The design of Subexperiment 1 did not have a factorial design, but it was assimilated into one with the following sum-coding scheme. There were two factors, Voice and Markedness. Voice was coded to compare the mean of the conditions with active verbs (Exp1,a/AVP and 1,b/PVX = –1/2) to the mean of conditions with nonactive verbs (1,b/UVX and 1,c/UVG = +1/2). Markedness was coded to compare the mean of the subject initial, non-applicativized conditions (1,a/AVP and 1,b/UVX = –1/2) to the mean of the object-initial or applicativized conditions (1c,/UVG and 1,d/PVX = +1/2). This latter factor is rather artificial, conflating several grammatical dimensions. Log RTs were analyzed at the critical verb region, the postverbal noun, and another spillover region. Models use the maximal random-effect structure to converge (Barr et al. 2013).

4.1.3 Results

Figure 2 shows mean RTs for each word region.

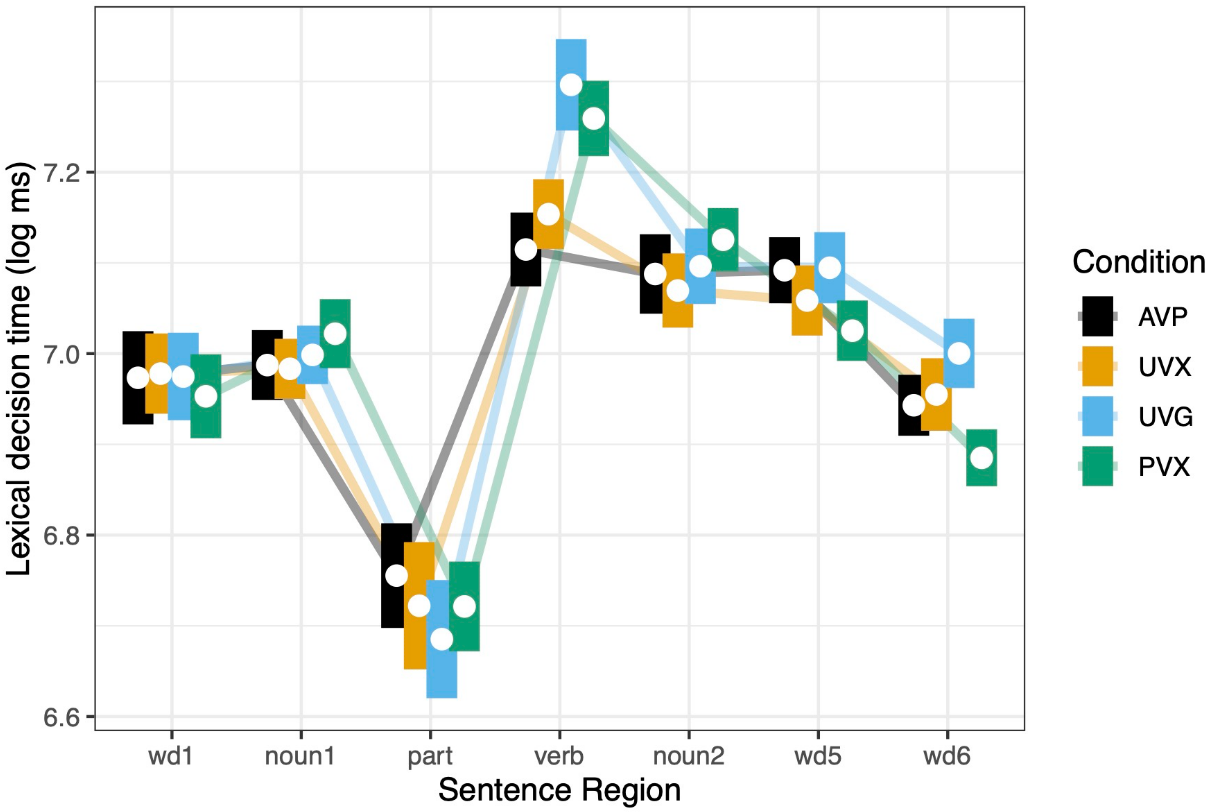

Figure 2: RTs by region for Subexperiment 1, in log milliseconds. The dots within colored bars indicate mean RTs ± one by-participant standard error.

Results of linear models are summarized in the following tables. First, consider the verb region (Table 6). Using the first coding scheme, we find a significant effect of the factor Markedness: verbs in the relatively marked 1,c/UVG and 1,d/PVX conditions were read reliably slower than verbs in the relatively unmarked conditions 1,a/AVP and 1,b/UVX.

Verb region
LogRT ~ Voice*Markedness + (1+Voice*Markedness|Participant) + (1+Voice*Markedness|Itemset)

	Estimate	SE	df	*t*	*p*	
Intercept	7.1	0.050	43	140	< 0.001	***
Voice	0.040	0.051	25	0.78	0.43	
Markedness	0.16	0.053	23	3.0	0.0058	**
Voice:Markedness	–0.0089	0.077	21	–0.11	0.90	

Table 6: Results of linear mixed effect modeling of log RTs at the verb region of Subexperiment 1. Random-effect structure is shown in *lmer* syntax.

Next, the first postverbal spillover region ('NOUN2'; Table 7). There is a marginal main effect of Markedness.

First postverbal spillover region
LogRT ~ Voice*Markedness + (1|Participant) + (1+Voice+Markedness|Itemset)

	Estimate	SE	df	t	p	
Intercept	7.0	0.043	67	160	< 0.001	***
Voice	–0.012	0.031	63	–0.39	0.69	
Markedness	0.048	0.033	57	1.7	0.086	.
Voice:Markedness	–0.020	0.044	950	–0.46	0.64	

Table 7: Results of linear mixed effect modeling of log RTs at the first postverbal spillover region of Subexperiment 1. Random-effect structure is shown in *lmer* syntax.

Finally, the second spillover region ('WD5'). There was a main effect of Markedness (the unmarked conditions were slower) and a significant interaction of Voice and Markedness. Pairwise comparisons revealed that this word was recognized significantly more slowly in the 'unmarked' version of the active transitive pair (i.e. 1,a/AVP $>_{RT}$ 1,d/PVX; Est. = 0.052, SE = 0.026, $t(883) = 1.9$; $p < 0.05$), but the 'marked' and 'unmarked' nonactive conditions (1,b/UVX and 1,c/UVG) were not significantly different in this region (Est. = –0.042, SE = 0.027, $t(881) = –1.5$, $p = 0.13$).

Second postverbal spillover region
LogRT ~ Voice*Markedness + (1+Voice|Participant) + (1|Itemset)

	Estimate	SE	df	t	p	
Intercept	7.0	0.049	51	140	< 0.001	***
Voice	–0.032	0.028	150	–1.1	0.25	
Markedness	–0.052	0.026	880	–1.9	0.049	*
Voice:Markedness	0.096	0.038	870	2.4	0.014	*

Table 8: Results of linear mixed effect modeling of log RTs at the second postverbal spillover region of Subexperiment 1. Random-effect structure is shown in *lmer* syntax.

4.1.4 Discussion

The starkest finding is how slow RTs are at verbs in the applicativized nonactive and object-initial transitive conditions (1,c/UVG and 1,d/PVX), compared to RTs for the subject-initial transitive and simple nonactive verbs (1,a/AVP and 1,b/UVX). The cost for the UVG condition is not surprising. Its verb eliminates the possibility of parsing $N1_{nom}$ as a transitive subject, thereby violating Prioritize Agent (see Section 3 and Table 4). The verb also entails a yet unencountered indirect object, violating Distinctness since U and G are relatively indistinct roles.

As for the difficulty associated with the PVX verb, that could be due to violations of Prioritize Subject or Prioritize Agent. A design confound, though, means we cannot confidently attribute the effect here to the

NOM=P parse per se. Unlike the other conditions, 1,d/PVX had a first or second person subject, signaled solely by verbal agreement. If there is a significant processing cost of processing first/second agreement morphology registering a null pronoun, or accommodating a first/second person discourse referent, it may be that these costs are inflating the RTs observed at the verb in condition 1,d/PVX.

The verbs easiest to process were those that disambiguated to AVP or UVX parses, and neither of those is significantly harder than the other. This could mean that Prioritize Agent does not guide Georgian comprehenders: they are as happy to entertain a nonactive (i.e. non-agentive) subject as an active one. Or, since monovalent parses satisfy Distinctness vacuously, perhaps the advantage that the AVP parse has vis-à-vis Prioritize Agent is cancelled out by the fact that it is bivalent, and therefore requires processing two arguments (albeit maximally distinct ones).

Differences at the postverbal regions are much smaller in magnitude than what we see at the verb. The marginal effect at NOUN1 and the interaction effect at WD5 seem to be driven by RTs in the PVX condition. Perhaps the first/second-person agreement there causes an initial processing inhibition that spills over into the first postverbal region, but then the comprehender bounces back at the second postverbal region. Or, perhaps the effects at WD5 are related to processing dative postverbal arguments (AVP, UVG) vs. non-verbal genitive arguments (UVX, PVX).

