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Abstract

Building on Shin (2022), the present study examines how Korean monolingual children comprehend suffixal passive constructions by employing a webcam eye-tracking method, aiming to test two theoretical accounts of grammatical generalisation (gradual vs. early abstraction). Twenty-eight children aged three to six, alongside 20 adults, joined picture-selection experiments paired with eye-gaze measurements. The findings indicate that children's utilisation of passive-voice heuristics remains limited yet developing, overshadowed by well-entrenched active-voice knowledge. In particular, the eye-gaze data reveal processing challenges related to the passive voice, mainly interpretive difficulties arising from passive morphology. These results replicate those of Shin (2022), offering further support for a moderate version of each account that emphasises the pivotal role of linguistic exposure in mastering linguistic knowledge. From a methodological standpoint, this study enhances the accessibility of webcam eye-tracking research for understudied languages in the field.

Keywords: Comprehension; Passive; Child; Korean; Webcam eye-tracking

Introduction

Two competing accounts have been proposed to explain how children generalise grammatical knowledge. One account, *gradual abstraction*, maintains that generalisation is delayed until sufficient evidence is accumulated, as children's initial knowledge is centred upon specific lexical items and more abstract constructions emerge in a piecemeal manner (Akhtar, 1999; Ambridge & Lieven, 2015; Childers & Tomasello, 2001; Dittmar et al., 2008; Matthews et al., 2007; Ninio, 1999; Theakston et al., 2015; Tomasello, 2003). The key idea is that learners are conservative when extending their knowledge to new items. The initial linguistic representation is based on a lexical frame containing a relatively stable and frequently observed element (e.g., verb, pronoun, morphological marker) that is combined with flexible slots. This lexically specific schema is thought to act as a stepping-stone, enabling the subsequent development of more abstract representations. In its strongest form, this account posits that such abstract knowledge does not surface until around the age of three (e.g., Tomasello, 1992). However, some studies have challenged this claim (e.g., Abbot-Smith et al., 2008; Pine et al., 1998), prompting a revision: in the absence of a strict age-related mechanism, the mastery of representations is considered to depend heavily on linguistic exposure, requiring a significant amount of time.

By contrast, the *early abstraction* account holds that children actively use current input to rapidly form abstract linguistic knowledge, acquiring both item-based frames and abstract representations early in development (Bencini & Valian, 2008; Brusini et al., 2016; Fisher, 1996; Marcus et al., 1999; Messenger & Fisher, 2018; Özge et al., 2019; Saffran et al., 1996). The strong version of this account asserts that, by the age of two or three, children already possess abstract structural representations without reference to input properties, owing to innate guidance in constructing such representations (e.g., Franck et al., 2011; Gertner et al., 2006; Lidz et al., 2003; Zhu et al., 2021). Its moderate version acknowledges early development of word- and sentence-level representations but argues that integrating the two types of knowledge relies on usage experience (e.g., Dąbrowska & Tomasello, 2008; Garcia et al., 2021; Rowland et al., 2012; Smolík, 2015). Thus, children's demonstration of abstract knowledge does not necessarily imply immediate, complete mastery or consistent application; substantial linguistic exposure remains vital for the knowledge to mature fully.

While extensive findings support each account in major (Indo-European) languages, relatively little research has explored how these two accounts apply to learners of typologically distinct languages. Certain studies focusing on Czech (Smolík, 2015), Tagalog (Garcia et al., 2021), and Turkish (Özge et al., 2019) endorse early abstraction, yet they differ in their claims regarding how abstract children's linguistic knowledge can be and the significance of language exposure in the generalisation process. In other words, investigations that move beyond major languages remain scarce, raising the question of whether developmental patterns observed amongst speakers of these major languages are reasonably applicable to learners of other languages.

Suffixal Passive Constructions in Korean

This study explores Korean, a language that has received relatively little attention in this line of research. Korean follows a Subject–Object–Verb word order and employs overt case-marking (via dedicated particles) and affixation to convey grammatical information. These structural features permit the scrambling of constituents, provided that such reordering maintains the original meaning without creating

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ambiguity. Moreover, Korean allows most sentential elements to be omitted if the missing information can be inferred from context.

