Processing the disambiguation of grammatical roles: Lexicality Maze evidence from Georgian

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Abstract: Processing who does what to whom is key to understanding a sentence, but grammars often render nouns' subjecthood and objecthood incrementally ambiguous, even in simple root clauses. Across typologically diverse languages, cues to agent-before-patient word orders are often comprehended more easily than patient-before-agent cues. However, the source of the agent first advantage remains unclear. Theoretical approaches might derive it from independent processing constraints, from an inherent cognitive bias towards agents, or from the relative distinctness of coarguments along various linguistic prominence scales. Novel evidence from Georgian contributes to a general theory of grammatical role processing by leveraging the language's uniquely complex morphosyntax. Georgian has flexible word order, null pronouns, and a split ergative case system that varies across tenses — facts that give rise to an unusually large number of incremental role ambiguities. A Lexicality Maze experiment tested how comprehenders process cues at verbs which disambiguate the roles of preceding arguments, across a wide range of case–order configurations. There are two key findings. First, effects of word order are highly circumscribed. An agent first advantage (and more generally, an advantage for orders where more prominent roles precede less prominent ones) is only observed in clauses with a case pattern which is relatively infrequent and morphosyntactically/semantically marked. This is especially notable because all clause initial nouns in Georgian are incrementally compatible with the agent role, so an agent first parsing strategy is always available. Second, cues to argument structures with an indirect object cause processing difficulty across the board. As indirect objects are relatively more agent-like than direct objects, this evidence that inherent properties of agents do not have a processing advantage per se. Together, these findings suggest that role processing effects are consequences of prominence scale mismatches and how they interact with independent contributors to representational complexity.

Keywords: grammatical roles, agent first advantage, word order, split ergativity, Maze task, Georgian

1. Introduction

In any language, an essential task during sentence comprehension is to process who did what to whom — that is, to identify what grammatical role each noun plays, vis-à-vis the event expressed by the verb. Grammatical strategies for encoding these roles are diverse: in one language, agents and patients might appear in a fixed linear order; in another, they have distinct case marking; in a third, roles must be inferred from some morphological cue on the verb. The parser must be equipped with sufficiently general strategies to process these morphosyntactic dependencies, and efficiently navigate any incremental ambiguities they may give rise to.

Contributing to a language general theory of grammatical role processing, this study examines one understudied language that encodes grammatical roles in a typologically unusual way. In Georgian, word order is flexible, pronouns are usually omitted, and case is assigned according to a complex split ergative system conditioned by tense. Thus, agents and patients are signaled neither by particular linear positions nor specific case morphemes. Rather, grammatical roles must be triangulated from the tense, agreement, and argument structure morphology of the verb — which is often sentence-final.

For the purposes of incremental sentence comprehension, these grammatical factors result in a perfect storm: many preverbal arguments are radically ambiguous for role. The following examples illustrate.[1] Depending on the inflection of the sentence final verb, note how the same sequence of nominative and dative nouns can be parsed as an agent and patient (1a), a patient and agent (1b), a patient and goal (1c), or a passive subject and goal (1d).

(1) a.

Agent	Patient	Verb
*ekʰim-**i***	*metʰevze-**s***	*gaaʧʰerebs.*
doctor-**NOM**	fisherman-**DAT**	stop:TR:FUT

"The doctor will stop the fisherman."

b.

Patient	Agent	Verb
*ekʰim-**i***	*metʰevze-**s***	*gauʧʰerebia.*
doctor-**NOM**	fisherman-**DAT**	stop:TR:PERF

"The fisherman has stopped the doctor."

c.

Patient	Goal	Verb
*ekʰim-**i***	*metʰevze-**s***	*gavuʧʰere.*
doctor-**NOM**	fisherman-**DAT**	stop:TR:APPL:AOR:1SG.A

"I [*pro*] stopped the doctor for the fisherman."

d.

Subject	Goal	Verb
*ekʰim-**i***	*metʰevze-**s***	*gauʧʰerda.*
doctor-**NOM**	fisherman-**DAT**	stop:PASS:APPL:AOR

"The doctor was stopped for the actor."

Which of these parses, disambiguated by the final verb, is easiest to process for the Georgian comprehender — and why? Previous crosslinguistic comparison has identified a few parsing strategies that might guide comprehenders faced with such nouns with incrementally ambiguous grammatical roles: strategies like 'prioritize identifying an agent' or 'commit to as few arguments as necessary'. However, the types of incremental ambiguities previously tested have been somewhat limited, since the average morphosyntactic grammar tends to signal grammatical roles in relatively straightforward way. Not so in Georgian — if anything, its case system seems gratuitously complex, rendering most preverbal nouns ambiguous. But this typologically unusual morphosyntax makes the language an ideal place to investigate how grammatical roles are processed in real time.

[1] Georgian data are given in IPA transcription, which is also a transparent transliteration of the orthography. For clarity and brevity, full morpheme-by-morpheme decomposition of verbs is avoided. The glossing convention "verb:X:Y:Z" can be read "verb with morphology cumulatively expressing inflectional features X, Y, and Z (e.g. argument structure, tense, and agreement)". Other abbreviations: A "transitive subject"; ABS "absolutive"; ACC "accusative"; AOR "aorist (perfective past)"; APPL "applicative"; DAT "dative"; Ex "experiencer subject"; FUT "future"; G "indirect object (e.g. applied affectee)"; GEN "genitive"; NOM "nominative"; P "direct object"; PASS "passive"; PERF "perfect (evidential past)"; PL "plural"; S "intransitive subject"; S_A "intransitive subject with A-like properties (as in an unergative)"; S_P "intransitive subject with P-like properties (as in a passive or unaccusative)"; St "psychological stimulus object"; SG "singular"; TR "transitive"; X·Y "X precedes Y in a string of words"; X→Y "X maps onto / is parsed as Y"; N1·N2→X·Y·Z "N1 and N2 are parsed as X and Y, respectively; Z continues the string".

To that end, a reading time experiments was designed to leverage Georgian's theoretically valuable properties. It comprised three copresented subexperiments, and employed the Lexicality Maze paradigm (Freedman & Forster 1985, Boyce et al. 2020). Stimuli manipulated the number of incrementally ambiguous preverbal arguments in a sentence, their case marking, and their grammatical roles ultimately disambiguated by morphology on the verb. The parses for these nouns were selected to test specific predictions derived from the extended Argument Dependency Model (eADM; Bornkessel-Schlesewsky & Schlesewsky 2009, 2013, 2016) and related theories of grammatical role processing.

To preview the results, a few notable patterns emerged across reading times of the disambiguating verbs. First, there was a clear processing cost for clauses containing goal arguments (like 1c,d), as opposed to ones with just agents, patients, or passive subjects. Goals have some properties of prototypical agents, and some of prototypical patients (Dowty 1991). The observed processing cost at goal-licensing verbs, then, supports the claim that comprehenders favor clauses/events that are prototypically transitive (Hopper & Thompson 1980), where arguments are maximally distinct across many linguistic dimensions (Bornkessel-Schlesewsky & Schlesewsky 2009). An alternative theory, predicting processing costs to increase as arguments have fewer properties of prototypical agents (Foley 2020), is not supported; goals should have had some advantage over patients, which tend to have very few agenthood properties at all. Many previous crosslinguistic studies on role processing have observed an advantage for agents (Bornkessel-Schlesewsky & Schlesewsky 2009, Sauppe et al. 2023), but usually they are only compared to patients. By including goals, this study sheds light on the nature of this crosslinguistic agent advantage. It seems that agents are privileged not because of their inherent properties, but rather because of their relational properties: namely, the fact agents and patients contrast with each other more distinctly than any other combination of arguments.

A second key set of findings relates to a putative agent first advantage. Evidence for such a processing effect has been found in many languages, even ones with dominant patient initial word orders (Sauppe et al. 2023; though cf. Koizumi et al. 2014). However, in Georgian it seems that the agent first strategy is at best highly qualified. This study does not find an overall processing cost for verbs that disambiguate patient initial or theme initial parses, relative to agent initial ones: some Patient·Agent·Verb clauses are just as easy as their A·P·V counterparts. The only clear P·A·V cost was in clauses like (1b), where the language's case grammar assigns dative to the agent because of the tense. There are a number of factors that could explain this observed interaction between case marking and word order — related, say, to the relative infrequency of dative agents in this language, or to their morphosyntactic and semantic markedness. In any case, the interaction shows that Georgian comprehenders favor agent first word orders only under very specific circumstances.

The rest of this paper has the following structure. Section 2 provides relevant background on the processing of grammatical roles across languages, summarizes key grammatical facts about Georgian, and reports novel corpus evidence. Section 3 presents the reading time experiment's design and results. Section 4 discusses findings in light of the theoretical background. Section 5 concludes.

2. Grammatical roles and how they are processed

Grammatical roles are morphosyntactic categories describing how nominal arguments of clauses relate to verbs (Sapir 1917, Dixon 1979, Hopper & Thompson 1980, Comrie 1981, Marantz 1981, and many others). This study focuses on the grammatical roles symbolized 'A' (transitive subject), 'P' (direct object), 'S' (intransitive subject), and 'G' (indirect object). Particular grammars express these categories in diverse ways — through word order, case, agreement, etc. — but within and across languages roles correlate robustly with clusters of thematic–interpretive properties. Adopting Dowty's (1991) terminology, the A argument of a clause tends to have many Proto Agent properties (volition, animacy, causing a change, etc.) and few Proto Patient properties (undergoing change, inanimacy, existential dependency on the event, etc.), and vice versa for P. G, typically expressing the goal or affectee of an event, is intermediate in both Proto Agent and Proto Patient properties. S is a thematically heterogenous role; when necessary to distinguish subtypes, the symbols ‘S_A’ and ‘S_P’ refer respectively to intransitive subjects with more Proto Agent or Proto Patient properties.

Such correlations streamline the task of real time sentence comprehension. If the comprehender can accurately identify a noun’s role, they have a leg up on processing how it relates to the event, even before the verb and its lexical semantics have been encountered. In psycholinguistics and neurolinguistics, the study of grammatical role processing investigates how comprehenders identify who did what to whom in an event, on the basis of morphosyntactic cues incrementally available across a clause. Since the nature and informativity of those cues varies widely, the study of role processing depends crucially on crosslinguistic comparison (Bates & MacWhinney 1982, Bornkessel-Schlesewsky & Schlesewsky 2009). And indeed the sample of languages investigated is becoming ever more typologically diverse. This section reviews key findings, and synthesizes theoretical perspectives on role processing phenomena — in particular on a frequently observed advantage for A-before-P word orders. To limit the scope of this paper, we focus as much as possible on clauses which only have high animacy arguments (i.e. human referring nouns), and which lack unbounded filler–gap dependencies like *wh*-movement or relativization. Animacy and FGDs interact in important ways with role processing (e.g. Vihman & Nelson 2019; Lau & Tanaka 2021), but we leave them for future research.

2.1 The A1 advantage across configurations

A common finding in crosslinguistic role processing is an advantage for agent initial word orders over patient initial ones — the agent first (A1) advantage. There are a few kinds of morphosyntactic configurations where this effect is routinely observed. First is at a clause final verb, whose morphology disambiguates the grammatical roles of two preceding nouns. Those temporary role ambiguities often stem from morphological syncretisms between cases that distinguish A and P. In German, for example, nominative and accusative forms of feminine and plural noun phrases are syncretic; verbs agree in number with their subject, and word order is flexible. So, if a transitive clause has one feminine and one plural argument, verbal agreement will be the crucial cue disambiguating which noun has which role — as illustrated in the following examples. Processing difficulty is consistently observed in German at clause final verb that disambiguates the preceding nouns as having a P·A order (2a), rather than A·P (2b). Various behavioral (Bader & Meng 1999, Fanselow et al. 2002) and electrophysiological (Friederici & Mecklinger 1996, Friederici et al. 2001, Haupt et al. 2008) measures evince an A1 advantage in this type of configuration for German.

(2) a. *…daß die neue Lehrerin einige der Kollegen angerufen haben.*
that the:NOM/ACC new teacher some:NOM/ACC the colleagues phoned **has:3PL**
“…that some of the colleagues phoned the new teacher.” [P·A order disambiguated at final V]

b. *…daß die neue Lehrerin einige der Kollegen angerufen hat.*
that the:NOM/ACC new teacher some:NOM/ACC the colleagues phoned **has:3SG**
“…that the new teacher phoned some of the colleagues.” [A·P order disambiguated at final V]
(German; Bader & Meng 1999:127)

A similar effect has been observed in Basque. In this language, nouns’ ergative singular and absolutive plural forms are usually identical; word order is free, and null pronouns can occupy any argument position. Erdocia et al. (2009, exp. 3) measured evoked response potentials during globally ambiguous sentences, where the clause final verb’s lexical semantics strongly biased the role parse of preceding nouns. They observe long lasting negativity at verbs that bias towards the P·A interpretation, relative to A·P cues: evidence of reanalysis away from an A1 parse.