4.2 Subexperiment 2 (NOM<DAT<V)

Subexperiment 2 investigated how nominative–dative sequences are processed across monotransitive and ditransitive argument structures with various word orders.

4.2.1 Materials

Thirty-two itemsets were constructed in a four-condition design, similar to the quartet of examples above (31a–d). Key regions were two preverbal nouns (N1 and N2), the verb, and a postverbal noun (N3). N1 was always in the nominative case, functioning either as an active subject (2,a/APVX and 2,b/AOVO) or a direct object (2,c/PAVX and 2,d/PGVX). N2 was always dative, parsable as a direct object (2,a/APVX and 2,b/AOVO), indirect object (2,b/AOVO and 2,d/PGVX), or active subject (2,c/PAVX).[7] N3 was a dative direct object in one condition (2,b/AOVO), and a genitive possessor within a clausal adjunct in the other conditions. Both N1 and N2 always referred to humans; N3 also referred to a human in almost every itemset. N1 was preceded by a single word (WD1), either an adjective or adverb.

After N3 were two words (WD6 and WD7) that formed an adjunct constituent (usually a PP). As in Subexperiment 1, in some conditions of some itemsets, the verb was immediately preceded by a grammatical particle (PART). This was either the modal particle /unda/ "must, should", the ordinary negation marker /ar/ "NEG", or the modal negation marker /ver/ "cannot". Of the 128 items (32 itemsets with 4 conditions each), 26 had one of these preverbal particles.

Table 9 summarizes the syntactic template for stimuli in Subexperiment 2.

[7] As discussed above, P and G are not distinguishable by case marking in Series I; both are dative. Therefore condition 2,b is globally ambiguous between an AGVP parse and an APVG parse. In order to bias comprehenders towards the AGVP parse, in almost every itemset N3 was a relational noun like "cousin" or "colleague". In general, an applied indirect object can be readily interpreted as an external possessor of the direct object in Georgian. If relational nouns are most felicitous with thematic possessors, and sentence-internal possessors are easier to accommodate than implicit ones, then comprehenders should be more likely to parse N3 as P than G in this condition (2,b); insofar as N2 is preferentially parsed as P than G, interpreting N3 as P will force reanalysis of N2 to G. The other applied condition (2,d/PGVX) does not have this ambiguity, since P and G have different case marking in Series II.

	WD1	NOUN1	NOUN2	(PART)	VERB	NOUN3	WD6 WD7
APVX (Exp2,a)		<u>Case</u>: NOM <u>Role</u>: A|V~~UPSt~~	<u>Case</u>: DAT <u>Role</u>: P|V~~AGEx~~		<u>Mapping</u>: A_{nom}/P_{dat}	<u>Case</u>: GEN <u>Role</u>: ¬V-arg.	*Adjunct continuation*
AOVO (Exp2,a)	*Mod-ifier*	<u>Case</u>: NOM <u>Role</u>: A|V~~UPSt~~	<u>Case</u>: DAT <u>Role</u>: PG|V~~AEx~~	(NEG, MOD)	<u>Mapping</u>: $A_{nom}/G_{dat}/P_{dat}$	<u>Case</u>: DAT <u>Role</u>: PG	*Adjunct*
PAVX (Exp2,a)		<u>Case</u>: NOM <u>Role</u>: P|V~~AUSt~~	<u>Case</u>: DAT <u>Role</u>: A|V~~PGEx~~		<u>Mapping</u>: A_{dat}/P_{nom}	<u>Case</u>: GEN <u>Role</u>: ¬V-arg.	*Adjunct continuation*
PGVX (Exp2,a)		<u>Case</u>: NOM <u>Role</u>: P|V~~AUSt~~	<u>Case</u>: DAT <u>Role</u>: G|V~~APEx~~		<u>Mapping, Agr.</u>: $A_{1/2erg}/G_{dat}/P_{nom}$	<u>Case</u>: GEN <u>Role</u>: ¬V-arg.	*Adjunct continuation*

Table 9: Syntactic template the four conditions of Subexperiment 2 (compare 30a–d). For critical verbs, various features/cues disambiguate the case–role mapping of the clause. For key nouns, case morphology is always unambiguous, but role is incrementally ambiguous. See Section 3 for notational conventions.

4.2.2 Analysis

Conditions were coded with two contrast factors, ArgStrux and NomTheta. The former factor compares the average of monotransitive conditions (2,a/APVX and 2,c/PAVX = –1/2) to the average of ditransitive ones (2,b/AOVO and 2,d/PGVX = +1/2). The latter factor compares the conditions where $N1_{nom}$ was a Proto-Agent (2,a/APVX and 2,b/AOVO = –1/2) to the conditions where $N1_{nom}$ was a Proto-Patient (2,c/PAVX and 2,d/PGVX = +1/2). Log RTs were analyzed at the critical verb region, the postverbal noun, and the next spillover region. See Section 4.1.2 for some elided details.

4.2.3 Results

Figure 3 shows mean RTs, in log milliseconds, for each word region.

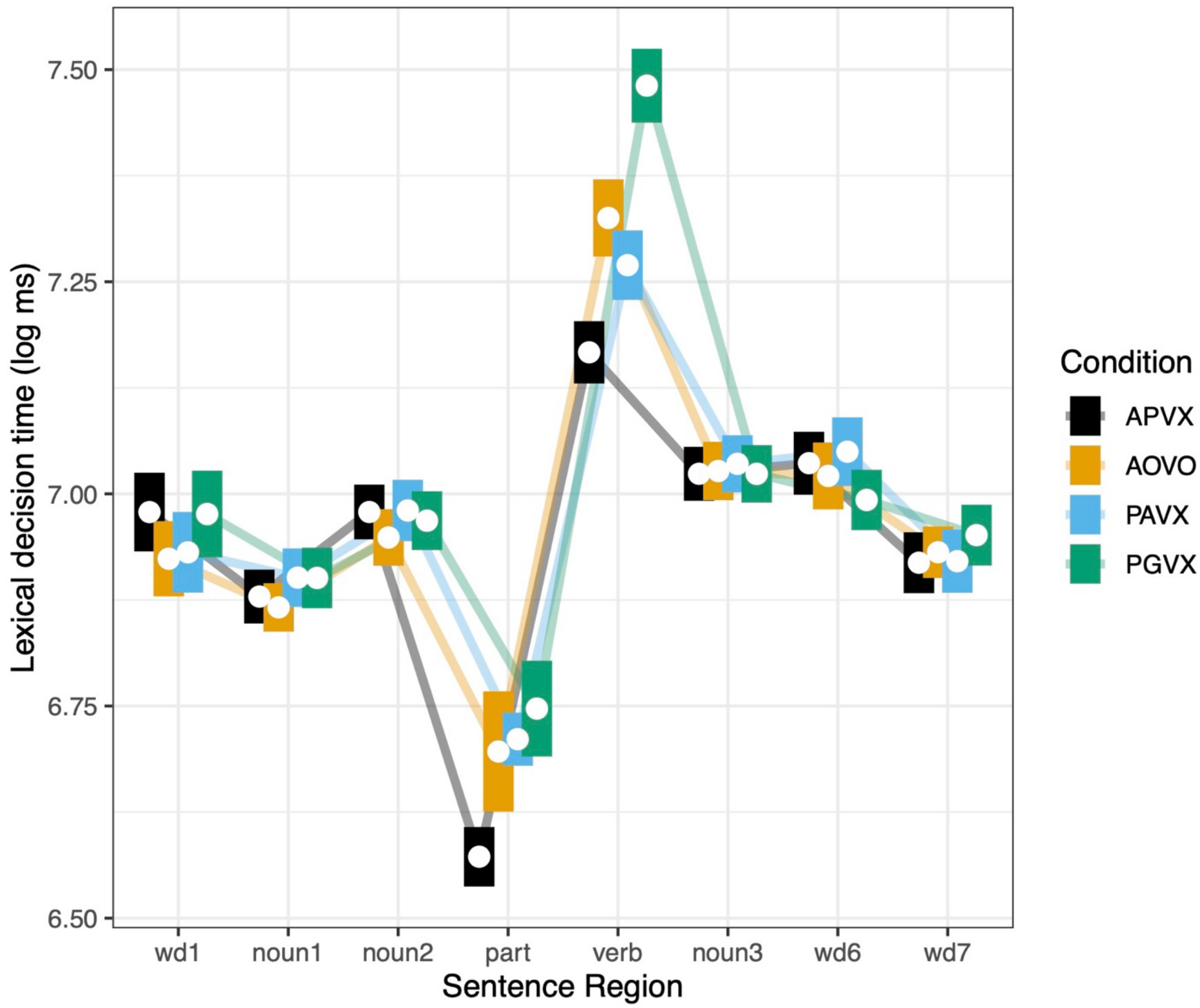

Figure 3: RTs by region for Subexperiment 2, in log milliseconds. The dots within colored bars indicate mean RTs ± one by-participant standard error.