In particular, we examine a passive construction, a major clausal device for expressing transitive events (although used infrequently) that is widely recognised as challenging for children to acquire (Borer & Wexler, 1987; Brooks & Tomasello, 1999; Huang et al., 2013; de Villiers & de Villiers, 1973; cf. Deen, 2011). A line of research using an eye-tracking method has shown English-speaking children's ability to parse English passive sentences in accordance with age and language proficiency, alongside their asymmetric performance by task type (Abbot-Smith et al., 2017; Messenger & Fisher, 2018). The passive voice is marked across many languages (Haspelmath, 1990; Siewierska, 2013), and its frequency in Korean is notably low in comparison with the active voice (Park, 2021; Shin & Mun, 2023; Woo, 1997). Of the three types of Korean passive construction—lexical, suffixal, and periphrastic (Sohn, 1999), the suffixal passive is most frequently observed in caregiver input (Shin & Deen, 2023), and thus represents the primary passive form children are likely to encounter.

The suffixal passive features a nominative-marked theme, a dative-marked agent, and passive verbal morphology (PSV) (Table 1).[1] PSV, a core feature for the suffixal passive, necessitates revising the initial interpretation of associations between thematic roles and case markers (agent-nominative + recipient-dative → theme-nominative + agent-dative). This results in (i) the *Theme-First* heuristic (first NP = theme) competing with the *Agent-First* strategy in the active voice (cf. Sinclair & Bronckart, 1972; see Shin, 2021 for detailed explanations on this strategy for Korean monolingual children's sentence comprehension) and (ii) the *Nominative-as-Theme* (N-nominative = theme) and *Dative-as-Agent* (N-dative = agent) heuristics competing with agent-nominative and theme-accusative mappings in the active voice (cf. Shin & Mun, 2023).

Table 1. Active transitive and suffixal passive constructions in Korean (canonical word order)

Type	Active transitive	Suffixal passive
Example	Ciwu-ka Mia-lul Ciwu-NOM Mia-ACC cap-ess-ta. catch-PST-SE 'Ciwu caught Mia.'	Ciwu-ka Mia-hanthey Ciwu-NOM Mia-DAT cap-hi-ess-ta. catch-PSV-PST-SE 'Ciwu was caught by Mia.'
Thematic role ordering	agent–theme	theme–agent
Case-marking	Typical (agent-NOM; theme-ACC)	Atypical (theme-NOM; agent-DAT)
Verbal morphology	No	Yes (-*i/hi/li/ki*-)

Shin (2022), the foundational study underlying the present work, examined Korean monolingual children's comprehension of the suffixal passive through four picture-selection experiments, incorporating a novel method in which portions of test sentences were systematically withheld or masked using acoustic sounds (e.g., coughs, chewing). In each experiment, participants were presented with two pictures illustrating the same transitive action but with reversed thematic roles (e.g., a dog kicking a cat vs. a cat kicking a dog). After hearing a sentence twice, three groups of participants (three-and-four-year-olds, five-and-six-year-olds, and adults) selected the picture that matched the sentence. These four experiments produced three major findings regarding comprehension of the suffixal passive. First, given the competition between passive-voice knowledge (induced by verbal morphology) and the more frequent, entrenched active-voice knowledge, the extent to which children relied on passive-voice knowledge was shaped by age (serving as a proxy for language-usage experience). Second, children aged five to six were able to apply passive-voice knowledge, although the degree of its application decreased as the computational complexity of the sentence increased (e.g., in relation to the number of arguments or the presence/absence of case markers). Third, children aged three and four did not consistently interpret passive sentences as though they were active. These findings collectively suggest that, while an initial sensitivity to passive morphology emerges early, its full mastery is achieved later and requires extensive usage experience, particularly in relation to the interplay between different aspects of voice-related knowledge involving a given stimulus.