(3) a. *Otso-ak* *ardi-ak* *jan* *ditu.*
wolf-**ERG.SG/ABS.PL** sheep-**ERG.SG/ABS.PL** **eaten** AUX:3SG.A:3PL.P
"The wolf has eaten the sheep.PL." [A·P order is more plausible given final V]

b. *Ardi-ak* *otso-ak* *jan* *ditu.*
sheep-**ERG.SG/ABS.PL** wolf-**ERG.SG/ABS.PL** **eaten** AUX:3SG.A:3PL.P
"The wolf has eaten the sheep.PL." [P·A order is more plausible given final V]
(Basque; Erdocia et al. 2009:5)

A cost associated with clause final P·A disambiguation has also been observed in languages without any case morphology. In Austrian Sign Language (Krebs et al. 2018), word order of caseless nouns is flexible, but verbal inflection for arguments' spacial index can disambiguate their roles. Krebs et al.'s EEG study found widely distributed negativity elicited by verbs disambiguating to the P·A word order, relative to the A·P parse.

These studies on German, Basque, and Austrian Sign Language tested configurations where a clause final cue disambiguates the roles of two preceding arguments. Other designs have measured the effect of a clause medial cue, disambiguating a single preceding noun as either A or P. In some cases, that disambiguating cue is verbal morphology. Take the Oceanic Austronesian language Äiwoo (Sauppe et al. 2023). Here, A·V·P and P·V·A orders are both available; the role of the initial argument is conveyed not by a case morpheme on the noun, but voice inflection on the verb. Sauppe et al.'s EEG study found frontally distributed negativity elicited by verbs that disambiguated clause initial human nouns to the P-parse, rather the A-parse. The advantage for A-disambiguation is particularly remarkable for this language, where the P·V·A order is more frequent than A·V·P, especially when the first noun denotes a non-human event participant. Moreover, P·V·A arguably involves a simpler syntactic structure (Næss 2015; though compare Roversi 2025).

Comparable evidence comes from Turkish. Demiral et al. (2008) tested sentences where a single preverbal noun was either morphology unmarked (thus incrementally parseable as S, A, or nonspecific P), or marked with an accusative affix (unambiguously a specific P); in both conditions, first person agreement on the following verb excludes parses where that noun is a subject. The authors find broadly distributed positivity elicited by the verb following the incrementally ambiguous, caseless noun: again interpreted as a reanalysis effect. This A1 effect is notable for Turkish, where subjects are frequently omitted in discourse, giving comprehenders plenty of experience with P1 strings.

A final configuration to consider is such that the role of a clause initial noun (N1) is disambiguated by a coargument noun in medial position (N2), rather than a verb. This is possible, for instance, in a German clause ordered N1·Aux·N2·V. Suppose that N1 is morphologically ambiguous between nominative and accusative, and that agreement on the auxiliary is matches the features of N1, thereby keeping both the N1→A and N1→P parses on the table. If N2 has a non-syncretic nominative form, that will be the key role disambiguator for N1. In an EEG study on sentences like these, Frish et al. (2002) found a P600 component evoked by the cue disambiguating to the N1→P parse (i.e. unambiguous nominative at N2; 4a), relative to the N1→A disambiguator (accusative at N2; 4b).

(4) a. *Die* *Detektivin* *hatte* *der* *Kommissar* *gesehen…*
the.NOM/ACC detective had:3SG the.**NOM** commissar seen
"The commissar had seen the detective." [N1 disambiguated to P by non-syncretic NOM on N2]

b. *Die* *Detektivin* *hatte* *den* *Kommissar* *gesehen…*
the.NOM/ACC detective had:3SG the.**ACC** commissar seen
"The detective had seen the commissar." [N1 disambiguated to A by non-syncretic ACC on N2]
(German; Frisch et al. 2002:B86)

A similar result has been found for Basque. When N1 is absolutive–ergative ambiguous, a subsequent noun (N2) in a non-syncretic ergative form will be the crucial N1→P disambiguator (5a); non-syncretic absolutive at N2 would cue N1→A (5b). Comparing across two of Erdocia et al.'s (2009) reading time studies, there is evidence that the N1→P cue is harder to process (mean reading time of N2.ERG = 1471 ms; Exp. 2) than the N1→A cue (mean RT of N2.ABS = 989 ms; Exp. 1).

(5) a. *Emakume-ak* *gizon-a* *ikusi* *du.*
woman-ERG.SG/ABS.PL man-**ABS.SG** seen AUX:3SG>3SG
"The woman has seen the man." [N1 disambiguated to A.ERG by non-syncretic ABS on N2]

b. *Gizon-ak* *emakume-ek* *ikusi* *dituzte.*
man-ERG.SG/ABS.PL woman-**ERG.PL** seen AUX:3PL>3PL
"The women have seen the men." [N1 disambiguated to P.ABS by non-syncretic ERG on N2]
(Basque; Erdocia et al. 2009:5)

In sum, behavioral and neurophysiological measures in diverse languages point to processing difficulty caused by morphosyntactic cues that resolve incrementally ambiguous noun–role mappings towards a P1 parse, eliminating the previously available A1 parse. The crucial cue might be associated with (i) a string final verb in an N1·N2·V clause, (ii) a string medial verb in a N1·V(·N2) clause, or (iii) a string medial noun in an N1·N2·V clause.

It is worth noting precisely the evidence available incrementally to comprehenders across these clause types. In the first configuration, the comprehender has unambiguous evidence for a transitive clause, having observed two nominal arguments. Encountering the verb gives access to its lexical semantics, and also disambiguates the respective roles of N1 and N2. In the second configuration, N1 alone is not bottom up evidence for transitivity; if the noun is morphologically compatible with the S role, an intransitive parse of the clause is still available. Thus the verb here cues several types of linguistic information. It disambiguates the role of N1, to A or P; it contributes to the lexical semantic interpretation of the event; and, assuming that it is an unambiguously transitive verb, it also eliminates the intransitive parse of the clause. And in the third configuration: N2 disconfirms an intransitive parse for the clause, disambiguates the role of N1, and it provides the semantic content of a second event participant. In sum, A1 effects are observed with or without bottom up evidence of transitivity, with or without access to the verb. Verb independence is an important property of the phenomenon (Bornkessel-Schlesewsky and Schlesewsky 2009, 2015). It shows that the comprehender is weighing properties of abstract morphosyntactic categories — grammatical roles — rather than the thematic entailments of a particular lexicalized event.

2.2 Theoretical perspectives on the A1 advantage

There are a few theoretical directions to take when seeking an explanation for the A1 advantage. Three are discussed here: the reductionist approach, the inherent approach, and the distinctness approach. Reductionist theories derive A1 effects from independently necessary linguistic factors, like frequency or representational complexity. For many flexible word order languages, P-before-A order is in fact relatively infrequent, associated with extra syntactic operations, and/or licensed by special discourse contexts (see Bader & Meng 1999 on German). This is the case for most of the languages surveyed above; for them, it seems reasonable to reduce the A1 advantage to a more general advantage for less complex structures. However, the relevant factors vary crosslinguistically. The grammatical terrains of certain languages should give rise to a P1 advantage instead.

To test this prediction, crucial are languages with basic P-before-A word order. Only a handful have been investigated psycholinguistically; one is the Mayan language Kaqchikel (Koizumi et al. 2014, Yasunaga et al. 2015). V·P·A is basic there, but V·A·P and both verb medial orders can be derived from it. Nouns are caseless, but their roles can be disambiguated by cues on the verb: either number agreement or lexical semantics. Behavioral results of a plausibility judgement task show that the V·P·A order is processed more quickly than A·V·P or V·A·P, and more accurately than V·A·P (Koizumi et al. 2014). In an EEG study on sentences where verbal agreement disambiguated roles, several findings also indicate a processing advantage for the basic V·P·A order (Yasunaga et al. 2015). Late parietal positivity was evoked by the first noun in a V·A·P clause, relative to the V·P·A one: a cost for processing the more complex A-before-P order. The authors also find long lasting negativity at the final word of a A·V·P clause, compared to V·P·A. This differential wrap up effect also points towards a processing advantage for the basic word order. The cost for A·V·P in particular is remarkable for Kaqchikel — due to its discourse function, that order is in fact the most frequent one for transitive clauses, despite the syntactic complexity.

The parsimony of a reductionist account is generally appealing. But it offers no obvious explanation for a very glaring fact about language typology: languages with basic P-before-A word order are rare (Dryer 2013). Suppose instead that A1 orders in fact have an inherent processing advantage, one perhaps rooted in deep cognitive biases towards other sentient entities (Bornkessel-Schlesewsky & Schlesewsky 2015, Sauppe et al. 2015). Under this inherent account of the A1 advantage, there is at least a foothold to explain the typological preponderance of A1 orders (see discussion in Koizumi et al. 2014, Sauppe et al. 2015). Moreover, an inherent account of the A1 advantage makes a few key empirical predictions. If A1 and P1 orders have equal complexity (and are indistinguishable on all other relevant independently necessary dimensions), a reductionist account predicts no processing difference, while the inherent account favors A1.

Arguably this is the case even in Kaqchikel. In addition to the P1 advantages described above, Yasunaga et al. 2015 find an A1 advantage in one configuration: clause medial verbs in P·V·A clauses elicit late positivity relative to A·V·P clauses. Both verb medial orders in Kaqchikel involve a filler–gap dependency between the preverbal noun and its postverbal base position. In terms of phrase structure and movement operations, then, they are equally complex. Therefore the fact that the A1 disambiguation is processed more easily can be interpreted as a sort of emergence of the unmarked (McCarthy & Prince 1994): comprehenders of Kaqchikel indeed have a preference for A-before-P orders, but in verb initial clauses it is outweighed by their dispreference for complex structures.[2]

Another key prediction of an inherent account is differential processing for intransitive clauses. As mentioned above, the S role is semantically heterogenous; there are intransitive verbs whose subjects have more Proto Agent properties (S_A), or more Proto Patient properties (S_P). If is those thematic properties which make A easier to process than P in initial position, then S_A should likewise be easier than S_P. One study to compare the processing of S-disambiguation is Isasi-Isasmendi et al. 2024. They conducted an EEG study on verb medial intransitive sentences in Basque, where N1 was or was not ergative–absolutive syncretic. (In this language, S_A is ergative just like A , and S_P absolutive like P.) An N400 effect was elicited by verbs disambiguating the initial syncretic noun to S_P, compared to the N1→S_A disambiguation. So, it seems that S_A has a processing advantage across intransitive clauses, just as A has an advantage within transitive clauses: some evidence that Proto Agent properties per se are what make certain roles inherently easier to process.

A final theoretical approach seeks to derive the A1 advantage from constraints on how multiple arguments can be processed simultaneously. Take for a starting point some version of similarity based interference (e.g. Jäger et al. 2017). As coarguments become less distinct along the relevant linguistic dimensions, it should be harder to process them together. Suppose that the relevant dimensions are linguistic

[2] Yasunaga et al. (2015) give an alternative explanation. Upon encountering the verb in a P·V·A clause, they argue, the comprehender will process the filler–gap dependency between the fronted P and its postverbal base position: [P [V _ A]]. In the A·V·P clause, however, that dependency will not be fully processed until the final noun, since A gaps are at the end of the clause: [A [V P _]]. However, in languages with flexible word order like Kaqchikel, it is not clear when the comprehender can be said to encounter a gap. Moreover, there are theoretical arguments that comprehenders project a gap position as soon as they encounter the licensing head (Gibson & Hickock 1993). So encountering the verb should be able to cue either an A or P gap equally well. Another important factor consider is whether and how N-before-V and V-before-N argument dependencies are processed differently.

prominence scales, following the extended Argument Dependency Model (eADM; Bornkessel-Schlesewsky & Schlesewsky 2009, 2015). These scales crucially include grammatical role (A outranking P) and linear order (first outranking last). In a bivalent clause, the arguments will be maximally distinct if one has as many possible high prominence values, and the other has as many possible low prominence values. In other words, A-before-P will have an advantage over P-before-A — the latter order's arguments have clashing prominence values, which cause interference in processing. Note that a P1 advantage (as we see for Kaqchikel verb initial clause) could be accommodated in this theory if linear order scale varies across languages. The '*Ang*-Last' processing constraint observed in certain Austronesian languages (Pizarro-Guevarra & Garcia 2024) suggests further parametric variations on the linear prominence scale are possible. It seems unlikely that the prominence scale for grammatical role differs crosslinguistically, for the same semantic reasons that inspired the inherent approach. Other prominence scales are also assumed to be relevant for distinctness calculations (e.g. animacy, case, topicality, person, etc.), and future research should interrogate the etiology and crosslinguistic variability of each.