Results of linear models of RTs at the verb region are summarized in the following table. There were significant main effects of ArgStrux and NomTheta: ditransitive verbs were recognized more slowly than monotransitive ones, and verbs licensing a nominative P were slower than ones with nominative A. There were no significant effects at either postverbal spillover region.

Verb region
LogRT ~ ArgStrux*NomTheta + (1|Participant) + (1+ArgStrux|Itemset)

	Estimate	SE	df	*t*	*p*	
Intercept	7.3	0.045	88	160	< 0.001	***
ArgStrux	–0.15	0.032	78	–4.7	< 0.001	***
NomTheta	0.16	0.029	1300	5.5	< 0.001	***
ArgStrux:NomTheta	–0.064	0.041	1300	–1.5	0.12	

Table 10: Results of linear mixed effect modeling of log RTs at the verb region of Subexperiment 2. Random-effect structure is shown in *lmer* syntax.

4.2.4 Discussion

The main effect of NomTheta shows that sentence-initial high-animacy nominative arguments are more easily parsed as A than as P. This accords with the predictions of Prioritize Subject, Prioritize Agent, and Incremental Harmonic Alignment, but not Prioritize Frequency — since NOM=P is in fact more a common mapping than NOM=A.

The main effect of ArgStrux shows that ditransitive verbs are harder to process than monotransitive ones. This is strong evidence in favor of Distinctness as a constraint guiding Georgian comprehenders, rather than Incremental Harmonic Alignment. G arguments might be relatively more prominent that P, meaning they make for more harmonic parses for high-animacy nouns (e.g. for $N1_{dat}$ in the 2,c/AOVO condition). However, the arguments of a monotransitive A/P verb will always be more thematically distinct than those of a ditransitive A/G/P verb. It might also be that the global ambiguity of the case-mapping for the ditransitive AOVO condition contributes to the processing difficulty of this condition. As for condition 2,d/PGVX, the first/second person agreement morphology on the verb might also be contributing to processing difficult, just as in condition 1,c/PVX (Section 4.1.4).

4.3 Subexperiment 3 (DAT<NOM<V)

Subexperiment 3 investigated how preverbal dative–nominative sequences are processed across monotransitive and ditransitive argument structures with various word orders.

4.3.1 Materials

Thirty-two itemsets were constructed in a four-condition design, similar to the quartet of examples above (32a–d). Key regions were two preverbal nouns (N1 and N2), the verb, and a postverbal noun (N3). N1 was always in the dative case, functioning either as an active subject (3,a/APVX), applied indirect object (3,b/OAVO and 3,c/GPVX), or direct object (3,b/OAVO and 3,d/PAVX). N2 was always nominative, functioning as direct object (3,a/APVX and 3,c/GPVX) or active subject (3,b/OAVO and 3,d/PAVX). N3 was a dative direct object in one condition (3,b/OAVO), and a genitive possessor within a clausal adjunct in the other conditions. Just as in Subexperiment 2, the Series I ditransitive condition (3,b/OAVO) is globally ambiguous between PAVG and GAVP parses.[8] Both N1 and N2 always referred to humans, except in one itemset where they were animals; N3 was also almost always human.

[8] N3 was typically a relational noun, meant to bias participants towards the PAVG reading; see footnote 6.

N1 was preceded by a single word (WD1), either an adjective or adverb. After N3 were two words (WD6 and WD7) that formed an adjunct constituent (usually a PP). In some conditions of some itemsets, the verb was immediately preceded by a grammatical particle (PART). This was either the modal particle /unda/ "must, should", the ordinary negation marker /ar/ "NEG", or the modal negation marker /ver/ "cannot". As in the other subexperiments, these particles were included to increase an item's global plausibility, generally by facilitating particular readings of the various tenses used. Of the 128 items (32 itemsets with 4 conditions each), 42 had one of these preverbal particles.

Table 11 summarizes the syntactic template for target stimuli in Subexperiment 3.

<table>
<tr><th></th><th>WD1</th><th>NOUN1</th><th>NOUN2</th><th>(PART)</th><th>VERB</th><th>NOUN3</th><th>WD6</th><th>WD7</th></tr>
<tr><td>APVX
(Exp3,a)</td><td rowspan="4">Mod-
ifier</td><td>Case: DAT
Role: $\mathrm{A|V}_{\cancel{\mathrm{PGEx}}}$</td><td>Case: NOM
Role: $\mathrm{P|V}_{\cancel{\mathrm{AUSt}}}$</td><td rowspan="4">(Negation
or modal
particle)</td><td>Mapping:
$\mathrm{A}_{dat}/\mathrm{P}_{nom}$</td><td>Case: GEN
Role: ¬V-arg.</td><td colspan="2">Adjunct
continuation</td></tr>
<tr><td>OAVO
(Exp3,b)</td><td>Case: DAT
Role: $\mathrm{PG|V}_{\cancel{\mathrm{AEx}}}$</td><td>Case: NOM
Role: $\mathrm{A|V}_{\cancel{\mathrm{UPSt}}}$</td><td>Mapping:
$\mathrm{A}_{nom}/\mathrm{G}_{dat}/\mathrm{P}_{dat}$</td><td>Case: DAT
Role: PG</td><td colspan="2">Adjunct</td></tr>
<tr><td>GPVX
(Exp3,c)</td><td>Case: DAT
Role: $\mathrm{G|V}_{\cancel{\mathrm{APEx}}}$</td><td>Case: NOM
Role: $\mathrm{P|V}_{\cancel{\mathrm{AUSt}}}$</td><td>Mapping:
$\mathrm{A}_{1/2erg}/\mathrm{G}_{dat}/\mathrm{P}_{nom}$</td><td>Case: GEN
Role: ¬V-arg.</td><td colspan="2">Adjunct
continuation</td></tr>
<tr><td>PAVX
(Exp3,d)</td><td>Case: DAT
Role: $\mathrm{P|V}_{\cancel{\mathrm{AGEx}}}$</td><td>Case: NOM
Role: $\mathrm{A|V}_{\cancel{\mathrm{APSt}}}$</td><td>Mapping, Agr.:
$\mathrm{A}_{nom}/\mathrm{P}_{dat}$</td><td>Case: GEN
Role: ¬V-arg.</td><td colspan="2">Adjunct
continuation</td></tr>
</table>

Table 11: Syntactic template the four conditions of Subexperiment 3. For critical verbs, various features/cues disambiguate the case–role mapping of the clause. For key nouns, case morphology is always unambiguous, but role is incrementally ambiguous. See Section 3 for notational conventions.

4.3.2 Analysis

As in Subexperiment 2, conditions were coded with two contrast factors: ArgStrux and NomTheta. The former factor compares the average of monotransitive conditions (3,a/APVX and 3,d/PAVX = –1/2) to the average of ditransitive ones (3,b/OAVO and 3,c/GPVX = +1/2). The latter factor compares the conditions where $N2_{nom}$ was a Proto-Agent (3,b/OAVO and 3,d/PAVX = –1/2) to the conditions where $N2_{nom}$ was a Proto-Patient (3,a/APVX and 3,c/GPVX = +1/2). Log RTs were analyzed at the critical verb region, the postverbal noun, and the next spillover region. See Section 4.1.2 for some elided details.

4.3.3 Results

Figure 4 shows mean RTs, in log milliseconds, for each word region.