Current Study

We extend Shin (2022) to further investigate Korean monolingual children's comprehension behaviours involving the suffixal passive under the two theoretical accounts. To this end, this study employs a webcam eye-tracking method (*WebGazer.js*; Papoutsaki et al., 2016). Developed during the COVID-19 pandemic to address data collection limitations in eye-tracking studies, this method has proven effective as an alternative to physical eye-trackers (Özsoy et al., 2023; Semmelmann & Weigelt, 2018; Slim & Hartsuiker, 2022).

Methods

Twenty-eight three-to-six-year-olds[2] (M_{month} = 56, SD_{month} = 11) and 20 adult controls (20s and 30s) participated in two picture selection experiments. Their task was to match aurally presented sentences to one of two images, combined with a visual-world paradigm using webcam eye-tracking on a portable laptop (Lenovo YOGA 7i 14.8-inch, Windows OS,

[1] Abbreviation throughout the manuscript: ACC = accusative case marker; CASE = case marker (unspecified); DAT = dative marker; NOM = nominative case marker; PST = past tense marker; PSV = passive suffix; SE = sentence ender; strikethrough = obscured.

[2] We initially recruited 44 children but excluded 18 who did not pass the calibration threshold or were unable to maintain focus throughout the task. Given the modest sample size, we treated the remaining participants as a single cohort and did not examine developmental milestones or trajectories in detail.

Intel core 13th generation i7, 16GB RAM, 1280 × 720 resolution webcam).

We controlled for the animacy of arguments in the test stimuli by using animals to ensure that each test item was semantically reversible, thus preventing children from using animacy as a clue for the thematic roles of the arguments. The sentences were recorded by a male native Korean speaker who was unaware of the experimental purpose. Canonical–scrambled pairs were devised such that they were matched in overall duration and pitch to avoid noticeable vocal variety that might adversely affect participants' comprehension. There was a 100-ms interval between the words in each sentence. All sentences, along with their corresponding pictures and recordings, were normed by 10 native Korean speakers for their naturalness/felicitousness and intended events prior to the experiment. No specific comments were made regarding vocal variety among these stimuli.

When the experiment started, the main character (a human figure appearing on the computer screen) greeted participants and asked for help in learning Korean; the actual task was to listen to his utterances and choose the picture that matched the utterance by pressing large arrows on the keyboard while looking at the scene on the screen. Then a 12-point calibration session began, with the main character raising a hand in each point randomly; if participants did not pass the threshold success rate—75%, the calibration process occurred again until they passed it. Following the calibration session, a training session was conducted to familiarise participants with the procedure, using three practice items that were not related to the test items.

In the main session, two pictures of the same size appeared, one on the left and one on the right side of the screen. For each trial, a pair of pictures depicted the same action but with reversed thematic roles, and this arrangement was counterbalanced both within and across participants. The pictures were displayed 2000 milliseconds prior to sentence onset and remained on the screen throughout sentence presentation and for 2000 milliseconds after its completion. Each auditory stimulus was presented through headphones only once. For each trial, participants' eye movements were traced and recorded from the time when the two pictures appeared to the time when they disappeared (time bin: 50 milliseconds). Any eye gaze deemed invalid due to blinks, notable head movements, or a 5% margin from each half of the screen (Figure 2) was removed from the dataset. Consequently, looks to either picture were essentially in complementary distribution.

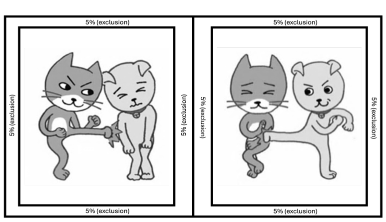

Figure 2. Illustration of 5 per cent margin from each half of the screen.

Experiment 1

Twenty-four test sentences were created by crossing voice type (active for fillers; passive for testing) and word-order type (canonical; scrambled), with six instances per condition, as exemplified in (1a–b) and (2a–b). Two sub-lists were made and participants were randomly distributed to one of the sub-lists. Sets of the stimuli appeared in random order.

(1a) Canonical active transitive (filler): $N_{NOM}N_{ACC}V_{act}$
kangaci-ka   koyangi-lul   cha-yo.
dog-NOM   cat-ACC   kick-SE
'The dog kicks the cat.'