There are a few key predictions of the distinctness approach to role processing. First is a general preference for structures with fewer arguments. An intransitive/monovalent clause's argument structure is vacuously distinct (Bornkessel-Schlesewsky & Schlesewsky 2009c), therefore disambiguation to S should always be preferable to disambiguation to A or P. Compatible with this prediction is a frequently observed processing penalty for ergative case (only incrementally compatible with A) relative to absolutive (parseable as S or P) — as in Avar (Polinsky et al. 2012) or Basque (Erdocia et al. 2012, Isasi-Isasmendi et al. 2024). Initial inanimate nouns seem also to be preferentially parsed as S rather than A, whenever possible (Bornkessel-Schlesewsky & Schlesewsky 2009, 2015). A second prediction is differential processing among transitive clauses: all else equal, there will be a processing advantage for canonical transitives where A has many Proto Agent properties and P has few, compared to non-canonical transitives where A has fewer Proto Agent properties and P has relatively more (see Hopper & Thompson 1980 for other factors that make transitives more or less canonical). Experiencer–stimulus verbs are one common type of non-canonical transitive, and indeed they are frequently observed to impede processing relative to canonical agentive transitives (e.g. Dillon & Wilson 2023). However, differential processing of intransitives cannot be derived from distinctness; S is vacuously distinct, whatever its thematic interpretation. Findings like Isasi-Isasmendi et al.'s (2024) would need to be explained through some other factor, like the representational prominence of S_A, its case marking, or its frequency relative to S_P.

As role processing is investigated in more typologically diverse languages, the theoretical taxonomy outlined here helps identify design confounds and prioritize linguistic configurations to target experimentally. Awareness of factors like surprisal and representational complexity helps identify the limits of reductionist approaches. Designs that look beyond A vs. P disambiguation are important for teasing apart what, if anything, makes A1 orders inherently easy to process. If it is the A role's thematic properties, then in monotransitives canonical agentive subjects should be easier than noncanonical ones, in intransitives S_A should be easier than S_P, and in ditransitives G should be harder than A but easier than P. Finally, argument structure and word order manipulations are key to understanding the possible interaction of prominence scales relevant for distinctness calculations. Fewer arguments should be better all else equal, as should A·P orders (and A·G·P for ditransitives).

3. Grammatical roles in Georgian

Georgian offers a valuable testing ground for better understanding the mechanisms of role processing, and how they interact with morphosyntactic variation. It is a weakly head final language with flexible word order and null pronouns. Arguments are distinguished by case marking, but different patterns obtain for the same verb in different tenses. The language is therefore classified as a split ergative language (similar to Hindi; cf. Dillon et al. 2012, Bickel et al. 2015). There are no relevant syncretisms, as in German or Basque; a noun's case category is never ambiguous in Georgian. It is the case-to-role mapping which is often up in the air, since the crucial tense cue on the verb might be delayed until the end of the sentence. To wit, the socalled nominative case in incrementally compatible with A, S_A, S_P, or P roles, and the dative case with A, S_A, G, or P. Consequently, sequences of nominative and dative nouns can be parsed in a remarkable number of ways, as illustrated above (1).

As background for the present experiment, this section gives more background on the Georgian language: key morphosyntactic facts (Section 3.1), novel corpus findings (Section 3.2), and some psycholinguistic discussion including a review of a few previous studies on the language (Section 3.3).

3.1 Background on Georgian morphosyntax

Georgian (Shanidze 1953, Aronson 1990, Hewitt 1995) is a member of the South Caucasian language family (Boeder 2005). Word order is very free in Georgian, but A·P·V order is taken to be basic; other orders, including P·A·V, are derived by scrambling operations (Skopeteas et al. 2009, Borise 2023). There is rich verbal agreement (Foley 2021), and null pronouns can occupy any argument position (Harris 1981).

Case marking follows a split ergative pattern conditioned by tense (Harris 1984, Nash 2017). Depending on what tense category the verb is inflected in, subjects and objects will be marked differently. In two of the tenses (including the very frequent aorist / perfective past), ergative case marks A and S_A, nominative case marks P and S_P, and dative case marks G. Examples from the aorist tense follow. This case–role mapping will be referred to as the ErgA pattern.

(6) **The ErgA case pattern**

a.

Amiran-ma	*Giorgi-s*	*P'et're*	*atʃ^{h}vena.*
Amiran-**ERG**	Giorgi-**DAT**	Petre.**NOM**	show:AOR

"Amiran showed Petre to Giorgi"

b.

Salome-m	*its^{h}ina.*
Salome-**ERG**	laugh:AOR

"Salome laughed."

c.

Sp'iridon-i	*daik'arga.*
Spiridon-**NOM**	get_lost:AOR

"Spiridon got lost."

If the ErgA pattern were the only one in Georgian, case would in fact be a very reliable cue to a preverbal noun's grammatical role. In these tenses, ergative case is dedicated to arguments with many Proto Agent properties, nominative to those with many Proto Patient properties, and dative to arguments with few of either. However, the waters are muddied by two parallel case–role mappings, found in other tenses. The second pattern, call it the NomA, is found in a group of tenses that includes the present, future, and imperfective past. There, nominative marks all subjects (A, S_A, and S_P) while dative marks all objects (P and G). See example (7), and compare to the ErgA pattern above (6). Finally, in two other tenses (perfect and pluperfect, which are less frequent and have evidential uses): dative case marks A and S_A, nominative marks P and S_P, and an oblique postposition marks transitive G. Call this the DatA pattern (8). Table 1 summarizes the case marking of A, S_P, P, and G across tense groups.

(7) **The NomA case pattern**

a.

Amiran-i	*Giorgi-s*	*P'et're-s*	*atʃ^{h}venebs.*
Amiran-**NOM**	Giorgi-**DAT**	Petre-**DAT**	show:FUT

"Amiran will show Petre to Giorgi"

b. *Salome* *its*^{h}*inebs.*
Salome.**NOM** laugh:FUT
"Salome will laugh."

c. *Sp'iridon-i* *daik'argeba.*
Spiridon-**NOM** get_lost:FUT
"Spiridon will get lost."

(8) **The DatA case pattern**

a. *Amiran-s* *Giorgi-s-t*^{h}*vis* *P'et're* *utʃ*^{h}*venebia.*
Amiran-**DAT** Giorgi-GEN-**for** Petre.**NOM** show:PERF
"Amiran has shown / must have shown Petre to Giorgi"

b. *Salome-s* *uts*^{h}*inia.*
Salome-**DAT** laugh:PERF
"Salome has laughed / must have laughed."

c. *Sp'iridon-i* *dak'argula.*
Spiridon-**NOM** get_lost:PERF
"Spiridon has gotten / must have gotten lost."

<table>
<tr><th></th><th>Transitive Subject (A)</th><th>Non-agentive Intransitive Subject (S_P)</th><th>Direct Object (P)</th><th>Indirect Object (G)</th></tr>
<tr><td>ErgA Pattern (AOR…)</td><td>ERG</td><td colspan="2">NOM</td><td>DAT</td></tr>
<tr><td>NomA Pattern (FUT…)</td><td colspan="2">NOM</td><td colspan="2">DAT</td></tr>
<tr><td>DatA Pattern (PERF…)</td><td>DAT</td><td colspan="2">NOM</td><td>OBL / DAT</td></tr>
</table>

Table 1: Summary of case marking patterns in Georgian, triggered in different groups of tenses. In the DatA Pattern, G is a postpositional oblique when coargument to A/S_A, but dative elsewhere.

Syntactically, the three case patterns are mostly indistinguishable. Most relevantly, case has no effect on scrambling. (Other major phenomena like *wh*-movement, binding, and idiomatic interpretations are likewise unaffected. Agreement, though, does behave differently in DatA compared to the NomA and ErgA patterns; Harris 1981, Foley 2021.) Nonetheless, theorists of Georgian syntax have posited representational differences in order to derive the case shift (Harris 1981, Nash 2017, Bondarenko & Zompì 2025). These structural differences are mainly motivated by the complexity of inflectional morphology on the verb. The simplest verb forms are found in the ErgA tenses, so these are usually taken to have the simplest clausal structure. In NomA tenses, the verb bares a 'thematic' suffix, taken to evince extra functional structure in the clause. And in the DatA tenses, verbs tend to have both the thematic suffix and an incorporated auxiliary verb. Moreover, transitive clauses in these tenses seem to have noncanonical argument structure, more akin to an applied passive (Marantz 1987 et seq.; cf. Harris 1981). It has been proposed that dative A is introduced not by the canonical functional head, *v*, but rather by another, Appl

(Lomashvili 2011, Bondarenko & Zompì 2025).[3] The following syntactic representations illustrate the hypothesized structural differences across the three tense groups, for ordinary transitive clauses.

(9) a. **Structure of ErgA clauses**[4]
$[_{\text{TP}}\ [_{v\text{P}}\ \text{A}_{\text{ERG}}\ [_{\text{VP}}\ \text{P}_{\text{NOM}}\ \text{V}\ ]\ \text{-}v\ ]\ \text{-T}\ ]$

b. **Structure of NomA clauses**
$[_{\text{TP}}\ [_{\text{ThP}}\ [_{v\text{P}}\ \text{A}_{\text{NOM}}\ [_{\text{VP}}\ \text{P}_{\text{DAT}}\ \text{V}\ ]\ \text{-}v\ ]\ \text{-Th}\ ]\ \text{-T}\ ]$

c. **Structure of DatA clauses**
$[_{\text{TP}}\ [_{\text{AuxP}}\ [_{\text{ThP}}\ [_{v\text{P}}\ [_{\text{ApplP}}\ \text{A}_{\text{DAT}}\ [_{\text{VP}}\ \text{P}_{\text{NOM}}\ \text{V}\ ]\ \text{-Appl}\ ]\ \text{-}v\ ]\ \text{-Th}\ ]\ \text{-Aux}\ ]\ \text{-T}\ ]$

A final important piece of background concerns argument structure alternations. In Georgian, transitive verbs productively alternate with morphological passives. The passive subject is an S_P argument that corresponds thematically to the transitive direct object, P. Both transitives and passives can applicativized — that is, an indirect object G argument can be added. It will trigger characteristic morphology on the verb, usually the prefix *u-*; applied G is usually interpreted as the event's affectee, a benefactor or malefactor. We assume that passives contain a version of the functional morpheme *v* which cannot introduce A (adapting Alexiadou et al. 2015), and that applied G is introduced by a functional item Appl above VP (Pylkkänen 2008).

(10) a. **Baseline transitive** = $[_{\text{TP}}\ [_{v\text{P}}\ \text{A}\ [_{\text{VP}}\ \text{P V}\ ]\ \text{-}v\ ]\ \text{-T}\ ]$
Amiran-ma *Uriel-i* *gaatʃʰera*
Amiran-ERG Uriel-NOM stop:TR:AOR
"Amiran stopped Uriel."

b. **Passive** = $[_{\text{TP}}\ [_{v\text{P}}\ [_{\text{VP}}\ \text{S}_{\text{P}}\ \text{V}\ ]\ \text{-}v\ ]\ \text{-T}\ ]$
Uriel-i *gatʃʰerda*
Uriel-NOM stop:PASS:AOR
"Uriel was stopped."

c. **Applicative transitive** = $[_{\text{TP}}\ [_{v\text{P}}\ \text{A}\ [_{\text{ApplP}}\ \text{G}\ [_{\text{VP}}\ \text{P V}\ ]\ \text{-Appl}\ ]\ \text{-}v\ ]\ \text{-T}\ ]$
Amiran-ma *Giorgi-s* *Uriel-i* *gautʃerʰa*
Amiran-ERG Giorgi-DAT Uriel-NOM stop:APPL:TR:AOR
"Amiran stopped Uriel for/on Giorgi."

[3] It is not clear whether the base position of A differs across case patterns. For NomA clauses, Nash 2017 proposes that A is introduced not by the usual *v* (as in 9a), but by Th (her "Ev"); nonetheless A still has a semantic dependency with *v*. For DatA clauses, Bondarenko & Zompì 2025 propose that A is introduced by Appl in a passive clause lacking *v*; nevertheless a special interpretive rule ensures that it is interpreted identically to A that is introduced by the canonical transitive *v*.