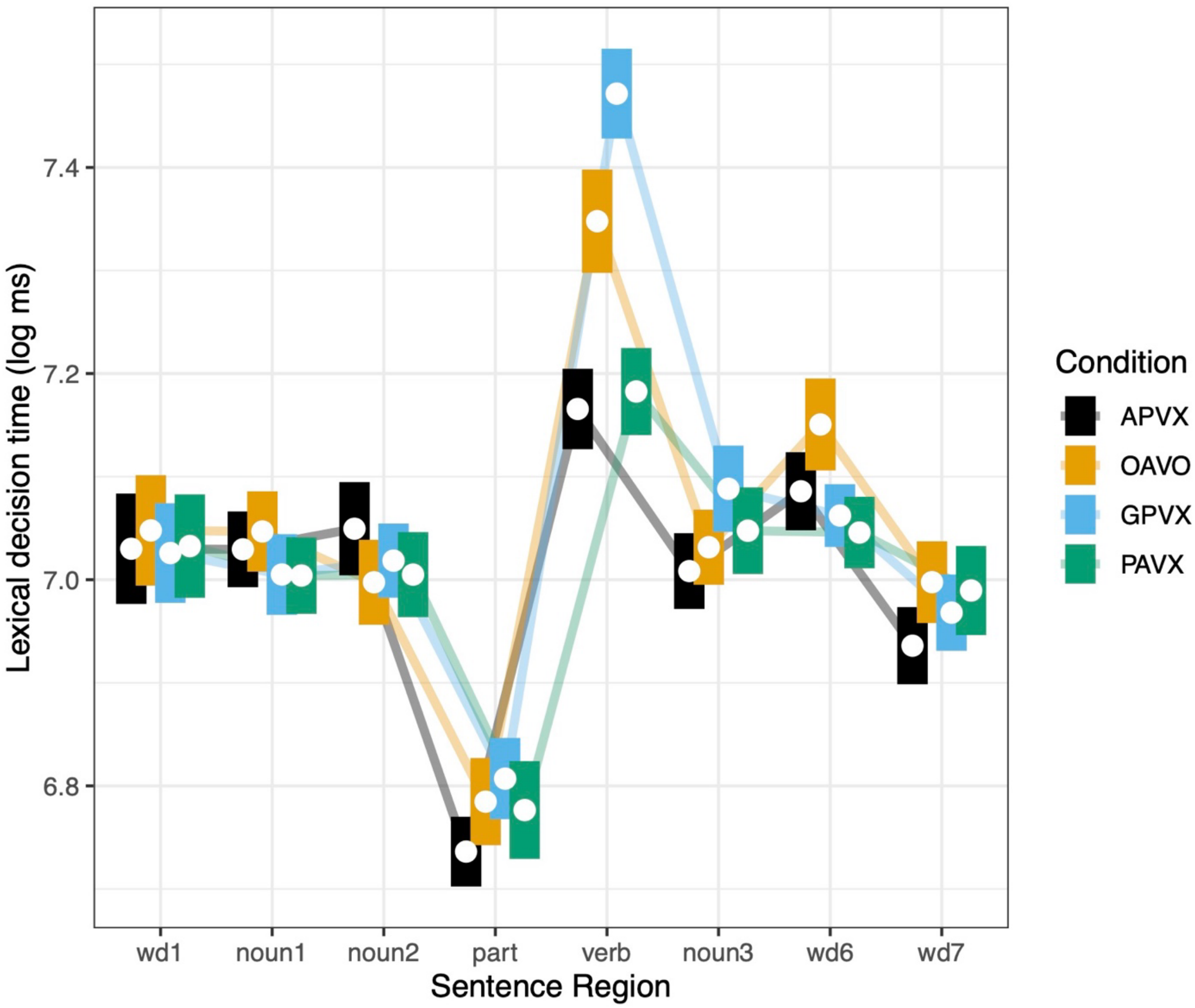

Figure 4: RTs by region for Subexperiment 3, in log milliseconds. The dots within colored bars indicate mean RTs ± one by-participant standard error.

Results of linear models are summarized in the following tables. First, at the verb region (Table 12), there was a significant main effects of ArgStrux (ditransitive verbs were recognized more slowly than monotransitive ones) and NomTheta (on average, conditions where NOM=P were read more slowly than those where NOM=A). There was also a marginal ArgStrux:NomTheta interaction. Pairwise comparison found that the two ditransitive conditions were significantly different (with 3,c/GPVX being read more slowly than 3,b/OAVO; Est. = 0.10, SE = 0.043, $t(28) = 2.4$, $p < 0.05$) but the two monotransitive conditions were not (3,a/APVX and 3,d/PAVX; Est. = 0.019, SE = 0.041, $t(28) = 0.46$, $p = 0.64$).

Verb region
LogRT ~ ArgStrux*NomTheta + (1|Participant) + (1+ArgStrux*NomTheta|Itemset)

	Estimate	SE	df	*t*	*p*	
Intercept	7.3	0.056	55	130	< 0.001	***
ArgStrux	–0.18	0.052	27	–3.4	0.0018	**
NomTheta	0.10	0.042	24	2.4	0.022	*
ArgStrux:NomTheta	–0.12	0.060	29	–2.0	0.051	.

Table 12: Results of linear mixed effect modeling of log RTs at the verb region of Subexperiment 3. Random-effect structure is shown in *lmer* syntax.

At the first postverbal region (Table 13), we find a marginal main effect of NomTheta (suggesting that, on average, N3 was read more slowly in conditions where $N2_{nom}$=P), and a significant ArgStrux:NomTheta interaction. Pairwise comparisons found a significant difference between the conditions where $N2_{nom}$=P (GPVX being read more slowly than APVX; Est. = 0.085, SE = 0.025, $t(1200) = 3.3$, $p < 0.001$), but no difference between the conditions where $N2_{nom}$=A (Est. = 0.017, SE = 0.026, $t(1200) = 0.66$, $p = 0.50$).

First postverbal spillover region
LogRT ~ ArgStrux*NomTheta + (1|Participant) + (1+NomTheta|Itemset)

	Estimate	SE	df	*t*	*p*	
Intercept	7.0	0.044	90	150	< 0.001	***
ArgStrux	0.017	0.026	1200	0.66	0.50	
NomTheta	0.057	0.031	64	1.8	0.073	.
ArgStrux:NomTheta	–0.10	0.036	1200	–2.7	0.0052	**

Table 13: Results of linear mixed effect modeling of log RTs at the first postverbal spillover region of Subexperiment 3. Random-effect structure is shown in *lmer* syntax.

In the second postverbal spillover region (Table 14), there were significant main effects of ArgStrux (ditransitive conditions were on average slower than the monotransitive ones) and NomTheta (conditions where $N2_{nom}$=A were slower on average than ones where $N2_{nom}$=P). There was also a significant ArgStrux:NomTheta interaction. Pairwise comparisons found significant differences between the conditions where $N2_{nom}$=A (3,b/OAVO being slower than 3,d/PAVX; Est. = 0.088, SE = 0.030, $t(49) = 2.9$, $p < 0.01$) and between the ditransitive conditions (3,b/OAVO being slower than 3,c/GPVX; Est. 0.073, SE = 0.033, $t(50) = 2.1$, $p < 0.05$), but no significant differences between the conditions where $N2_{nom}$=P (Est. = 0.0075, SE = 0.027, $t(49) = 0.27$, $p = 0.78$) or between the monotransitive conditions (Est. = 0.023, SE = 0.026, $t(48) = 0.88$, $p = 0.38$).

Second postverbal spillover region
LogRT ~ ArgStrux*NomTheta + (0+ArgStrux*NomTheta|Participant) + (1|Itemset)

	Estimate	SE	df	*t*	*p*	
Intercept	7.1	0.052	77	130	< 0.001	***
ArgStrux	–0.088	0.030	70	–2.9	0.0046	**
NomTheta	–0.073	0.033	53	–2.2	0.031	*
ArgStrux:NomTheta	0.096	0.042	55	2.2	0.025	*

Table 14: Results of linear mixed effect modeling of log RTs at the second postverbal spillover region of Subexperiment 3. Random-effect structure is shown in *lmer* syntax.

4.3.4 Discussion

As in Subexperiment 2, the ditransitive verbs were harder to process than monotransitive ones — likely because of the Distinctness violations their event structure incurs. For condition 3,b/OAVO, we cannot rule out the possibility of an independent cost associated with lingering role ambiguity ($N1_{dat}$ and $N3_{dat}$ both being parsable as G or P). And given the very long RTs in 3,c/GPVX, reflected in the ArgStrux:NomTheta interaction found at the verb region, there may be an independent processing cost associated with first/second person verbal agreement.

Particularly notable is the fact that verbs in the 3,a/APVX and 3,d/PAVX conditions are recognized at about the same speed. So, given DAT<NOM, cues disambiguating to P_{dat}<A_{nom} order (3,d) are not any harder to process than than cues disambiguating to A_{dat}<P_{nom} order (3,a). This contrasts with the clear P_{nom}<A_{dat} cost in Subexperiment 2.

In postverbal regions, the first/second agreement cost in 3,c/GPVX seems to linger into the processing of N3; the slow RTs of the following spillover region in the 3,c/OAVO condition is likely related to the fact that N3 is a verbal argument, rather than a possessor within an adjunct as in the other conditions.

4.4 Exploratory analyses

Here we report a few exploratory findings related to quirks of the design of Subexperiments 1–3 and the task / procedure of the study as a whole.

Word order was not an independent design factor in this study. However, conditions between Subexperiments 2 and 3 correspond directly to each other, identical in design except for word order and lexical items: for instance, 2,a/APVX and 3,d/PAVX are each other's SOV and OSV counterparts. Table 15 reports log RTs in all 12 conditions of this study, grouping together conditions with comparable arguments structures and case mappings.

Arranging data this way highlights a few notable findings. First, for SOV sentences, the A_{dat}/P_{nom} mapping of Series-III tenses is not markedly harder to process than the A_{nom}/P_{dat} mapping of Series I. Second, OSV order is harder to process than SOV order for Series III clauses, but not Series I clauses. Third, for Series-II ditransitives, where P and G get distinct cases, PGV order is not harder than GPV order.