(1b) Scrambled active transitive (filler): $N_{ACC}N_{NOM}V_{act}$
koyangi-lul   kangaci-ka   cha-yo.
cat-ACC   dog-NOM   kick-SE
'The dog kicks the cat.'

(2a) Canonical suffixal passive: $N_{NOM}N_{DAT}V_{psv}$
kangaci-ka   koyangi-hanthey   cha-i-eyo.
dog-NOM   cat-DAT   kick-PSV-SE
'The dog is kicked by the cat.'

(2b) Scrambled suffixal passive: $N_{DAT}N_{NOM}V_{psv}$
koyangi-hanthey   kangaci-ka   cha-i-eyo.
cat-DAT   dog-NOM   kick-PSV-SE
'The dog is kicked by the cat.'

The $N_{NOM}N_{DAT}V_{psv}$ condition involves competition between active-voice knowledge (*Agent-First*; agent-nominative), which is typical and frequent, and passive-voice heuristics (*Theme-First*; *Nominative-as-Theme*; *Dative-as-Agent*), which are less typical and infrequent in use, driven by verbal morphology. The $N_{DAT}N_{NOM}V_{psv}$ condition involves a similar kind of competition, except for the word-order facts (*Agent-First* versus *Theme-First*), because this condition starts with the agent-dative pairing, which inherently coincides with the *Agent-First* strategy.

Participants' responses were coded as 0 (incorrect) or 1 (correct). To compare mean scores across the conditions and groups, all data were fitted to logistic mixed-effects models using *lme4* (Bates et al., 2015) in R (R Core Team, 2024), with *Group* (child, adult) and *Canonicity* (canonical; scrambled) per voice type as fixed effects (centred around the mean and contrast-coded) and with *Participant* and *Item* as random effects. Alongside the global model, we constructed a separate model for child participants, with *Canonicity* (canonical; scrambled) per voice type as fixed effects (centred around the mean and contrast-coded) and with *Participant* and *Item* as random effects. All the models included the maximal random-effects structure allowed by the design for each model (Barr et al., 2013). We also computed each model's R^2 value by using Nakagawa's R^2 (Nakagawa et al., 2017; conditional R^2 taking into account both fixed and random effects) which can apply to both linear and generalised linear mixed-effects models (Nakagawa & Schielzeth, 2013).

Participants' eye-gaze data were analysed through non-parametric permutation analysis (Abbot-Smith et al., 2017; Garcia et al., 2021; cf. Maris & Oostenveld, 2007). This technique builds a sampling distribution (i.e., the permutation distribution) by resampling the observed data, and is ideal for our purposes because it identifies processing events in the eye-gaze record in a data-driven manner, determining the time in the record when looks to the target diverge across word order conditions for each voice type. The analysis followed a series of steps. In the first step, linear regression models were conducted to evaluate the effects of word order on fixations to the target for every 50-millisecond time bin. The models were conducted separately for each voice type. The proportion of fixations to the target was calculated by dividing the number of fixations to the target by the total number of fixations to the agent and to the patient. The regressions provided a list of time bins with significant *p*-values. In the second step, significant adjacent time bins were clustered under the assumption that they likely constitute a single processing event. In the final step, a permutation distribution was created by randomly permuting the word order labels of the clusters to fit a regression model on this randomised data. The procedure was repeated 1,000 times. The outcome of this procedure provides a distribution of sum *t*-values for each cluster, showing the likelihood that a cluster occurred by chance if we carried out the experiment multiple times and permuted the labels. We then compared our cluster statistic against this distribution to determine the significance of our effects.

Experiment 2

We devised a novel situation in which the main character was hungry and eating food. We strategically placed yum-yum sounds over the markers, obscuring case-marking. There were six instances by voice type (active for fillers; passive for testing) as exemplified in (3a–b), amounting to 12 sentences in total. We used the same verbs as in Experiment 1 but with different combinations of animals. All sentences were normed by 10 adult Korean native speakers, confirming that the picture-aided sentences were interpreted as the transitive events described in each picture with the intended verbs. Two sub-lists were created, and participants were randomly distributed to one of the sub-lists. Sets of the stimuli appeared in random order.