[4] These representations assume broadly a Minimalist Program / Distributed Morphology framework, with respect to argument structure and to the relationship between syntax and morphology (Marantz, Halle & Marantz, Chomsky, Kratzer; for Georgian specifically in this framework, see Lomashvili 2011). The heads of the functional projections posited here generally correspond to verbal affixes. Hence strings like "V] -*v*] -T]" correspond to a single word: the fully inflected verb. Note, though, that the mapping between syntactic structure and observed morphological form is often not straightforward. The -Th of NomA and DatA clause is the thematic suffix, which correlates with certain aspect properties. -Aux is an affix which often resembles a form of the verb "be". -Appl is introduced below, as the usual introducer/licensor of G.

d. **Applicative Passive**[5] = [$_{TP}$ [$_{vP}$ [$_{ApplP}$ G [$_{VP}$ P V] -Appl] -*v*] -T]
Uriel-i *Giorgi-s* *gautʃʰerda*
Uriel-NOM Giorgi-DAT stop:APPL:PASS:AOR
"Uriel was stopped for/on Giorgi."

In sum, Georgian grammar affords many possible ways to combine the grammatical roles A, P, S_P, and G in a clause. Null pronouns and flexible word order make a noun's position within the clause a poor cue to its role. Case is a mixed bag. In preverbal contexts, without reliable cues to tense, only ergative is an informative cue: nominals marked ergative must be A or S_A arguments, and they entail the ErgA pattern. That second inference unlocks the mapping of any other case marked noun preceding the verb: nominative must be P, and dative must be G. But elsewhere — namely in preverbal contexts, without any evidence of ergative — nominative can be grammatically parsed A, S_A, S_P, or P, while dative can be parsed A, S_A, P, or G. Thus preverbal Nom·Dat and Dat·Nom strings can be parsed as combinations of A/P (transitive), S/G (applied intransitive), A/G (ditransitive, with P yet unencountered), or G/P (ditransitive, with A yet unencountered) arguments. The present study focuses on how Georgian comprehenders process the disambiguations of these dramatic role ambiguities.

3.2 Corpus findings

There are many grammatical combinations of case and role in Georgian, and it is possible that their relative frequencies influence how they are processed in real time. We use the morphologically parsed Georgian Reference Corpus (GRC; part of the Georgian National Corpus project, Gippert & Tandashvili 2015) to count key configurations of nouns and verbs, shedding some light on comprehenders' experience with case–role mappings.

First, to give an impression of the relative frequencies of the different case patterns, Table 2 gives frequencies of verbs by tense group and argument structure. The leftmost column of numbers shows clearly that DatA tenses are much less frequent than tenses triggering the other case patterns. The topmost row shows that, among possible argument structures, passive and transitive verbs are comparably frequent. Also, the applicative alternation (which adds a G argument to a transitive or passive) is not at all rare.

		A/P	**S_P**	**A/P/G**	**S_P/G**
		35,500.00	21,000.00	11,100.00	11,900.00
ErgA tenses	39,400.00	18,000.00	10,200.00	6,230.00	4,670.00
NomA tenses	36,400.00	15,200.00	9,920.00	4,580.00	6,780.00
DatA tenses	3,780.00	2,380.00	909.00	—	490.00

Table 2: Number of verbs per million words in the Georgian Reference Corpus (size >202 million words) morphological parsed for various tenses and argument structures. These counts include verbs with first or second person agreement. One cell is blank because the applicative alternation is not available to verbs with dative subjects, including transitive verbs in DatA tenses (Harris 1981).

Second, Table 3 estimates the relative frequency of each grammatical combination of case and role. Verbs were counted in the GRC according to morphological tags for various tense, argument structure, and

[5] The syntactic behavior of applicative passives is more labile than transitives. For some predicates and/or in some discourse contexts, either the S_P or the G argument can exhibit subjecthood properties like number agreement and binding (Tuite 1987, Cherchi 1997). There might in fact be multiple phrase structural representations for this clause type, with either one in a higher base position.

agreement features, following Foley (to appear). From this it can be deduced the number of syntactic arguments from each role licensed by the verbs. The first row shows that nouns in A, S_P, or P roles are roughly comparable in frequency, while G is less common. Scanning across the case categories in the first column: nominative nouns are more common than dative, which are more common than ergative. All ergative nouns, of course, take the A role. As for nominative nouns, they usually have the parse P or S_P, but the A role is not rare. Dative nouns are mostly P or G, and only rarely A.

		N→A	**N→S_P**	**N→P**	**N→G**
	131,000.00 (100%)	37,200.00 (28%)	30,100.00 (23%)	46,000.00 (35%)	18,200.00 (14%)
N.NOM	72,500.00 (55%)	15,800.00 (12%)	30,100.00 (23%)	26,600.00 (20%)	—
N.DAT	39,400.00 (30%)	1,780.00 (1%)	—	19,400.00 (15%)	18,100.00 (13%)
N.ERG	19,500.00 (15%)	19,500.00 (15%)	—	—	—

Table 3: Estimated number of nominal arguments per million words in the GRC, by case and grammatical role. (Namely, the estimated number of third person arguments licensed throughout the corpus, as deduced from the morphological features of counted verb.) Given in parentheses are percentages for each combination across the total number of deduced arguments.

The above estimates, being derived from counts of verbs, abstract away from nominal arguments' linear position and even overtness. Another set of counts were conducted for strings of morphologically parsed nouns and verbs. First, Table 4 gives counts for singleton strings of nominative, dative, and ergative nouns. Relative proportions of parses for immediately preverbal nouns is qualitatively similar to the order-independent estimates in Tables 2 and 3. So, with respect to their case–role mapping, immediately preverbal nouns are representatives of nouns across all linear positions.

	Nom	**Dat**	**Erg**
Anywhere	71,900.00	30,000.00	8,530.00
/ _ $V_{\{A\}}$	1,100.00	57.60	905.00
/ _ $V_{\{S\}}$	3,710.00	—	—
/ _ $V_{\{P\}}$	3,040.00	2,450.00	—
/ _ $V_{\{G\}}$	—	2,160.00	—

Table 4: Number of nouns per million words in the GRC, by case and role. This only includes N·V strings that do not follow another noun, and which only have 3rd person agreement morphology. "Anywhere" refers to case marked nouns found in any sentential context, parsed in any role. The other rows report numbers of nouns immediately before (i.e. "/ _ ") a verb, whose morphology disambiguates their role (e.g. "$V_{\{A\}}$", abbreviating "a verb disambiguating the previous noun to A").

Table 5 reports counts of key noun–noun strings. Boxed together are clauses with the same case–role mappings, but with opposite word order. When it comes to strings parsable as transitive N1·N2·V clauses (the first two rows under "Anywhere"), the disharmonic P·A order is always less frequent than the harmonic A·P order. Note, though, that the bias towards A·P order is weaker for clauses with the DatA case pattern (14.40 vs. 9.04) than for the ErgA (253.00 vs. 73.70) or NomA patterns (346.00 vs. 98.80). As for applicative passive clauses (next two rows), recall that there nominative and dative can only be parsed as S_P and G, respectively. Both word order alternatives are about equally frequent, G1 in fact pulling out ahead. (This is unsurprising given the argument structural lability of applicative passive clauses; see footnote 5.) For applicative transitive verbs — and other ditransitives; last four rows — harmonic word orders where A precedes G and G precedes P are more frequent than the opposite disharmonic word orders (G·A and P·G).

Values in the first two columns give an impression of comprehenders' experience with the relative frequency of various parses for incrementally ambiguous N1·N2 strings. Nom·Dat most often has an A·P parse; disharmonic orders, especially P·A, are infrequent. As for Dat·Nom, the most frequent parses are G·P and G·S_P; A·P and G·A parses are infrequent.

	Nom·Dat	**Dat·Nom**	**Erg·Nom**	**Nom·Erg**
Anywhere	1,590.00	1,300.00	520.00	289.00
/ _ $V_{\{A\cdot P\}}$	205.00	9.98	141.00	—
/ _ $V_{\{P\cdot A\}}$	†5.14	†59.00	—	†43.40
/ _ $V_{\{S\cdot G\}}$	85.60	—		
/ _ $V_{\{G\cdot S\}}$	—	†94.30		
/ _ $V_{\{A\cdot G\}}$	70.20	—		
/ _ $V_{\{G\cdot A\}}$	—	†8.61		
/ _ $V_{\{P\cdot G\}}$	†25.90	—		
/ _ $V_{\{G\cdot P\}}$	—	94.20		

Table 5: Number of noun–noun strings per million words in the GRC, by case and role. This only includes N·V strings that do not follow another noun, and which only have 3rd person agreement morphology. "Anywhere" refers to strings in any sentential context, roles parsed in any way. "/ _ $V_{\{A\cdot P\}}$" means "immediately before a verb whose morphology disambiguates N1 to A, and N2 to P". The symbol "†" marks a disharmonic word order, where a thematically less prominent argument precedes a more prominent one. Cells boxed together correspond to clause types differentiated only by word order.

A way to express the degree of word order freedom for a given case–role mapping is a 'linear harmony ratio': the count of strings parsed in harmonic orders (A·P, A·G, S_P·G, or G·P) divided by the disharmonic string count (P·A, G·A, G·S_P, or P·G). Among bivalent clauses (first four rows), the strongest bias towards the harmonic word order is for ErgA and NomA transitive clauses. The harmony ratio is markedly lower for DatA transitives. Recall that in this case pattern the A role has noncanonical agreement properties. Moreover, the tenses triggering it often have evidential interpretations — a semantic property that lowers a clause's prototypical transitivity (Hopper & Thompson 1980). Consequently, on both morphosyntactic and interpretive grounds, the distinctness of A and P arguments is diminished given the DatA pattern. So it is worth remarking that scrambling is more frequent for A_{DAT}/P_{NOM} clauses; the A1 bias is more modest than for these transitives with for the other case patterns. The weakest bias of all is for S_P/G applicative passives. Among bivalent clauses, this is the least thematically distinct, as neither argument has many Proto Agent properties. Together, these facts evince a deep correlation between prominence scales. Word order has few grammatical constraints in Georgian, and none that interact directly with case. Yet, what emerges from corpus data is the generalization that word order becomes less variable (i.e. harmonic orders are more frequent) as the morphosyntactic–semantic distinctness of the two arguments increases.

Case–role pair	Linear harmony ratio
A_{ERG}/P_{NOM}	3.26
A_{NOM}/P_{DAT}	3.49
A_{DAT}/P_{NOM}	1.94
S_{NOM}/G_{DAT}	0.91
A_{NOM}/G_{DAT}	8.15
G_{DAT}/P_{NOM}	3.64

Table 5: Linear prominence ratios (see text) for various case–role strings.

It is worth considering the opposite state of affairs: a language where word order flexibility is positively correlated with distinctness, rather than negatively. That is, a language Georgian′ where applicative passives had the highest harmony ratio, and NomA/ErgA transitives the lowest. From the point of view of hearer economy (Horn 2006), this would be a more optimal system. Less variable, more harmonic word order for S_P/G clauses would compensate for their arguments' relative indistinctness; comprehenders would be more likely to retrieve the signal. Contrariwise, more variable word order for A_{ERG}/P_{NOM} transitives would be tolerated due to the arguments' relative distinctness, facilitating comprehension. It is an empirical question whether there are any flexible word order languages like Georgian′. For Georgian proper, it seems that word order flexibility is negatively correlated with distinctness. Perhaps some aspect of language production (like speaker economy), is a better explanation for these corpus findings.

That being said, the negative flexibility–distinctness correlation does not seem to extend to pairs of arguments of a ditransitive (last two rows of Table 5): G frequently precedes P, and A very frequently precedes G. Yet, both of those argument pairs is less thematically distinct than the A/P pair; we might have expected the bias towards harmonic orders to be weaker. The difference in harmony ratios between G/P and S_P/G strings is particularly stark, given those argument structures' phrase structural similarity (10c,d).

3.3 Georgian sentence processing

To date a handful of sentence processing experiments have been conducted on Georgian (Skopeteas et al. 2012, Foley 2020, Lau et al. 2022), most grappling in one way or another with split ergativity and incrementally ambiguous grammatical roles. The seminal study is Skopeteas et al. 2012, a forced choice acceptability judgement task on Nom/Dat verb final sentences. The two nouns were displayed in isolation, and after a delay the verb appeared, along with a binary acceptability prompt. In one experiment, the design crossed word order (A·P·V or P·A·V) and case pattern (NomA or DatA) for transitive clauses. In the second, word order was crossed with verb class: applied passives (S_{NOM}/G_{DAT}) were compared to psych verbs (Ex_{DAT}/Th_{NOM}, where Ex is the experiencer subject and Th is the stimulus object). All critical items were grammatical.

Analyzing response times, Skopeteas et al. find in Experiment 1 that DatA transitives were endorsed more slowly than NomA transitives; there was neither a main effect of nor interaction with word order. From this the authors infer a processing cost associated with the DatA case — sensible, as that is the most marked and least frequent of the case patterns. The lack of word order effect suggests that the scrambling operation responsible for P1 orders does not come with a major processing cost during this task. In Experiment 2, they find an interaction between word order and verb class, such that the Nom·Dat→Th·Ex condition was endorsed more slowly than all the others. The authors suggest this may have something to do with representational differences between dative Ex as opposed to A or G arguments.