In other words, neither a disharmonic word order (i.e. where a less-prominent role precedes a more prominent one: O<S or P<G) nor an infrequent case mapping (with A_{dat} rather than A_{nom}) is difficult on its own to process in Georgian, but the two properties in combination (as in the P_{nom}<A_{dat}<$V_{series\text{-}III}$ condition, 2,c) do in fact inhibit processing. Post-hoc analysis, pooling the monotransitive conditions from Subexperiments 2 and 3, lends some credence to this generalization. A mixed-effects linear model[9] finds no significant effects or interactions, but pairwise comparison finds a significant difference between the SOV and OSV conditions just in case the verb disambiguates to the A_{dat}/P_{nom} mapping (i.e. 2,c/P_{nom}<A_{dat}<V was slower than 3,a/A_{dat}<P_{nom}<V; Est. = 0.098, SE = 0.043, $t(100) = 2.2$, $p < 0.05$).

	SV	**SOV**	**OSV**
Active transitive, Series-I tense	**A_{nom} < V < P_{dat}** 1,a: 7.11 log ms (0.040)	**A_{nom} < P_{dat} < V** 2,a: 7.16 log ms (0.036)	**P_{dat} < A_{nom} < V** 3,d: 7.18 log ms (0.042)
Active transitive, Series-III tense	A_{dat} < V < P_{nom}	**A_{dat} < P_{nom} < V** 3,a: 7.16 log ms (0.039)	**P_{nom} < A_{dat} < V** 2,c: 7.26 log ms (0.040)
Nonactive, Any tense	**U_{nom} < V < X** 1,b: 7.15 log ms (0.038)	———	———
Nonactive appl., Any tense	**U_{nom} < V < G_{dat}** 1,c: 7.29 log ms (0.050)	U_{nom} < G_{dat} < V	G_{dat} < U_{nom} < V
Active appl., Series I tense	A_{nom} < V < O_{dat} < O_{dat}	**A_{nom} < O_{dat} < V < O_{dat}** 2,b: 7.32 log ms (0.045)	**O_{dat} < A_{nom} < V < O_{dat}** 3,b: 7.34 log ms (0.050)

	OV	**GPV**	**PGV**
Active transitive, Series-II, S-Agr	**P_{nom} < $V_{1/2Agr}$ < X** 1,d: 7.25 log ms (0.041)	———	———
Active appl., Series-II, S-Agr	G_{dat} < $V_{1/2Agr}$ < P_{nom} P_{nom} < $V_{1/2Agr}$ < G_{dat}	**G_{dat} < P_{nom} < $V_{1/2Agr}$ < X** 3,c: 7.47 log ms (0.043)	**P_{nom} < G_{dat} < $V_{1/2Agr}$ < X** 2,d: 7.48 log ms (0.043)

Table 15: Summary of mean log recognition times (by-participant standard errors in parentheses) at the verb region across Subexperiments 1–3, arranged by morphosyntactic features and word order. Corresponding stimuli are schematized above each observation. In grey are grammatically possible word orders not included in this study.

Next, we consider the possibility of adaptation effects across the course of the study. The experimental sessions were rather long; the median completion time of one session was 49 minutes, including two breaks. It could be that the same structures elicit qualitatively different processing behavior towards the beginning or the end of an experiment, or between the first and second experimental session completed. Table 16

[9] Fixed effects were NomTheta (sum-coded as for Subexperiments 2 and 3, such that $A_{nom} = –1/2$ and $P_{nom} = +1/2$) and WordOrder (sum-coded such that SOV = –1/2 and OSV = +1/2). The maximal random-effect structure to converge had the following *lmer* syntax: LogRT ~ WordOrder*NomTheta + (1|Participant) + (1+WordOrder|Itemset).

reports RTs at the verb region across experiments, broken up grossly by trial order and also pooled across all observations. (Recall that the subexperiments were intermixed, the stimuli for both sessions including half of each subexperiment's itemsets.) Unsurprisingly, RTs decrease as trial order increases: participants become better at the L-Maze methodology over time. Effects across conditions of each experiment are quite consistent across as exposure increases, though it is notable that the relative processing cost of SV monotransitive vs. nonactives (1,a/AVP vs. 1,b/UVX) seems rather variable.

	Session 1		**Session 2**		**Across sessions**
	First half	**Second half**	**First half**	**Second Half**	
1,a/AVP	7.28 (0.050)	7.06 (0.056)	6.96 (0.061)	7.03 (0.063)	7.11 (0.040)
1,b/UVX	7.19 (0.051)	7.20 (0.063)	7.19 (0.068)	6.97 (0.060)	7.15 (0.038)
1,c/UVG	7.38 (0.066)	7.40 (0.074)	7.20 (0.078)	7.20 (0.075)	7.29 (0.050)
1,d/PVX	7.32 (0.068)	7.31 (0.067)	7.13 (0.058)	7.11 (0.068)	7.25 (0.041)
2,a/APVX	7.27 (0.050)	7.12 (0.053)	7.02 (0.045)	7.05 (0.059)	7.16 (0.036)
2,b/AOVO	7.39 (0.071)	7.45 (0.079)	7.19 (0.061)	7.16 (0.060)	7.32 (0.045)
2,c/PAVX	7.38 (0.058)	7.25 (0.052)	7.13 (0.052)	7.09 (0.057)	7.26 (0.040)
2,d/PGVX	7.53 (0.063)	7.50 (0.067)	7.50 (0.068)	7.28 (0.061)	7.48 (0.043)
3,a/APVX	7.26 (0.054)	7.11 (0.049)	7.06 (0.049)	7.05 (0.051)	7.16 (0.039)
3,b/OAVO	7.47 (0.072)	7.26 (0.062)	7.24 (0.070)	7.18 (0.067)	7.34 (0.050)
3,c/GPVX	7.63 (0.067)	7.47 (0.068)	7.36 (0.068)	7.27 (0.083)	7.47 (0.043)
3,d/PAVX	7.28 (0.053)	7.18 (0.074)	7.16 (0.062)	7.00 (0.066)	7.18 (0.042)

Table 16: Mean RTs at the verb region for each condition of each subexperiment, in log ms (with standard errors). Each experimental session had 104 trials, including non-experimental fillers, in a random order; each half-session is thus a block of 52 sentences.

5. General discussion

Three L-Maze subexperiments investigated how Georgian comprehenders parse preverbal nominative and dative arguments. Those case categories are radically ambiguous for grammatical role, due to a complex split-ergative morphosyntax sensitive to tense and argument structure (Table 1). To recap key findings: (i) the presence of an applied G argument impedes processing of both nonactive and active verbs; (iii) nominative arguments are about as easy to parse as the subject of a simple nonactive (U) as they are the subject of an active monotransitive (A); (iii) verbs agreeing with a first- or second-person null subject are harder to process than ones with an overt preverbal third-person subject; and, by post-hoc reasoning, (iv) disharmonic word orders (e.g. O<S) impede processing only for verbs with A_{dat}/P_{nom} case mapping, triggered by Series-III tenses.

Table 17 summarizes empirical findings and theoretical predictions (cf. Table 4). Besides the constraints introduced in Section 3 (25–29), three more are included (33–35), reflecting speculative explanations for processing costs discussed in the previous sections.

(33) **1/2-Agreement:* There is a cost associated with processing agreement morphology registering null 1st and 2nd person subjects.

(34) **Ambiguity:* There is a processing cost associated with globally ambiguous case–role mappings (viz. DAT=P/G in Series-I ditransitives).

(35) *O_{nom}<S_{dat}: There is a processing cost associated with the disambiguation to an O<S word order just in case the case mapping is S_{dat}/O_{nom}, as in Series-III active transitives.

		LogRT$_V$	*Pr-S*	*Pr-A*	*Pr-F*	*IHA*	*Dist*	**Agr*	**Amb*	**OS$_{dat}$*
NOM<V	**1,a/AVP**	7.11			**					
	1,b/UVX	7.15		*		*				
	1,c/UVG	7.29		*		*	*			
	1,d/PVX	7.25	*	*	*	*		*		
NOM<DAT<V	**2,a/APVX**	7.16			*,*	*				
	2,b/APVG	7.32			*,*	*	*		*	
	2,b/AGVP				*,		*		*	
	2,c/PAVX	7.26	*	*	,**	*				*
	2,d/PGVX	7.48	**	**		**	*	*		
DAT<NOM<V	**3,a/APVX**	7.16			**					
	3,b/PAVG	7.34	*	*	*,*	**	*		*	
	3,b/GAVP		*	*	,*	*	*		*	
	3,c/GPVX	7.47	**	**		***	*	*		
	3,d/PAVX	7.18	*	*	*,*	**				

Table 17: Summary of empirical findings (mean log-RTs at the verb region for Subexperiments 1–3) and corresponding constraint violations (see examples 25–29, 33–35); conditions 2,b and 3,b are globally ambiguous for P<G or G<P order. Violations for Prioritize Frequency at N1 and N2 are collapsed and separated by commas (cf. Table 4).