(3a) Active transitive, no case marker (filler): N~~CASE~~N~~CASE~~V_{act}
kangaci-*yum-yum* koyangi-*yum-yum* cha-yo.
dog-~~CASE~~ cat-~~CASE~~ kick-SE
'The dog/cat kicks the cat/dog.'

(3b) Suffixal passive, no case marker: N~~CASE~~N~~CASE~~V_{psv}
kangaci-*yum-yum* koyangi-*yum-yum* cha-i-eyo.
dog-~~CASE~~ cat-~~CASE~~ kick-PSV-SE
'The dog/cat is kicked by the cat/dog.'

The N~~CASE~~N~~CASE~~V_{psv} condition involves competition between the typical and frequent active-voice knowledge (*Agent-First*) and the less typical, infrequent passive-voice heuristic (*Theme-First*), driven by verbal morphology, given the computation of two arguments in identifying thematic roles. The scoring for these conditions, which can in principle be interpreted in more than one way due to the hidden case markers indicating the thematic role of each argument, was based on the high likelihood of agent-first interpretation (0: theme-first; 1: agent-first). Statistical analysis of responses and eye-gaze patterns was conducted following the same procedures as in Experiment 1.

Results

Picture selection

Figures 3 presents two groups' response rates measured in Experiment 1.

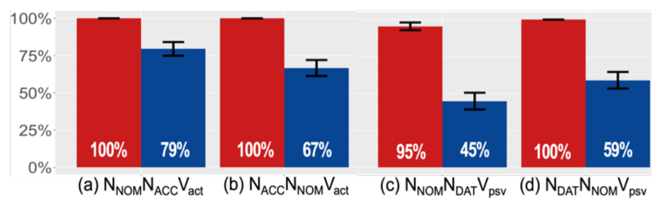

Figure 3. Results: Picture selection (Experiment 1). Red = Adult; Blue = Child. X-axis = Condition; y-axis = accuracy.

In the global model ($R^2 = 0.618$), we found only a main effect of *Group* ($\beta = -4.200$, $SE = 0.678$, $z = -6.196$, $p < 0.001$), indicating a clear by-group difference in accuracy independently of *Condition*: adults (100% for both active conditions; 95% for the canonical passive condition; 100% for the scrambled passive condition) outperformed children (79% for the canonical active condition; 67% for the scrambled active condition; 45% for the canonical passive condition; 59% for the scrambled passive condition). For the active conditions ($\alpha = 0.025$), the numeric difference in children's accuracy was not statistically significant ($p = 0.055$); however, accuracy was positively correlated with age: $t(76) = 3.452$, $p < 0.0001$ for the canonical condition; $t(76) = 3.169$, $p < 0.002$ for the scrambled condition. For the passive conditions ($\alpha = 0.025$), the difference in accuracy was insignificant and showed no correlation with age.

Figure 4 presents two groups' response rates measured in Experiment 2.

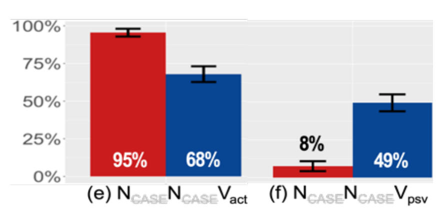

Figure 4. Results: Picture selection (Experiment 2). Red = Adult; Blue = Child. X-axis = Condition; y-axis = agent-first response rate.

In the global model ($R^2 = 0.376$), we found only a main effect of *Group* ($\beta = -2.539$, $SE = 0.291$, $z = -8.709$, $p < 0.001$), indicating a clear by-group difference in accuracy independently of *Condition*: adults (95% for the active condition; 92% for the passive condition) outperformed children (68% for the active condition; 51% for the passive condition). The mean rate of agent-first responses in the active condition exceeded chance level, whereas that of theme-first responses in the passive condition did not; neither showed any correlation with age.