Building on Skopeteas et al. 2012, Foley (2020, chapter 2) ran a self paced reading experiment manipulating word order (A·P·V or P·A·V) and case pattern (ErgA or NomA) of transitive clauses. Sample stimuli follow. Foley finds fast reading times at the verb in Erg·Nom→A·P·V (11a), but slow verb RTs for the other three conditions (11b–d). As a potential explanation, Foley (2020) hypothesizes that a role ambiguous noun will be assigned the most prominent role grammatically compatible with its case. Since ergative can only be parsed as A, and since it disambiguates the role of all following arguments, the Erg·Nom→A·P·V condition (11a) will never require grammatical role revisions upon encountering the verb. As for the Nom·Erg→P·A·V condition (11b), nominative would be most optimally parsed as A (the most prominent role compatible with that case out of the blue); ergative at N2 disconfirms that. The slow RTs for the verb at this condition is considered a spillover effect of the revision caused by Erg2. In this way, comprehenders of Georgian seem to behave like those of other verb final ergative languages (like Basque and Avar; see Section 2.2).

(11) a. **Erg·Nom→A·P·V (N1 disambiguates)**

ianvar-ʃi	*pʰeχburtʰel-ma*	*q'ru*	*dedopʰal-i*	*gaitsʰno*	*it'aliur*	*op'era-ʃi.*
January-in	footballer-ERG	deaf	queen-NOM	meet:AOR	Italian	opera-in

"In January the footballer met the deaf queen at the Italian opera."

b. **Nom·Erg→P·A·V (N2 disambiguates)**

ianvar-ʃi	*pʰeχburtʰel-i*	*q'ru*	*dedopʰal-ma*	*gaitsʰno*	*it'aliur*	*op'era-ʃi.*
January-in	footballer-NOM	deaf	queen-ERG	meet:AOR	Italian	opera-in

"In January the deaf queen met the footballer at the Italian opera."

c. **Nom·Dat→A·P·V (V disambiguates)**

ianvar-ʃi	*pʰeχburtʰel-i*	*q'ru*	*dedopʰal-s*	*gaitsʰnobs*	*it'aliur*	*op'era-ʃi.*
January-in	footballer-NOM	deaf	queen-DAT	meet:FUT	Italian	opera-in

"In January the footballer will meet the deaf queen at the Italian opera."

d. **Dat·Nom→P·A·V (V disambiguates)**

ianvar-ʃi	*pʰeχburtʰel-s*	*q'ru*	*dedopʰal-i*	*gaitsʰnobs*	*it'aliur*	*op'era-ʃi.*
January-in	footballer-DAT	deaf	queen-NOM	meet:FUT	Italian	opera-in

"In January the deaf queen will meet the footballer at the Italian opera."

(Foley 2020:42, glosses adapted)

As for the NomA conditions (11c,d), verb RTs were about equal across word orders, and both slower than Erg1 (11a). This result is interpreted as further evidence for the incremental harmonic alignment strategy, crucially assuming that G is ranked between A and P in terms of role prominence. By the logic of that theory, Nom1 and Dat1 are both most optimally mapped to the A role upon disambiguation by the verb. Given the Dat·Nom string, since Dat1 has claimed the A role, the most optimal parse for Nom2 is P. However, this A·P parse will be foiled by verb in condition 11d. There tense cues signal instead the NomA case pattern, and thus P·A order. For Nom·Dat, the most optimal parse for Dat2 is predicted to be G; the monotransitive verb in 11c would foil that A·G parse, interfering with processing. Thus incremental harmonic alignment predicts processing difficulty for both orders of NomA transitives. Extrapolating, DatA transitives are expected to be easy to process in Dat·Nom→A·P configurations (cf. 14a below), but hard in Nom·Dat→P·A (13b) due to the possibility of Nom1→A.

Taking stock, for simple verb final clauses in Georgian, effects of word order have been observed in only certain configurations. Foley 2020 finds an A1 advantage for ErgA transitive clauses — i.e. Erg·Nom→A·P configurations are easier than Nom·Erg→P·A. Skopeteas et al. 2012 finds an Ex1 advantage for dative subject experiencer clauses — Dat·Nom→Ex·Th is easier than Nom·Dat→Th·Ex, with the verb disambiguating. But in NomA and DatA transitives, verb RTs are about equal across A·P and P·A word orders; for applied passives, S_P·G and G·S_P are also about equal (Skopeteas et al. 2012; also Foley 2020 for NomA). Some of these facts suggest a penalty for structurally complex clause types (viz.

DatA transitives, relative to NomA), and others are compatible with a parsing strategy involving incremental harmonic alignment.

4. Lexicality Maze experiment

Following up on Skopeteas et al. 2012 and Foley 2020, a reading time experiment was designed to test how comprehenders of Georgian process role disambiguation in Nom·Verb, Nom·Dat·Verb, and Dat·Nom·Verb configurations. Three subexperiments featured each of those strings, manipulating word order and grammatical role via tense and argument structure morphology on the verb. These subexperiments were copresented together with fillers, across two experimental sessions.

The methodology was Lexicality Maze task (Freedman & Forster 1985, Boyce et al. 2020). This version of self paced reading involves a series of lexicality decisions between a real Georgian word and a pseudoword. Correctly selecting the real words incrementally spells out a grammatical sentence. This methodology was chosen over standard self paced reading because it should encourage whole sentence comprehension more, and minimize spillover effects in reading time measures.[6]

The three subexperiments each had four conditions, corresponding to different parses of Nom and Nom/Dat strings. The configurations tested in each condition of the experiment are characterized in the following examples. (The actual stimuli sentences were a bit longer, and lexical items were held constant within itemsets only within subexperiments; see Section 4.1.1.)

(12) **Nom→A·V·P – Monotransitive, NomA case pattern**

a. *ekʰim-i* *gaatʃʰerebs* *mts'eral-s* *ezo-ʃi*
doctor-NOM stop:TR:FUT writer-DAT garden-in
"The doctor will stop the writer in the garden"

Nom→S_P·V·X – Passive, any case pattern

b. *ekʰim-i* *gatʃʰerdeba* *mts'erl-is* *ezo-ʃi*
doctor-NOM stop:PASS:FUT writer-GEN garden-in
"The doctor will be stopped in the writer's garden"

Nom→S_P·V·G – Applicative passive, any case pattern

c. *ekʰim-i* *gautʃʰerdeba* *mts'eral-s* *ezo-ʃi*
doctor-NOM stop:PASS:APPL:FUT writer-DAT garden-in
"The doctor will be stopped on/for the writer in the garden"

Nom→P·V_{AgrA}·X – Monotransitive, ErgA/DatA case pattern, 1st/2nd person A-agreement

c. *ekʰim-i* *gavatʃʰere* *mts'erl-is* *ezo-ʃi*
doctor-NOM stop:TR:AOR:1SGA writer-GEN garden-in
"I [*pro*] stopped the doctor in the writer's garden"

(13) a. **Nom·Dat→A·P·V·X – Monotransitive, NomA case pattern**

ekʰim-i *metʰevze-s* *gaatʃʰerebs* *mts'erl-is* *ezo-ʃi*
doctor-NOM fisherman-DAT stop:TR:FUT writer-GEN garden-in
"The doctor will stop the fisherman in the writer's garden"

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[6] Arguably the Grammaticality Maze is an even better alternative for these reasons (Boyce et al. 2020). However, this version of the Maze requires generating for each word an ungrammatical or high surprisal foil, rather than a pseudoword foil. There was no practical way for to accomplish that in this research project.

b. **Nom·Dat→P·A·V·X – Monotransitive, DatA case pattern**
ekʰim-i *metʰevze-s* *gautʃʰerebia* *mts'erl-is* *ezo-ʃi*
doctor-NOM fisherman-DAT stop:TR:PERF writer-GEN garden-in
"The fisherman has stopped the doctor in the writer's garden"

c. **Nom·Dat→A·G·V·P – Ditransitive, NomA case pattern**
ekʰim-i *metʰevze-s* *gautʃʰerebs* *mts'eral-s* *ezo-ʃi*
doctor-NOM fisherman-DAT stop:TR:APPL:FUT writer-DAT garden-in
"The doctor will stop the writer for/on the fisherman in the garden" [A·G·V·P reading]
or "The doctor will stop the fisherman for/on the writer in the garden" [A·P·V·G reading]

d. **Nom·Dat→P·G·$\mathbf{V_{AgrA}}$·X – Ditransitive, ErgA case pattern, 1st/2nd A-agreement**
ekʰim-i *metʰevze-s* *gavutʃʰere* *mts'erl-is* *ezo-ʃi*
doctor-NOM fisherman-DAT stop:TR:APPL:AOR:1SGA writer-GEN garden-in
"I [*pro*] stopped the doctor for/on the fisherman in the writer's garden."

(14) a. **Dat·Nom→A·P·V·X – Monotransitive, DatA case pattern**
ekʰim-s *metʰevze* *gautʃʰerebia* *mts'erl-is* *ezo-ʃi*
doctor-DAT fisherman.NOM stop:TR:PERF writer-GEN garden-in
"The doctor has stopped the fisherman in the writer's garden"

b. **Dat·Nom→P·A·V·X – Monotransitive, NomA case pattern**
ekʰim-s *metʰevze* *gaatʃʰerebs* *mts'erl-is* *ezo-ʃi*
doctor-DAT fisherman.NOM stop:TR:FUT writer-GEN garden-in
"The fisherman will stop the doctor in the writer's garden"

c. **Dat·Nom→G·A·V·P – Ditransitive, NomA case pattern**
ekʰim-s *metʰevze* *gautʃʰerebs* *mts'eral-s* *ezo-ʃi*
doctor-DAT fisherman.NOM stop:TR:APPL:FUT writer-DAT garden-in
"The fisherman will stop the writer for/on the doctor in the garden" [G·A·V·P reading]
or "The fisherman will stop the doctor for/on the writer in the garden" [P·A·V·G reading]

d. **Nom·Dat→G·P·$\mathbf{V_{AgrA}}$·X – Ditransitive, ErgA case pattern, 1st/2nd A-agreement**
ekʰim-s *metʰevze* *gavutʃʰere* *mts'erl-is* *ezo-ʃi*
doctor-DAT fisherman.NOM stop:TR:APPL:AOR:1SGA writer-GEN garden-in
"I [*pro*] stopped the fisherman for/on the doctor in the writer's garden."

The targeted parses were chosen to test the following theoretical questions about role comprehension, crucially leveraging unique properties of Georgian grammar. The complexity/economy questions (15a–c) are motivated in particular by evidence from Kaqchikel that cues to structurally complex word orders cause processing difficulty (Yasunaga et al. 2015). For Georgian, we assume that DatA tenses are more structurally complex than NomA tenses (9); we also assume that the applicative alternation corresponds to an extra functional projection (10). It is also worth considering whether the number of arguments in a clause contributes processing costs (Bornkessel-Schlesewsky & Schlesewsky 2009c), rather than the number of functional projections. Disharmonic word orders (viz. P·A, G·S_P, G·A, and P·G) are taken to be derived by a movement operation like scrambling (i.e. from the harmonic/basic orders A·P, S_P·G, A·G or G·P), which could incur an different kind of complexity cost.

The remaining questions (15d–f) are relevant to the nature of the A1 advantage. One typologically notable property of Georgian split ergativity is that any of the core cases can be parsed as A out of the blue. An inherent approach to the A1 advantage predicts processing difficulty whenever the initial noun has any other role (cf. 15d): namely, cues to Nom→S_P, Nom→P, Dat→P, or Dat→G parses. In contrast, the relational approach predicts differential processing costs to various cues (15e), depending on the linguistic properties of elements across the clause. Cues to less distinct argument structures (e.g. S_P/G applicative passives and DatA/perfect-tense transitives) will impede processing relative to more distinct ones (NomA and ErgA transitives). Ditransitives (A/G/P clauses) should also be hard, since G is relatively indistinct from both A and P roles, compared to just the A/P pair on its own in a monotransitive. On the other hand, if the P parse are harder to process than G due to incremental harmonic alignment, then Nom·Dat→A·G cues will be easier than Nom·Dat→A·P (15f). Table 6 summarizes these predictions.