Two of these constraints do not seem to be good models of sentence processing in Georgian. Prioritize Frequency predicts that comprehenders will prioritize parses where NOM=U or NOM=P, and where DAT=G, since those are the most common ways that those cases are mapped to grammatical roles (Tables 2–3; Foley 2022). In fact the NOM=A mapping (1,a) is about as easy to process as NOM=U (1,b); and, parses where DAT=A (especially 3,a) are not strikingly harder than ones where preverbal DAT is unambiguously mapped G (2,d; 3,c), despite the relative rarity of dative subjects. There is of course a need for more corpus research on Georgian; Foley (2022) counted nouns only indirectly, via licensing verbs, and abstracted away from linear order of overt arguments. But, results of the present study strongly suggest that Georgian comprehenders navigate incremental role ambiguities using sophisticated grammatical knowledge, not just frequency.

The second constraint whose predictions are not borne out is Incremental Harmonic Alignment, proposed by Foley (2020) to explain slower processing times of Series I monotransitives (disambiguating to an A_{nom}/P_{dat} mapping) compared to Series II monotransitives (disambiguating to A_{erg}/P_{nom}). All else equal, IHA predicts a bias to parse high-animacy dative argument as G, not P, if the A role is already claimed. In fact, applied active ditransitives (2,b/AOVO) are clearly harder to process than non-applied active monotransitives (2,a/APVX).

Indeed, there is processing cost associated with all applied verbs in this study (1,c; 2,b; 2,d; 3,b; 3,c) — a finding particularly striking given how rich Georgian is in indirect objects (Table 2–3). This is strong evidence in favor of Distinctness (Bornkessel-Schlesewsky & Schlesewsky 2009b, 2009c). That constraint predicts a processing cost for G in any polyvalent clause, since the intermediate prominence of that grammatical role will always lower event participants' distinctness.

As for Prioritize Subject and Prioritize Agent, these constraints predict a processing advantage for subject-initial and agent-initial parses, respectively. It does not seem that either of these constraints is weighted very highly for Georgian comprehenders, since O<S orders can be quite easy to process (3,d). It is also notable that P<G (2,d) and G<P (3,c) orders are processed at about equal speeds. That casts some doubt on a more general constraint like "Prioritize Prominence Roles", which would penalize not just O<S but also P<G orders.

As discussed in Section 4.1.4, a valence confound across conditions of Subexperiment 1 makes it difficult in principle to tease apart Prioritize Subject and Prioritize Agent. But, U_{nom}-initial (1,a) parses are not obviously harder than A_{nom}-initial ones (1,b; 2,a), suggesting that Georgian comprehenders are happy with any subject, even ones with Proto-Patient properties. This challenges fundamental assumptions of eADM, regarding the primacy of agents in event perception and processing. Of course, that theory is a neurolinguistic one; future ERP studies on Georgian might ultimately find evidence of an agent advantage that is too subtle for a reading-time methodology to detect.

Finally, let us turn to the three ad-hoc constraints motivated by certain unexpected findings. A constraint like *1/2-Agreement seems reasonable. Georgian verbal agreement morphology is quite complicated, manifesting across the verb as combinations of prefixes and suffixes (e.g. Foley 2021). *Ambiguity is a bit more suspect, since cues that reduce parse-entropy less in fact tend to be easier to process than ones that reduce entropy more (Hale 2003, 2006). For instance, when it comes to adjunct attachment, ambiguous structures have been shown to have a processing advantage (e.g. Traxler et al. 1998). Here, though, Distinctness can also explain why the globally ambiguous AOVO (2,b) and OAVO (3,b) conditions are relatively difficult.

As for $*O_{nom}<S_{dat}$, it correctly predicts the slow reading times of verbs in condition 2,c/PAVX, but it does so by picking out a suspiciously specific set of sentences. I suggest that it is better conceived of as the interaction of semantic–pragmatic factors. Recall that Series III tenses, especially the perfect, are used as inferential evidentials. According to Skopeteas et al. (2011), the evidential in Georgian is particularly felicitous when the A argument is in some intuitive sense pragmatically backgrounded. Elsewhere, it has been observed that focused constituents prefer the immediately preverbal position in the language (Skopeteas et al. 2009). If comprehenders in this study accommodated OSV order by interpreting the subject as focal, and accommodated evidential semantics of Series-III verbs by pragmatically backgrounding A, and if focus and this notion of pragmatic backgrounding are infelicitous in combination, then this could explain the superadditive processing penalty for $P_{nom}<A_{dat}<V_{series\text{-}III}$ verbs. Future studies could provide context sentences which facilitate scrambled word orders or evidential readings.

6. Conclusion

The present study, building on Skopeteas et al. (2011) and Foley (2020), was designed to better understand how comprehenders of a verb-final split-ergative language process morphosyntactic ambiguity. Incremental processing behavior evidences clear costs associated with parses that have applied indirect objects, but no clear cost for object-initial orders. These results contribute to a growing comparative literature in sentence processing (see Polinsky 2023 and Sauppe et al. 2023 for overviews), and in many ways they validate crosslinguistic processing predictions of the extended Argument Dependency Model (eADM; Bornkessel-Schlesewsky & Schlesewsky 2006, 2009a, 2009b, 2014, 2016).

Let us conclude by returning to the typological observation we began with: verb-final word orders are very frequent in the world's languages, and frequently associated with case marking. Georgian's complex split-ergative alignment system is prima facie evidence that case need not streamline incremental identification of preverbal arguments' grammatical roles. The language is a counterexample to the phylogenetic generalization that languages tend to mark subjects alike over time (Bickel et al. 2015). Indeed, over the attested and reconstructable history of Georgian, the language has if anything doubled down into its morphosyntactic complexity (Harris 1985, Tuite 1998). The way that Georgian comprehenders adapt to their non-optimized grammar is highly revealing: the general strategy for ambiguous arguments seems to be "if nominative, posit subject; if dative, posit direct object" (Skopeteas et al. 2011). This suggests that prototypically transitive parses (Hopper & Thompson 1980), with arguments that are highly distinct (Bornkessel-Schlesewsky & Schlesewsky 2006), are the ones privileged during comprehension — rather than parses with harmonically aligned scales, or ones with the most frequent case–role mappings.

References

Ackerman, Farrell and Robert Malouf. 2013. Morphological organization: The low conditional entropy conjecture. *Language*, 89(3): 429–464.

Aissen, Judith. 2003. Differential object marking: Iconicity vs. economy. *Natural Language and Linguistic Theory*, 21: 435–483.

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

Aronson, Howard I. 1990. *Georgian: A Reading Grammar*. Slavica Publishers.

Bader, Markus and Michael Meng. 1999. Subject-object ambiguities in German embedded clauses: An across-the-board comparison. Journal of Psycholinguistic Research, 28. 121–143.

Barr, Dale, Roger Levy, Christoph Sheepers, and Harry Tily. 2013. Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, 68(3): 255–278. doi:10.1016/j.jml.2012.11.001.

Bates, Douglas, Martin Mächler, Ben Bolker, and Steve Walker. 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1): 1–48. DOI: https://doi.org/10.18637/jss.v067.i01

Belletti, Adriana, and Luigi Rizzi. 1988. Psych verbs and Θ-Theory. *Natural Language and Linguistic Theory*, 6(3): 291–352.

Bhatia, Sakshi, and Brian Dillon. 2022. Processing agreement in Hindi: When agreement feeds attraction. *Journal of Memory and Language*, 125: 104322. DOI: https://doi.org/10.1016/j.jml.2022.104322

Bickel, Balthasar, Alena Witzlack-Makarevich, Kamal Choudhary, Matthias Schlesewsky, and Ina Bornkessel-Schlesewsky. 2015. The neurophysiology of language processing shapes the evolution of grammar: Evidence from case marking. *PLoS ONE*, 10(8): e0132819.

Boeder, Winfried. 2005. The South Caucasian languages. *Lingua*, 155: 5–89.

Bornkessel, Ina, Brian McElree, Matthias Schlesewsky, and Angela Friederici. 2004. Multi-dimensional contributions to garden path strength: Dissociating phrase structure from case marking. *Journal of Memory and Language*, 51. 495–522.

Bornkessel, Ina, and Matthias Schlesewsky. 2006. The extended argument dependency model: A neurocognitive approach to sentence comprehension across languages. *Psychological Review*, 113(4): 787–821.

Bornkessel, Ina, Stefan Zysset, Angela Friederici, D. Yves von Cramon, and Matthias Schlesewsky. 2005. Who did what to whom? The neural basis of argument hierarchies during language comprehension. *NeuroImage*, 26. 221–233.

Bornkessel-Schlesewsky, Ina and Matthias Schlesewsky. 2009a. *Processing Syntax and Morphology: A neurocognitive perspective*. Oxford University Press.