Eye gaze

Figure 5 presents the two groups' eye movements measured in Experiments 1 and 2. Sentence regions are indicated by rectangles. Small bars below 0.00 represent linear regression *p*-values per 50-ms bin: light blue for $p > 0.05$ (non-significant), orange for $p < 0.05$ (significant). Grey shading above 0.00 denotes significant bins identified by permutation analysis.

In the case-marked active transitive conditions (a), children fixated more on the target events for the canonical condition (agent-nominative + theme-accusative) than the scrambled condition (theme-accusative + agent-nominative) later at NP2 (theme-accusative for the canonical condition; agent-nominative for the scrambled condition). This indicates that the advantage of canonical thematic-role ordering in real-time processing of active transitives may have emerged at a later stage in sentence comprehension.

In the case-marked suffixal passive conditions (b), children fixated more on the target events for the scrambled condition (agent-dative + theme-nominative) than for the canonical condition (theme-nominative + agent-dative) at Verb. In the case-less conditions (c), children fixated less on the target events in the passive condition (theme-first) than in the active condition (agent-first) at Verb. The findings from (b) and (c) indicate that (i) the children spent an extended period observing the two-picture displays and their accompanying auditory stimulus in these conditions, and (ii) their final interpretation conformed more to the canonical thematic-role ordering of active transitives (i.e., agent–theme).

Discussion and Conclusion

The results from the picture selection data are broadly consistent with previous studies on children's interpretive difficulties with scrambling across languages (e.g., Kim et al., 2017; Schipke et al., 2012; Slobin & Bever, 1982; Shin, 2022). Specifically, the findings regarding children's degraded performance on the suffixal passive replicate those observed in Shin (2022). This underscores the acquisitional challenges stemming from the competition between weaker heuristics on the passive voice (driven by passive morphology) and stronger knowledge about the active voice, with the passive-voice heuristics often overshadowed by the active-voice knowledge.

The results from the eye-gaze data further elucidate online processing dynamics, showing that the children's fixations diverged substantially by experimental conditions. Within a transitive event, the children's processing was facilitated when word order and case-marking cues aligned in a typical manner—nominative-marked agent nominal first, accusative-marked theme nominal second—as demonstrated in the case-marked active transitive conditions (a). The children struggled to associate the nominative-marked theme and dative-marked agent correctly with the target picture, as shown in the case-marked suffixal passive conditions (b). This suggests persistent challenges with the passive voice due to the dominant active-voice knowledge, despite some sensitivity to passive morphology. Their performance in the case-less conditions (c), the conditions that allow us to directly measure the impact of passive morphology on comprehension, further confirms its weaker role in processing the suffixal passive. In other words, considering the children's eye-gaze patterns observed in (a), the results from (b) and (c) suggest that the children may ultimately have relied more on an agent-first, theme-second interpretation—which aligns with the aforementioned typicality within transitive events—given the competition between active-voice knowledge and passive-voice heuristics.

Interestingly, the adults in this study seem to benefit from the canonical ordering of thematic roles (i.e., agent-before-theme), indicated by the case markers contextualised via the pictures, when processing the suffixal passive (especially later at NP2). While adult performance is not a focal aspect of this study, this further highlights the asymmetric strength between the active-voice knowledge and the passive-voice heuristics during sentence processing even for adults.

Together, our findings in this study point to children's limited, albeit non-zero, reliance on passive-voice heuristics when comprehending the suffixal passive, attributable to the competition from more robust and entrenched active-voice knowledge. This replicates the results of Shin (2022) and resonate with prior studies (Dąbrowska & Tomasello, 2008; Garcia et al., 2021; Rowland et al., 2012), which in turn lends additional support for the moderate versions of the gradual- and early-abstraction accounts. That is, while children may demonstrate abstract grammatical knowledge early, the mastery of less frequent constructions (such as the suffixal passive in this study) necessitates prolonged exposure and usage-based learning.

On top of underscoring the interplay between linguistic exposure, processing strategies, and developmental trajectories, we believe our endeavour to apply a webcam eye-tracking method to under-explored languages will help to offset sampling biases and lower the barriers on research methodology, thereby contributing to democratising research practices in the field.