(15) a. **Structural Complexity:** Do processing costs increase with phrase structural complexity of tense / case patterns or argument structures?

b. **Argument Economy:** Is a monovalent clause easier to process than a bivalent one? Is bivalent easier than trivalent?

c. **Derivational Complexity:** Do cues to disharmonic/noncanonical word orders derived from scrambling interfere with processing?

d. **A1 Advantage:** Given a role ambiguous noun, is A always the best parse? (Particularly/only for high animacy arguments?)

e. **Distinctness:** Among bivalent clauses, are highly distinct ones (i.e. canonical transitives) easier to process than less distinct ones (noncanonical transitives and applied passives)?

f. **Incremental Harmonic Alignment:** After A, is G the next best parse for an ambiguous noun? (Particularly/only for high animacy arguments?)

		Strux	Deriv	Econ	A1	Dist	IHA
Nom→	**A·V·P (12a)**			*			
	S·V·X (12b)				*	—	*
	S·V·G (12c)	*		*	*	*	*
	P·V_{Agr}·X (12d)			*	*		*
Nom·Dat→	**A·P·V·X (13a)**			*			*
	P·A·V·X (13b)	*	*	*	*	*	*
	A·G·V·P (13c)	*		**		*	
	P·G·V_{Agr}·X (13d)	*	*	**	*	**	**
Dat·Nom→	**A·P·V·X (14a)**	*		*		*	
	P·A·V·X (14b)		*	*	*		*
	G·A·V·P (14c)	*	*	**	*	**	*
	G·P·V_{Agr}·X (14d)	*		**	*	**	**

Table 6: Summary of processing costs predicted by various theories of grammatical role processing, at the crucially disambiguating verbs across the experimental conditions.

Two minor design confounds of this experiment are important to mention. First, recall that both P and G are dative in NomA tenses; consequently the Nom·Dat→A·G·V·P (13c) and Dat·Nom→G·A·V·P

(14c) conditions are globally ambiguous, as the translations suggest. Applicative morphology, though, does make those conditions unambiguously ditransitive (i.e. trivalent, not merely bivalent) upon encountering the verb. The second potential issue is verbal agreement morphology in the P·V_{AgrA}·X (12d), P·G·V_{AgrA}·X (13d), and G·P·V_{AgrA}·X (14d) conditions. There, special affixes (which often occur in the middle of the word) unambiguously signal a first or second person A argument. It is possible that the visual processing of that morphology burdens the comprehender in a way independent of the case–role mapping, cued by different morphology on the verb.

Having outlined the present study and unpacked its design motivation, this section will next detail the materials, methods, participants, procedure, and data analysis (Section 4.1). Then the reading time data will be presented an analyzed, organized according to preverbal string: Nom·Verb, Nom·Dat·Verb, and Dat·Nom·Verb (Section 4.2). Post hoc pairwise comparisons are presented separately as an exploratory analysis (Section 4.3). Then a general discussion summarizes and synthesizes findings (Section 4.4).

4.1 Experimental design

4.1.1 Materials

208 total itemsets were constructed: 24 for the Nom·V subexperiment, 32 for Nom·Dat·Verb, and 32 for Dat·Nom·Verb, and 120 additional fillers of comparable length and complexity. Two lists of 104 items were created from half the fillers and half of the itemsets from each subexperiment. Those lists were the stimuli for two experimental sessions; most participants took both sessions, on different days. Within each session, critical itemsets were distributed by the Latin Square method, and shuffled among the fillers. All materials and instructions were created with the assistance of four native speaker research assistants based in Tbilisi.

Each subexperiment had four conditions, whose structural properties are discussed above (12–14). The first word of all itemsets was a single word modifier, an adjective or adverb. The last two words formed a modifier PP. The immediately postverbal noun was either a genitive constituent within that PP, or a dative argument of the verb, depending on the condition. A preverbal particle (either *ar* 'not', *ver* 'cannot', or *unda* 'must/should') appeared for some conditions of some itemsets, presented separately from the other words. These particles were included to improve the semantic naturalness of certain tense or argument structure combinations. The key nouns (N1, N2, and N3) mostly referred to humans, but in a few itemsets they were nonhuman animals. The templates are schematized in (16) and sample itemsets are given in (17).

(16) Sentence templates for critical stimuli

a. Nom·V subexperiment
Mod – N1:NOM – (PRT) – V – N2:DAT/GEN – Spill1 – Spill2

b. Nom·Dat·V subexperiment
Mod – N1:NOM – N2:DAT – (PRT) – V – N3:DAT/GEN – Spill1 – Spill2

c. Nom·Dat·V subexperiment
Mod – N1:DAT – N2:NOM – (PRT) – V – N3:DAT/GEN – Spill1 – Spill2

(17) a. *zʁvaze mek'obre* {(i) *gaabrazebs k'ap'it'ans* (ii) *gabrazdeba k'ap'it'nis* (iii) *gaubrazdeba k'ap'it'ans* (iv) *gaabraze k'ap'it'nis*} *ʃetsʰdomis gamo.*
(i) **A·V·P**: "At sea the pirate will anger the captain because of the mistake."
(ii) **S·V·X**: "At sea the pirate will get angry because of the captain's mistake."
(iii) **S·V·X**: "At sea the pirate will get angry on/for the captain because of the mistake."
(iv) **P·V_{AgrA}·X**: "At sea you angered the pirate because of the captain's mistake."

b. *enamziani eltʃʰi p'rezident's* {(i) *daap'at'iʒebs tsʰolis* (ii) *daup'at'iʒebs tsʰols* (iii) *ar daup'at'iʒebia tsʰolis* (iv) *davup'at'iʒetʰ tsʰolis*} *saaʁdgomo zeimze.*
   (i) **A·P·V·X**: "The eloquent ambassador will invite the president to his wife's Easter party."
   (ii) **P·A·V·X**: "The president hasn't invited the eloquent ambassador to his wife's Easter party."
   (iii) **A·G·V·P**: "The eloquent ambassador will invite his wife to the Easter party for/on the president."
   (iv) **P·G·V$_{\mathbf{AgrA}}$·P**: "We invited the eloquent ambassador for the for his wife's Easter party."

c. *mosiq'varule bebias datʰo* {(i) *unda gamoek'veba ʃviliʃvilis* (ii) *gamouk'vebavda ʃviliʃvils* (iii) *gamovuk'vebetʰ ʃviliʃvilis* (iv) *gamok'vebavda ʃviliʃvilis*} *ardadegebis dros.*
   (i) **A·P·V·X**: "The loving grandmother should have provided for Dato during her/his grandchild's school holidays."
   (ii) **P·A·V·X**: "Dato would provide for the loving grandmother during her/his grandchild's school holidays."
   (iii) **A·G·V·P**: "Dato would have provided for the loving grandmother's grandchild during the school holidays."
   (iv) **G·P·V$_{\mathbf{AgrA}}$·X**: "We provided for Dato for/on the loving grandmother during her/his grandchild's school holidays."

4.1.2 Method, procedure, and participants

As described above, the L-Maze tasks participants with making a series of incremental forced choice lexicality decisions across a sentence. For every itemset, each word was paired with a pseudoword of equal orthographic length. Pseudowords were generated automatically from Georgian trigram frequencies. Each real/pseudo pair 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.

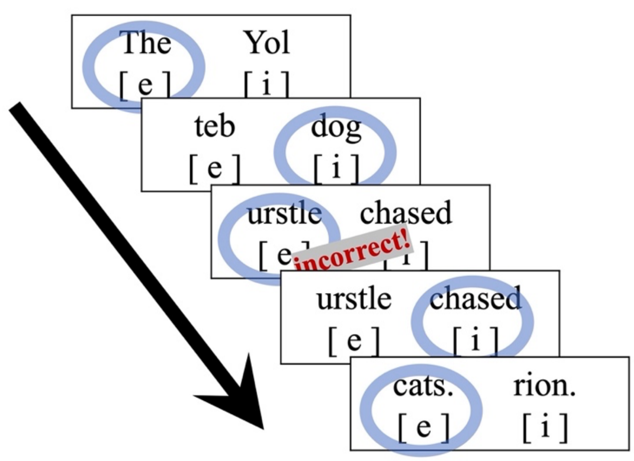

Figure 1: Illustration of the L-Maze methodology in English. The participant's selections, input with the keyboard, are indicated with blue circles.

This experiment had no comprehension questions, or any other attention check besides the L-Maze task itself. A button mashing strategy is not viable in the Maze, so there is little doubt that the participants are reading the stimuli. However, deep syntactic processing is not strictly necessary to complete the L-Maze, and perhaps a comprehension check could have incentivized it more. Nonetheless, the results are quite clear and interpretable overall, suggesting that participants' engagement with the materials was more than superficial. Results were also highly localized to the disambiguating verbs, without spillover effects.

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 evenly spaced. Each session ended with optional debriefing questions.

56 native speakers of Georgian residing across Georgia participated in the study. They were recruited through the social networks of four research assistants residing in Tbilisi. 44 participants took both experimental sessions; 38 took Session A first, and 6 took Session B first. Another eight participants took only Session A, and four took only Session B. Every participant was paid 30 GEL per experimental session they participated in.

4.1.3 Analysis

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; 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, all correct lexicality decisions made after an error were also excluded. This left 88% of all collected critical data for analysis.

Mixed linear effects models were run on log transformed RTs, using the R package *lme4* (Bates et al. 2015). For each subexperiment, the critical verb region and the immediately following noun were analyzed. The contrast coding schemes used for the models are given in Table 7.[7] Models use the maximal random effect structure that converged (Barr et al. 2013). Interaction effects were investigated by pairwise comparison using *emmeans* (Lenth et al. 2020).

		F1 = Voice	**F2 = Mark**
Nom→	**A·V·P**	–1/2	–1/2
	S·V·X	+1/2	–1/2
	S·V·G	+1/2	+1/2
	P·V_{AgrA}·X	–1/2	+1/2

		F3 = ArgStrux	**F4 = NomRole**
Nom·Dat→	**A·P·V·X**	–1/2	–1/2
	P·A·V·X	–1/2	+1/2
	A·G·V·P	+1/2	–1/2
	P·G·V_{AgrA}·X	+1/2	+1/2
Dat·Nom→	**A·P·V·X**	–1/2	+1/2
	P·A·V·X	–1/2	–1/2
	G·A·V·P	+1/2	–1/2
	G·P·V_{AgrA}·X	+1/2	+1/2

Table 7: Summary of the contrast coding scheme used to analyze the three subexperiments. See footnote 7 for details.

[7] The Nom·Verb subexperiment was sum coded with two contrast factors: F1 compared active transitive clauses to passive clauses; F2 compared unmarked structures (A1 transitives; simple passives) to marked structures (applied passives; P1 transitives with A-agreement). The Nom·Dat·Verb and Dat·Nom·Verb subexperiments were sum coded with the same two factors: F3 compared monotransitive to ditransitive clauses; F4 compared the conditions with the Nom→A parse to the Nom→P conditions.

4.2 Results

Figures 2–4 show mean log transformed response times for each word region. RTs at preverbal particles, which only appeared in a small number of items, are omitted. The following visual conventions aid in comparison across plots. Color groups together conditions with similar verbal inflection: i.e. tense, argument structure, and/or agreement. Shape distinguishes intransitive (circle), monotransitive (triangle), and ditransitive (square) argument structures. Harmonic word orders have shapes with a flat edge at the bottom; disharmonic word orders have a corner pointing down.

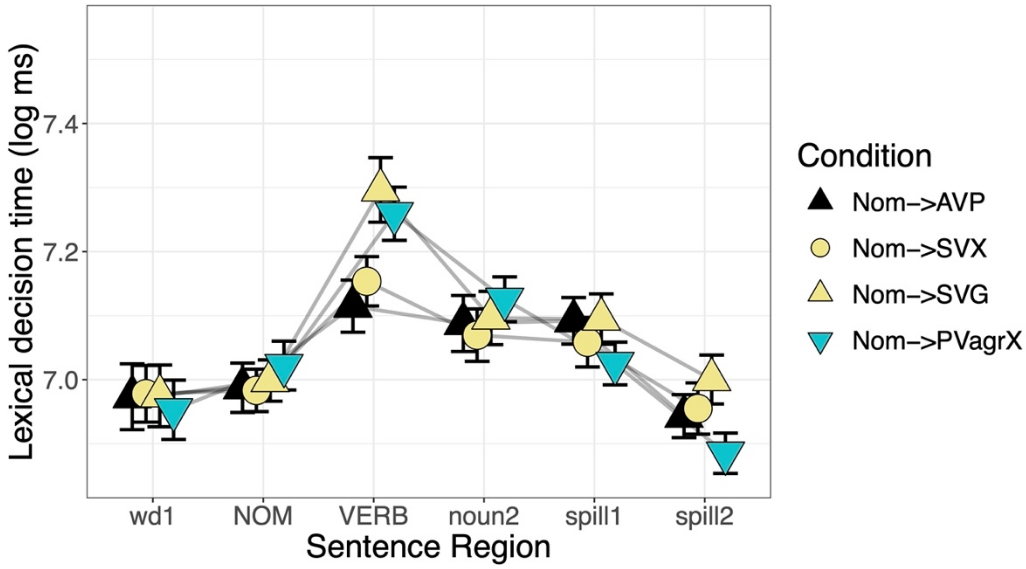

Figure 2: RTs by region for the Nom·Verb subexperiment, in log milliseconds. Points give mean RTs, and bars indicate one by-participant standard error.