Bornkessel-Schlesewsky, Ina and Matthias Schlesewsky. 2009b. The role of prominence information in the real time comprehension of transitive constructions: A cross-linguistic approach. *Language and Linguistics Compass*, 3. 19–58.

Bornkessel-Schlesewsky, Ina and Matthias Schlesewsky. 2009c. Minimality as vacuous distinctness: Evidence from cross-linguistic sentence comprehension. *Lingua*, 119: 1541–1559.

Bornkessel-Schlesewsky, Ina and Matthias Schlesewsky. 2014. Scales in real-time language comprehension: A review. In *Scales and Hierarchies: A cross-disciplinary perspective*, eds. Ina Bornkessel-Schlesewsky, Andrej Malchukov, and Marc Richards. Trends in Linguistics: Studies and Monographs, 277. De Gruyter Mouton. 321–352.

Bornkessel-Schlesewsky, Ina and Matthias Schlesewsky. 2016. The Argument Dependency Model. In *Neurobiology of Language*, eds. Gregory Hickok and Steven L. Small. Academic Press. 357–369.

Boneh, Nora, and Léa Nash. 2017. The syntax and semantics of dative DPs in Russian ditransitives. *Natural Language and Linguistic Theory*, 35: 899–953. DOI: 10.1007/s11049-017-9360-5

Bosse, Solveig, Benjamin Bruening, and Masahiro Yamada. 2012. Affected experiencers. *Natural Language and Linguistic Theory*, 30. 1185–1230. DOI: 10.1007/s11049-012-9177-1

Boyce, Veronica, Richard Futrell, and Roger Levy. 2020. Maze made easy: Better and easier measurement of incremental processing difficulty. *Journal of Memory and Language*, 111: 104082. DOI: https://doi.org/10.1016/j.jml.2019.104082

Clemens, Laura Eby, Jessica Coon, Pedro Mateo Pedro, Adam Milton Morgan, Maria Polinsky, Gabrielle Tandet, and Matthew Wagers. 2015. Ergativity and the complexity of extraction: A view from Mayan. *Natural Language and Linguistic Theory*, 33: 417–467.

Cherchi, Marcello. 1997. *Modern Georgian Morphosyntax: A grammatico-categorial hierarchy-based analysis with special reference to indirect verbs and passives of state*. Harrassowitz Verlag.

Choudhary, Kamal K. et al. 2010. An Actor-preference in a split-ergative language: Electrophysiological evidence from Hindi. Poster presented at the 23rd Annual Meeting of the CUNY Conference on Human Sentence Processing.

Comrie, Bernard. 1989. *Linguistic Universals and Language Typology*. 2nd edition. Blackwell.

de Vincenzi, Marica. 1991. *Syntactic Parsing Strategies in Italian*. Dordrecht: Kluwer.

Demiral, Şükrü Barış, Matthias Schlesewsky, and Ina Bornkessel-Schlesewsky. 2008. On the universality of language comprehension strategies: Evidence from Turkish. *Cognition* 106: 484–500.

Dixon, R. M. W. 1979. Ergativity. *Language*, 55. 59–138.

Dowty, David. Thematic proto-roles and argument selection. *Language*, 67(3): 547–619.

Dröge, Alexander, Elisabeth Rabs, Jürg Fleischer, Sara K. H. Billion, Martin Meyer, Stephan Schmid, Matthias Schlesewsky, and Ina Bornkessel-Schlesewsky. 2020. Case syncretism, animacy, and word order in Continental West Germanic: Neurolinguistic evidence from a comparative study on Standard German, Zurich German, and Fering (North Frisian). *Journal of Germanic Linguistics*, 32(3): 217–310.

Foley, Steven. 2020. Case, agreement, and sentence processing in Georgian. Dissertation, University of California Santa Cruz.

Foley, Steven. 2021. Agreement in the languages of the Caucasus. In Maria Polinsky (ed.), *The Oxford Handbook of Languages of the Caucasus*. Oxford University Press. 845–872.

Foley, Steven. 2022. Quantifying performance constraints on case-alignment typology with information theory. Poster presented at the 35th Annual Conference on Human Sentence Processing (HSP 2022). University of California Santa Cruz, Santa Cruz, CA. March 24–26.

Freedman, Sandra, and Kenneth Forster. 1985. The psychological status of overgenerated sentences. *Cognition*, 19: 101–131.

Frisch, Stefan, and Matthias Schlesewsky. 2001. The N400 reflects problems of thematic hierarchizing.

Fuchs, Zuzanna. 2023. Processing of grammatical gender agreement morphemes in Polish: Evidence from the Visual World Paradigm. *Morphology*. https://doi.org/10.1007/s11525-023-09418-3

Gippert, Jost, and Manana Tandashvili. 2015. Structuring a diachronic corpus: The Georgian National Corpus project. In *Historical Corpora: Challenges and perspectives*, eds. Jost Gippert and Ralf Gehrke. Narr Verlag. 305–322.

Gérardin, Hélène. 2016. Les verbes intransitifs primaires et dérivés en Géorgien: Description morphosyntaxique, sémantique, et dérivationnelle [Primary and derived intransitive verbs in Georgian: Morphosyntactic, semantic, and derivational description]. Dissertation, Institut National des Langues et Civilisations Orientales (Inalco).
Greenberg, Joseph. 1963. Some universals of grammar with particular reference to the order of meaningful elements. In *Universals of Language*, ed. Joseph Greenberg. MIT Press. 73–113.
Hale, John. 2001. A probabilistic Earley parser as a psycholinguistic model. In the *Proceedings of the Second Meeting of the North American Chapter of the Association for Computational Linguistic*s. Association for Computational Linguistics. 159–166.
Hale, John. 2003. The information conveyed by words in sentences. *Journal of Psycholinguistic Research*, 32(2): 101–123.
Hale, John. 2006. Uncertainty about the rest of the sentence. *Cognitive Science*, 30(4): 643–672.
Hammerly, Christopher, Adrian Staub, and Brian Dillon. 2022. Person-based prominence guides incremental interpretation: Evidence from obviation in Ojibwe. *Cognition*, 225: 105122. https://doi.org/10.1016/j.cognition.2022.105122
Harley, Heidi, and Shigeru Miyagawa. 2017. Syntax of ditransitives. *Oxford Research Encyclopedia of Linguistics*.
Harris, Alice. 1981. *Georgian Syntax: A study in Relational Grammar*. Cambridge University Press.
Harris, Alice. 1985. *Diachronic Syntax: The Kartvelian Case*. Academic Press.
Harris, Alice. 1990. Georgian: A language with active case marking: A reply to B. G. Hewitt. *Lingua*, 80: 35–53.
Harris, Alice (ed). 1991. *The Indigenous Languages of the Caucasus, Vol. 1: The Kartvelian Languages*. Caravan Books.
Haspelmath, Martin. 1993. *A Grammar of Lezgian*. Mouton de Gruyter.
Haspelmath, Martin. 2021. Explaining grammatical coding asymmetries: Form–frequency correspondences and predictability. *Journal of Linguistics*, 57. 605–633.
Hemforth, Barbara, Lars Konieczny, and Gerhard Strube. 1993. Incremental syntax processing and parsing strategies. In the *Proceedings of the 15th Annual Conference of the Cognitive Science Society*. Erlbaum. 539–545.
Henry, Nick, Holger Hopp, and Carrie N. Jackson. 2017. Cue additivity and adaptivity in predictive processing. *Language, Cognition and Neuroscience*, 32:10. 1229–1249.
Hewitt, B. G. 1995. *Georgian: A Structural Reference Grammar*. John Benjamins Publishing Company.
Hoeks, John, and Petra Hendriks. 2011. Optimality Theory and human sentence processing: Towards a cross-modular analysis of coordination. *Journal of Cognitive Science*, 12: 83–128.
Holisky, Dee Ann. 1981. *Aspect and Georgian Medial Verbs*. Academic Resources Corp.
Hopper, Paul, and Sandra Thompson. 1980. Transitivity in grammar and discourse. *Language*, 56(2): 251–299.
Inoue, Atsu, and Janet Dean Fodor. 1995. Information-paced parsing of Japanese. In *Japanese Sentence Processing*, eds. Reiko Mazuka and Noriko Nagai. Psychology Press. 19–48.
Jackendoff, Ray. 1972. *Semantic Interpretation in Generative Grammar*. The MIT Press.
Kaiser, Elsi and John C. Trueswell. 2004. The role of discourse context in the processing of a flexible word-order language. *Cognition*, 11: 223:237.
Kalin, Laura. 2018. Licensing and differential object marking: The view from Neo-Aramaic. *Syntax*, 21(2): 112–159.
Keenan, Edward L., and Bernard Comrie. 1977. Noun phrase accessibility and Universal Grammar. *Linguistic Inquiry*, 8(1): 63–99.
Keshev, Maayan, and Aya Meltzer-Asscher. 2017. Active dependency formation in islands: How grammatical resumption affects sentence processing. *Language*, 93(3): 549–568.
Knoeferle, Pia, Matthew W. Crocker, Christoph Scheepers, and Martin J. Pickering. 2005. The influence of the immediate visual context on incremental thematic role-assignment: evidence from eye-movements in depicted events. *Cognition*, 95: 95–127.