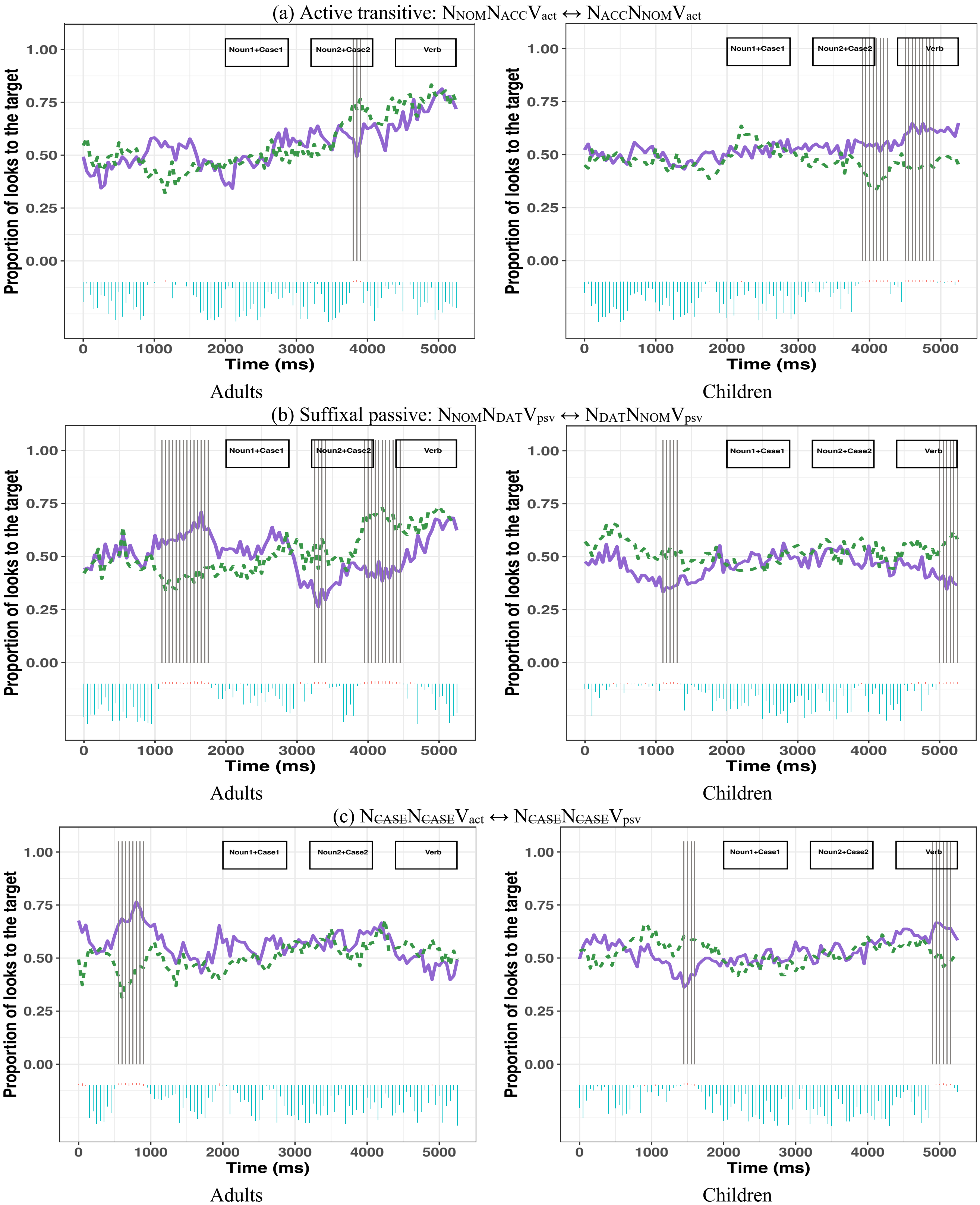

Figure 5. Results: Eye-tracking (average proportion of looks to the target from 2000 ms prior to a sentence onset until the end of a trial). Purple = (a, b) canonical, (c) active; Green = (a, b) scrambled, (c) passive.

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