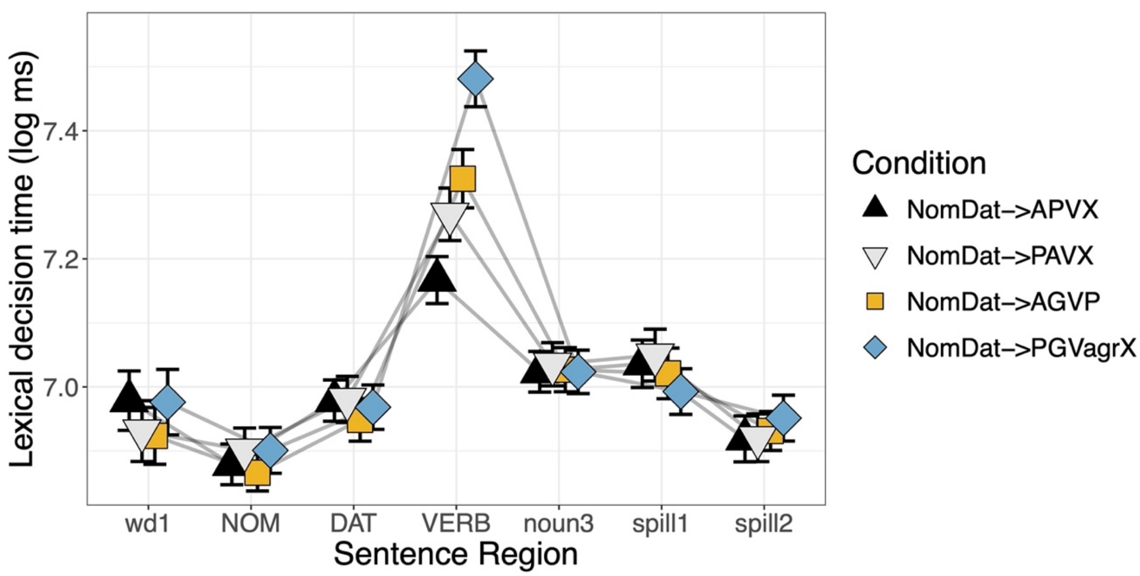

Figure 3: RTs by region for the Nom·Dat·Verb subexperiment, in log milliseconds. Points give mean RTs, and bars indicate one by-participant standard error.

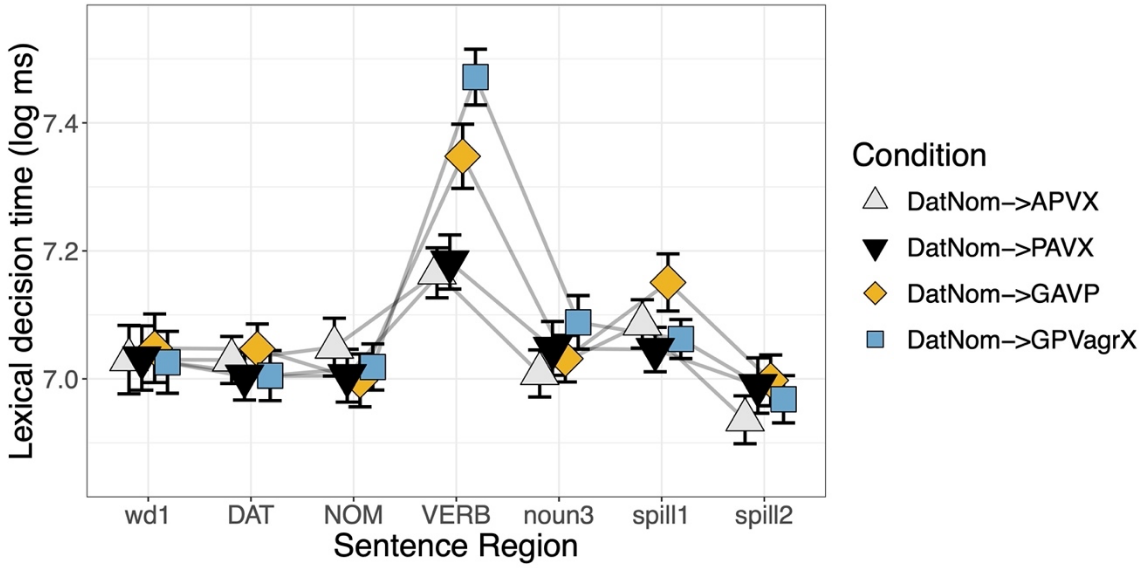

Figure 4: RTs by region for the Dat·Nom·Verb subexperiment, in log milliseconds. Points give mean RTs, and bars indicate one by-participant standard error.

Results of linear modeling are summarized in the following tables. First consider the Nom·Verb subexperiment. At the disambiguating verb, there was a main effect of the factor Markedness (Table 8): on average, verbs in the relatively marked S·V·G and P·V_{AgrA}·X conditions were read more slowly than verbs in the unmarked A·V·P and S·V·X conditions. At the postverbal noun region, the effect of Markedness is marginal (Table 9).

Nom·Verb subexperiment, Verb region
LogRT ~ Voice*Mark + (1+Voice*Mark|Participant) + (1+Voice|Itemset)

	Estimate	**SE**	**df**	***t***	***p***	
Intercept	7.1	0.046	57	150	< 0.001	***
Voice	0.037	0.045	42	0.85	0.41	
Mark	0.16	0.037	51	4.2	< 0.001	***
Voice:Mark	0.0054	0.050	81	0.11	0.91	

Table 8: Results of linear mixed effect modeling of log RTs at the verb region of the Nom·Verb subexperiment. Random effect structure is shown in *lmer* syntax.

Nom·Verb subexperiment, Postverbal noun region
LogRT ~ Voice*Mark + (1|Participant) + (1+Voice+Mark|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	
Mark	0.048	0.033	57	1.7	0.086	.
Voice:Mark	–0.020	0.044	950	–0.46	0.64	

Table 9: Results of linear mixed effect modeling of log RTs at the first postverbal spillover region of the NomVerb subexperiment. Random effect structure is shown in *lmer* syntax.

Next consider the Nom·Dat·Verb subexperiment. At the verb, there were main effects of ArgStrux and NomRole (Table 10): ditransitive verbs were read more slowly than monotransitives, and verbs cueing Nom→P were read more slowly than verbs cueing Nom→A. There were no significant effects at the postverbal noun region.

Nom·Dat·Verb subexperiment, Verb region
LogRT ~ ArgStrux*NomRole + (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	***
NomRole	0.16	0.029	1300	5.5	< 0.001	***
Arg:Nom	–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 the Nom·Dat·Verb subexperiment. Random effect structure is shown in *lmer* syntax.

Finally, the Dat·Nom·Verb subexperiment. At the verb, there was a main effect of ArgStrux and NomRole (Table 11), ditransitive and Nom→P conditions being slower on average. There was also a marginal ArgStrux–NomRole interaction. Pairwise comparison found RTs to differ in the two ditransitive conditions (i.e. G·P·V_{AgrA}·X $>_{RT(V)}$ G·A·V·P; Est. = 0.10, SE = 0.043, $t(28) = 2.4$, $p < 0.05$) but not in the monotransitive conditions (viz. A·P·V·X and P·A·V·X; Est. = 0.019, SE = 0.041, $t(28) = 0.46$, $p = 0.64$). At the postverbal noun, there is a marginal effect of NomRole and a significant ArgStrux–NomRole interaction (Table 12). The marginal effect suggests that N3 might be read more slowly on average where N2=Nom→P. Pairwise comparisons found different RTs across argument structures where Nom2→P (i.e. G·P·V_{AgrA}·X $>_{RT(N3)}$ A·P·V·X; Est. = 0.085, SE = 0.025, $t(1200) = 3.3$, $p < 0.001$), but not where Nom2→A (Est. = 0.017, SE = 0.026, $t(1200) = 0.66$, $p = 0.50$).

Dat·Nom·Verb subexperiment, Verb region
LogRT ~ ArgStrux*NomRole + (1|Participant) + (1+ArgStrux*NomRole|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	**
NomRole	0.10	0.042	24	2.4	0.022	*
ArgStrux:NomRole	–0.12	0.060	29	–2.0	0.051	.

Table 11: Results of linear mixed effect modeling of log RTs at the verb region of the Dat·Nom·Verb subexperiment. Random effect structure is shown in *lmer* syntax.

Dat·Nom·Verb subexperiment, Postverbal noun region
LogRT ~ ArgStrux*NomRole + (1|Participant) + (1+NomRole|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	
NomRole	0.057	0.031	64	1.8	0.073	.
ArgStrux:NomRole	–0.10	0.036	1200	–2.7	0.0052	**

Table 12: Results of linear mixed effect modeling of log RTs at the first immediately postverbal noun region of the Dat·Nom·Verb subexperiment. Random effect structure is shown in *lmer* syntax.

4.4 Post hoc analyses

To complement the above analysis, post hoc analyses were conducted to study the effect of certain grammatical factors that the current design did not manipulate. Importantly, because preverbal strings were held constant within itemsets, only across subexperiments is it possible to compare word order variants of the same case pattern and argument structure (e.g. the harmonic and disharmonic orders for a NomA transitive, Nom·Dat→A·P vs. Dat·Nom→P·A). To facilitate exposition of the post hoc analyses and to summarize results, Table 13 rearranges the verb RTs into groups of conditions with similar properties orthogonal to word order.

Configuration	$LogRT_V$	Grammatical description
Nom·Dat→A·P·V·X	7.160 (0.036)	Monotransitive, NomA
Dat·Nom→P·A·V·X	7.180 (0.042)	
Dat·Nom→A·P·V·X	7.160 (0.039)	Monotransitive, DatA
Nom·Dat→P·A·V·X	7.260 (0.040)	
Nom·Dat→A·G·V·P	7.320 (0.045)	Ditransitive, NomA
Dat·Nom→G·A·V·P	7.340 (0.050)	
Nom·Dat→P·G·V_{AgrA}·P	7.480 (0.043)	Ditransitive, ErgA, A = 1st/2nd Agr
Dat·Nom→G·P·V_{AgrA}·P	7.470 (0.043)	
Nom→A·V·P	7.110 (0.040)	Monotransitive, NomA
Nom→S·V·X	7.150 (0.038)	Passive
Nom→S·V·G	7.290 (0.050)	Applicative Passive
Nom→P·V_{AgrA}·X	7.250 (0.041)	Monotr, DatA or ErgA, A = 1st/2nd Agr

Table 13: RTs of disambiguating verbs across the experiment, rearranged into groups reflecting the post hoc analyses. RTs are in log milliseconds, with by-participant standard errors in parentheses.

Data from the monotransitive NomA and DatA conditions — the first quartet in Table 13 — were grouped together for a post hoc test of the interaction between word order and case pattern. A linear mixed effect model finds a main effect of word order (Table 14), and pairwise comparison across case patterns finds a word order effect for DatA clauses (Est. = 0.099, SE = 0.044, $t(62) = 2.2$, $p < 0.05$) but not NomA clauses (Est. = 0.024, SE = 0.043, $t(56) = 0.56$, $p = 0.58$). This suggests that the main effect of word order is driven by slow RTs of the Nom·Dat→P·A·V condition in particular.

Post hoc analysis of data from monotransitive N1·N2·Verb conditions
LogRT ~ WordOrder*NomRole + (1|PartID) + (1+WordOrder+NomRole|Itemset)

	Estimate	SE	df	*t*	*p*	
Intercept	7.200	0.039	68	190	< 0.001	***
WordOrder	0.061	0.026	54	2.4	0.021	*
NomRole	0.040	0.026	54	1.5	0.130	
Order:Role	0.074	0.070	61	1.1	0.290	

Table 14: Results of linear mixed effect modeling of log RTs at the verb region of the monotransitive conditions of the Nom·Dat·Verb and Dat·Nom·Verb subexperiments.

As for the ditransitive conditions, a post hoc linear model finds a main effect of NomRole (Table 15). In other words, there is some evidence that NomA ditransitives are easier to process than ErgA ditransitives whose A argument is signaled by 1st or 2nd person agreement. There is little evidence that harmonic and disharmonic word orders of the same clause type are processed differently, though.