Krebs, Julia, Evie Malaia, Ronnie B. Wilbur, and Dietmar Roehm. 2018. Subject preference emerges as cross-modal strategy for linguistic processing. *Brain Research*, 1691: 105–117.

Larson, Richard. 1988. On the double object construction. *Linguistic Inquiry*, 19: 335–391.

Lau, Elaine and Nozomi Tanaka. 2021. The subject advantage in relative clauses: A review. *Glossa: a journal of general linguistics*, 6(1): 1–34. DOI: https://doi. org/10.5334/gjgl.1343

Legate, Julie Anne, Faruk Akkuş, Milena Šereikaitė, and Don Ringe. 2020. On passives of passives. *Language*, 96(4): 771–818.

Lenth, Russell, Ben Bolker, Paul Buerkner, Iago Giné-Vázquez, Maxime Herve, Maarten Jung, Jonathan Love, Fernando Miguez, Hannes Riebl, and Henrik Signman. 2020. *emmeans*: estimated marginal means, aka least-squares mean. R package version 1.5.2-2.

Levy, Roger. 2008. Expectation-based syntactic comprehension. *Cognition*, 106: 1126–1177.

Li, Ping, Elizabeth Bates, and Brian MacWhinney. 1993. Processing a language without inflections: A reaction time study of sentence interpretation in Chinese. *Journal of Memory and Language*, 32: 169–192.

Lomashvili, Leila. 2011. *Complex Predicates: The syntax–morphology interface*. John Benjamins Publishing.

McWhinney, Brian, Elizabeth Bates, and Reinhold Kliegl. 1984. Cue validity and sentence interpretation in English, German, and Italian. *Journal of Verbal Learning and Verbal Behavior*, 23: 127–150.

Miljan, Merilin, Elsi Kaiser, and Virve-Anneli Vihman. 2017. Interplay between case, animacy and number: Interpretations of grammatical role in Estonian. *Finno-Ugric Languages and Linguistics*, 6(1). 55–77.

Moravcsik, Edith A. 1974. Object–verb agreement. *Working Papers on Language Universals* 15, 25–140.

Muralikrishnan, R., Matthias Schlesewsky, and Ina Bornkessel-Schlesewsky. 2008. Universal and cross-linguistic influences on the processing of word order and animacy: Neurophysiological evidence from Tamil. Poster presented at the 21st Annual CUNY Conference on Human Sentence Processing.

Nash, Léa. 2017. The structural source of split ergativity and ergative case in Georgian. In *The Oxford Handbook of Ergativity*, eds. Jessica Coon, Diane Massam, and Lisa Demena Travis. 175–200.

Nash, Léa. 2022. Nonunitary structure of unergative verbs in Georgian. *Natural Language & Linguistic Theory*, 40. 1201–1267

Perlmutter, David M. 1978. Impersonal passives and the Unaccusative Hypothesis. In *Proceedings of the 4th Annual Meeting of the Berkeley Linguistics Society*. 157–189.

Perlmutter, David M. and Paul Postal. 1984. The 1-advancement exclusiveness law. In David M. Perlmutter and Carol Rosen (eds.), *Studies in Relational Grammar*, vol. 2. University of Chicago Press. 81–125.

Philipp, Markus, Ina Bornkessel-Schlesewsky, Walter Bisang, and Matthias Schlesewsky. 2008. The role of animacy in the real time comprehension of Mandarin Chinese: Evidence from auditory event-related brain potentials. *Brain and Language*, 205: 112–133.

Pizarro-Guevara, Jed and Matt Wagers. 2020. The predictive value of Tagalog voice morphology in filler–gap dependency formation. *Frontiers in Psychology*, 11(517). DOI:10.3389/fpsyg.2020.00517

Polinsky, Maria. 2023. Experimental syntax and linguistic fieldwork. In *The Oxford Handbook of Experimental Syntax*, ed. John Sprouse. Oxford University Press. 97–126.

Primus, Beatrice. 1999. *Case and Thematic Roles*. Niemeyer.

Roehm, Dietmar, Matthias Schlesewsky, Ina Bornkessel, Stefan Frisch, and Hubert Haider. 2004. Fractionating language comprehension via frequency characteristics of the human EEG. *Cognitive Neuroscience and Neuropsychology*, 15(3): 409–412.

Sapir, Edward. 1917. Het Passieve Karakter van het Verbum Transitivum of van het Verbum Actionis in Talen van Noord-Amerika [The Passive Character of the Transitive Verb or of the Active Verb in Languages of North America], C. C. Uhlenbeck [Review]. *International Journal of American Linguistics*, 1: 82–86.

Sauppe, Sebastian, Caroline Andrews, and Elisabeth Norcliffe. 2023. Experimental research in cross-linguistic psycholinguistics. In *Routledge Handbook of Experimental Linguistics*, eds. Sandrine Zufferey and Pascal Gygax. Routledge. 156–172. doi: 10.4324/9781003392972-12

Sauppe, Sebastian, Åshild Næss, Giovanni Roversi, Martin Meyer, Ina Bornkessel-Schlesewsky, and Balthasar Bickel. 2023. An agent-first preference in a patient-first language during sentence comprehension. *Cognitive Science*, 47: e13340. DOI: 10.1111/cogs.13340

Shanidze, Akaki. 1980 [1953]. Kartuli enis gramat'ik'is sapudzvlebi [Fundamentals of Georgian grammar]. In *Txzulebani* [Collected Works], vol. 3. Scientific Academy, Tbilisi State University.

Skopeteas, Stavros, Gisbert Fanselow, and Rusudan Asatiani. 2011. Case inversion in Georgian: Syntactic properties and sentence processing. In *Case, Word Order and Prominence: Interacting cues in language production and comprehension*, eds. Monique Lamers and Peter de Swart. Studies in Theoretical Psycholinguistics, 40. Springer. 145–172.

Skopeteas, Stavros, Caroline Féry, and Rusudan Asatiani. 2009. Word order and intonation in Georgian. *Lingua*, 119. 102–127.

Stewart, Andrew, Judith Holler, and Evan Kidd. 2007. Shallow processing of ambiguous pronouns: Evidence for delay. *The Quarterly Journal of Experimental Psychology*, 60(12): 1680–1696.

Testelets, Yakov. 2021. Kartvelian (South Caucasian) Languages. In *The Oxford Handbook of Languages of the Caucasus*, ed. Maria Polinsky. 490–528.

Tollan, Rebecca and Daphna Heller. 2022. Pronoun resolution and ergativity: Effects of subjecthood and case in Niuean. *Language*, 98(1): 157–183.

Traxler, Matthew J., Martin J. Pickering, and Charles Clifton, Jr. 1998. Adjunct attachment is not a form of lexical ambiguity resolution. *Journal of Memory and Language*, 39: 558–592.

Tuite, Kevin. 1998. Kartvelian morphosyntax: Number agreement and morphosyntactic orientation in the South Caucasian languages. Dissertation, University of Montreal.

Van Valin, Robert D., Jr. 1990. Semantic parameters of split intransitivity. *Language*, 66(2): 221–260.

Van Valin, Robert D., Jr. 2005. *Exploring the Syntax–Semantics Interface*. Cambridge University Press.

Villata, Sandra, Whitney Tabor, and Julie Franck. 2018. Encoding and Retrieval Interference in Sentence Comprehension: Evidence from Agreement. *Frontiers in Psychology*, 19. https://doi.org/10.3389/fpsyg.2018.00002

Wagers, Matt, Manuel Borja, and Sandra Chung. 2015. The real-time comprehension of *wh*-dependencies in a *wh*-agreement language. *Language*, 91(1): 109–144.

Wang, Luming, Matthias Schlesewsky, Balthasar Bickel, and Ina Bornkessel-Schlesewsky. 2009 Exploring the nature of the 'subject'-preference: Evidence from the online comprehension of simple sentences in Mandarin Chinese. *Language and Cognitive Processes*, 24(7–8). 1180–1226. DOI: 10.1080/01690960802159937

Yasunaga, Daichi, Masataka Yano, Yoshiho Yasugi, and Masatoshi Koizumi. 2015. Is the subject-before-object preference universal? An event-related potential study in the Kaqchikel Mayan language. *Language, Cognition and Neuroscience*, 30(9): 1209–1229. DOI: 10.1080/ 23273798.2015.1080372

Zehr, Jeremy, and Florian Schwarz. 2018. PennController for Internet Based Experiments (IBEX). Software. DOI: https://doi.org/10.17605/OSF.IO/MD832