Post hoc analysis of data from ditransitive N1·N2·Verb conditions
LogRT ~ WordOrder*NomRole + (1|PartID) + (1+WordOrder+NomRole|Itemset)

	Estimate	SE	df	*t*	*p*	
Intercept	7.400	0.053	84	140	< 0.001	***
WordOrder	–0.040	0.045	60	–0.88	0.380	
NomRole	0.120	0.058	52	2.2	0.036	*
Order:Role	0.030	0.086	57	0.35	0.730	

Table 15: Results of linear mixed effect modeling of log RTs at the verb region of the ditransitive conditions of the Nom·Dat·Verb and Dat·Nom·Verb subexperiments. WordOrder compares harmonic word orders (A·G·V and G·P·V_{AgrA}) to disharmonic ones (G·A·V and P·G·V_{AgrA}).

Finally, pairwise comparisons were conducted between each condition of Nom·Verb subexperiment (see results of the model in Table 8). As shown in Table 16, significant differences were found between each pair except A·V·P vs. S·V·X (i.e. the 'unmarked' conditions) and S·V·G vs. P·V_{AgrA}·X (the 'marked' conditions).

	Est.	SE	df	*t*	*p*
A·V·P – S·V·X	–0.037	0.045	38	–0.83	0.840
A·V·P – S·V·G	–0.200	0.050	46	–4.0	< 0.01
A·V·P – P·V_{AgrA}·X	–0.160	0.037	49	–4.3	< 0.001
S·V·X – S·V·G	–0.160	0.037	50	–4.4	< 0.001
S·V·X – P·V_{AgrA}·X	–0.120	0.043	36	–2.8	< 0.05
S·V·G – P·V_{AgrA}·X	–0.043	0.046	40	–0.92	0.79

Table 16: Results of pairwise comparisons between conditions in the Nom·Verb subexperiment.

5. General discussion

There are two main takeaways of the present L-Maze experiment, manifesting in lexicality decision times at critical disambiguating verbs (see Table 13 for a summary). First, the A1 advantage emerges only to a limited extent. There is a clear penalty for verbs in the Nom·Dat→P·A·V condition (i.e. transitives in a DatA tense with disharmonic P-before-A word order), compared to the Nom·Dat→A·P·V condition (harmonic NomA), and also to the Dat·Nom→A·P·V condition (harmonic DatA) by post hoc analysis. Yet the same penalty is not found for Dat·Nom→P·A·V (disharmonic NomA); in fact that condition seems as easy as its harmonic counterpart, Nom·Dat→A·P·V. Likewise in the ditransitive conditions, where post hoc analyses find no effects of word order for combinations of preverbal A/G and G/P.

The second main takeaway is a processing penalty for G arguments — indirect objects, in these stimuli mostly applied affectees. After either a Nom·Dat or Dat·Nom preamble, verbs with monotransitive voice morphology were easier to process on average than verbs with ditransitive (i.e. applied transitive) morphology. And after a simple Nom1 preamble, monovalent passive verbs are easier to process than bivalent applied passive ones.

Where do these behavioral results from Georgian this fit into the broader crosslinguistic picture on role processing and the A1 advantage? As discussed in Section 2, there are several theoretical approaches to A1 effects. First, it is important to consider where an A1 advantage is an epiphenomenon of representational complexity. For Georgian, disharmonic word orders like P·A are derived by scrambling. But there is little evidence that this syntactic operation is linked to a processing cost — except in DatA transitives. When it comes to structural complexity, it is standardly assumed that G arguments are associated with an extra layer of clausal structure, ApplP (10c,d). There was a clear G cost in this experiment, and a plausible interpretation for it is difficulty contributed by that extra syntactic layer. It might also be linked to argument economy. Ditransitive verbs take three arguments, yet in this experiment they only appear given bottom up evidence of two (i.e. after N1·N2 strings). Economy also predicts an advantage for monovalent rather than bivalent structures; in the Nom·Verb subexperiment, there were no clear processing differences between verbs disambiguating to S·V·X vs. A·V·P parses, but S·V·X verbs were easier than S·V·G verbs.

For Georgian, DatA transitives are analyzed as more structurally complex than NomA transitives (9b vs. 9c). If the extra structure in DatA transitive clauses inhibits processing, we would expect that case pattern to be across the board harder than the NomA pattern; Skopeteas et al. (2012) found such a penalty in their acceptability judgement study. Yet a post hoc analysis here did not find evidence of an across the board penalty for the DatA pattern. The discrepancy in findings might be due to the differing experimental methods, or some key property of the studies' stimuli. Future work on Georgian sentence processing should prioritize the direct comparison of NomA and DatA transitives, to investigate whether the latter case patterns comes at an inherent processing disadvantage.

So the evidence in this study for a reductionist approach to the A1 advantage is at best mixed. Perhaps instead the A role has an inherent processing advantage, such that clauses are easier to process as more Proto Agent properties cluster towards the beginning of the sentence. A unique property of Georgian is that an A1 parse is always incrementally available for preverbal arguments, since any of the core case categories (nominative, dative, and ergative) can be mapped to A. This is not due to mere morphological syncretisms between case categories (perhaps interacting with number, as in German or Basque), but rather due to the language's tense based split ergativity.

An inherent approach predicts cues disambiguating to the N1→A parse to be easier to process than cues to N1→P, N1→S_P, or N1→G. The Nom→A parse indeed has an advantage in Nom·Dat·Verb strings: that is, when the comprehender has unambiguous evidence of a polyvalent clause. But in Nom·Verb strings, there is no evidence that transitive verbs disambiguating to the Nom1→A parse are easier than passive verbs cueing Nom1→S_P. So insofar as there is an advantage to the Nom1→A parse, it is contingent on encountering a medial dative argument. Thus it might be reframed as a consequence of argument distinctness; see below.

It should be noted the theoretical importance of comparing Nom·Verb→A·V and Nom·Verb→P·V cues, since that holds transitivity constant while manipulating role. In the present experiment, the former type of disambiguation does seem easier to process than the latter. However, a confound in the experimental design prevents us from confidently characterizing this as an A1 advantage. The Nom·Verb→P·V verb had agreement morphology signaling a first or second person A argument, which might incur a cost independent of role processing. (Likewise direct comparison of the A/G and G/P ditransitive conditions is confounded.) Follow up work should address this confound by comparing P·V·A and A·V·P clauses that only have third person arguments. It might also be fruitful to compare the properties of unergative verbs — whose S_A arguments can be nominative, dative, or ergative, just like transitive A — putting Georgian in dialogue with Isasi-Isasmendi et al.'s (2025) findings from Basque.

As for the parsing of datives, there is no evidence from the Dat·Nom·Verb subexperiment that the Dat1→A parse has an advantage over Dat1→P. This might be a consequence of DatA being the least frequent case pattern, with the most marked morphosyntax. In medial position, Dat2→P has an advantage to Dat2→G — contradicting a key prediction of the incremental harmonic alignment hypothesis (Foley 2020). If it were always advantageous to parse an ambiguous argument in the most prominent unclaimed role grammatical possible, then Nom·Dat→A·G should be more optimal than Nom·Dat→A·P. Together with the lack of obvious cost to the Nom1→S_P parse, this suggests that it is not the absolute number of Proto Agent properties that facilitates the processing of an argument's role.

If it is not roles' inherent properties, perhaps it is the relative distinctness of coarguments that can give rise to the A1 advantage. This relational approach can be articulated in terms of the alignment of prominence scales (as in eADM, Bornkessel-Schlesewsky 2009b; cf. Aissen 1999). Among bivalent clause types in Georgian, monotransitives should be more distinct than applied passives; the A/P pair has less in common thematically and morphosyntactically than the S_P/G pair does (cf. Bornkessel-Schlesewsky & Schlesewsky 2009c). Post hoc analysis finds evidence compatible with this prediction: verbs were easier to process in Nom·Verb→A·V·P conditions than in Nom·Verb→S·V·G conditions. Ditransitives were also harder on average than monotransitives, which can also be explained by the indistinctness of three arguments relative to just two. And among monotransitives specifically, the DatA are arguably less distinct than NomA or ErgA tenses. That is due to certain morphosyntactic and semantic properties of dative transitive subjects, which make them less prominent than nominative or ergative ones. But as noted above, there is little evidence from this study that the DatA pattern is harder to process than NomA.

A lingering question about this experiment is why an A1 advantage — and more generally an advantage for harmonic word orders — emerges only in DatA clauses. On possible explanation is surprisal (Hale 2001, Levy 2008). Referring back to the corpus findings (Table 5), Nom·Dat→A·P·V strings are much more frequent than Nom·Dat→P·A·V strings. Perhaps it is simply the infrequency of a DatA verb in this context which explains the processing cost in this study. Future corpus research and computational modeling should pursue the extent to which processing effects in Georgian can be predicted from surprisal more generally.

Alternatively, what is offensive about Nom·Dat→P·A·V configurations might be a particular misalignment between the role, order, and case[8] prominence scales. Perhaps a role–order mismatch (e.g. P·A order) on its own incurs a processing cost too weak to detect in this experiment, and likewise a role–case mismatch (i.e. the DatA case pattern), but processing both types of mismatches simultaneously (as in $P_{Nom}·A_{Dat}$ clauses) leads to a superadditive effect that is detectable. To pursue this hypothesis further, other combinations of scale mismatches should be investigated. Are there also superadditive interactions involving other scales, like animacy? Are inanimate A arguments especially hard to process given P·A word order, or given DatA case? Empirical questions like these can be answered internal to Georgian. But addressing deeper theoretical questions will necessitate ever more crosslinguistic comparison, informed by rigorous corpus investigations and formal syntactic analysis. Theories like the Competition Model (Bates & MacWhinney 1982) and eADM (Bornkessel-Schlesewsky & Schlesewsky 2009) suppose that comprehenders of different languages assign more or less weight to various types of cues/scales (word order, case, animacy, etc.) in response to the linguistic landscape of their grammar and lexicon. A fundamental question is just how these weights are assigned, and why certain combinations of scale mismatches might inhibit processing superadditively.

6. Conclusion

Novel data from Georgian contribute to a language general theory of grammatical role processing. In diverse languages and across methodologies, it has been observed that A-before-P word orders tend to be easier to process than P-before-A orders. This is usually demonstrated in real time experiments by studying cues, often pieces of verbal inflection, that resolve the temporarily ambiguous grammatical roles of preceding nouns. There are several major theoretical approaches to the A1 advantage, but individual languages usually offer too few relevant morphosyntactic configurations to adjudicate between them.

Georgian stands out in having a grammar that gives rise systematically to a large number of temporary role ambiguities. It is typologically similar to better studied languages like German and Basque, in that it has flexible verb final word order and rich case morphology. But unlike those languages, the temporary ambiguities in Georgian do not stem from morphological syncretisms (e.g. between NOM and ACC, or ABS.SG and ERG.PL). Rather, they are the consequence of split ergativity: variable mapping between grammatical role and case category, here specifically conditioned by tense. To wit, a nominative noun out of the blue might be parsed as A, S_P, or P, and a dative noun as A, G, or P; the licensing verb with its rich arguments structure and tense morphology is usually the key disambiguator.

An L-Maze experiment tracked how Georgian comprehenders incrementally process Nom·Verb, Nom·Dat·Verb, and Dat·Nom·Verb strings. Comparing reading times at disambiguating verbs, an A1 advantage is only observed in one particular context: in tenses where dative maps to A, and nominative to P. There is no evidence that any other word order alternations (viz. among preverbal A_{Nom}/P_{Dat}, A_{Nom}/G_{Dat}, or G_{Dat}/P_{Nom} pairs) affect processing. Moreover in Nom·Verb strings, there is no evidence that cues to the Nom→A mapping have an advantage to Nom→S_P cues. What does clearly impact processing, though, are cues to a G argument. Together, this suggests that Georgian comprehenders are not guided by a general imperative to identify arguments with many as many Proto Agent properties as soon possible, at it might seem in other languages. Rather, multiple linguistic factors related to argument prominence and representational complexity interact during the processing of grammatical roles.

[8] We assume that Georgian nominative outranks dative on the case hierarchy; thus the DatA case mapping is a misalignment relative to NomA. But the language has a very unique split ergative alignment system, such that its case categories do not have typologically canonical distributions. So it is worth interrogating what might explain the Nom>Dat hierarchy, and where Erg should fall in it. It might also be connected to the relative frequencies of role mapping for each case, perhaps specifically the conditional probability of the A parse given that case — and given counts in Table 4, $p(A|Erg) > p(A|Nom) > p(A|Dat)$.

Data availability statement

Experimental materials, anonymized data, analysis files, and corpus queries are available in an OSF repository: https://osf.io/4j958/?view_only=d0c115549c004783973576aebc5603e2

Ethics and consent

Review of the procedures used to obtain informed consent to participate in research from the participants was reviewed and approved by the Institutional Review Board of Princeton University.

Competing interests

The author has no competing interests to declare.

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