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Bound to be noticed? Opposing effects of boundedness on attention to morphemes in L2 reading

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Introduction: Salience—the extent to which a feature stands out from its environment—has been posited as an important cognitive factor in second language (L2) acquisition. However, supporting empirical research remains scarce, particularly looking at specific effects of salience properties in isolation. For example, although morphological boundedness of a form has been theorized to impact its salience, to date no study has considered morphological boundedness individually as an independent variable in relation to linguistic salience.

Methods: To address this gap, the present study uses an English-based semi-artificial target language in an implicit, reading-based learning task that allows boundedness to be manipulated in isolation from other factors. This design makes it possible to compare the effects of boundedness on attention, awareness, and early-stage acquisition (intake) of L2 morphological forms. We further considered how boundedness interacts with another salience property: morpheme length. Finally, we considered the relationship between salience effects and certain external factors that might impact attention and awareness: learning condition (incidental versus intentional), and three individual learner variables (L2 proficiency, working memory capacity, and implicit learning ability). Eye-tracking measured attention to and intake of target forms, and retrospective interviews measured awareness.

Results: Results showed greater skipping rates of bound versus unbound morphemes, but also greater fixation durations for bound morphemes. Longer forms were skipped less and fixated longer than short forms regardless of boundedness. Individual learner variables had no moderating effect on either salience variable, while the intentional learning condition yielded longer fixations on the short morpheme specifically than the incidental condition. Attention results only partially correlated with awareness, and no evidence of intake was found.

Discussion: While the attention results were as expected regarding length, the opposing results of attention measures regarding awareness show differences in effects of boundedness on initial versus prolonged attention. Overall, the results suggest that the relationship between salience, attention, awareness, and acquisition might be more complex than some theories posit.

KEYWORDS

attention, awareness, L2 acquisition, morphological boundedness, salience, second language acquisition

1 Introduction

Attention—the guiding of cognitive resources toward certain information in the environment while ignoring other perceivable information (Robinson, 2003)—and awareness—the subjective heightened experience, knowledge, or recognition of a stimulus, which is most likely (but perhaps not necessarily) consciously registered (Schmidt, 2010)—are increasingly understood to play key roles in second language (L2) acquisition. Greater attention to and/or awareness of L2 features is expected to correlate with their ease of acquisition (cf. Schmidt, 1990, 2001). Consequently, exploring what drives these phenomena in L2 learners is vitally important to understanding the cognitive processes involved in L2 acquisition. Most related research focuses on language-external influences on attention and/or awareness, such as instruction techniques, task demands, or learner motivations. Less often considered, however, is how the language itself might influence these processes. The effect of L2 input on attention and awareness is believed to be driven by the *salience* of L2 features: the extent to which an entity stands out to the perceiver relative to its environment (Ravid, 1995). Greater salience of an L2 form is therefore expected to increase the potential that the learner will attend, become aware of, and ultimately acquire said form (Goldschneider and DeKeyser, 2001).

Several issues remain in causally relating an L2 form's salience and its ease of acquisition, however. First, there are many properties that have been theorized to manifest salience in linguistic features, but comparatively little empirical research on how they individually impact L2 acquisition (cf., Knell et al., 2025). Part of the problem is the challenge of isolating a given property to measure its specific effects, as most natural language features differ by multiple theorized salience properties. More generally, the relationship between attention, awareness, and acquisition is not without controversy, with some arguing that learning without awareness is possible (e.g., Leung and Williams, 2012), while others contend that acquisition only occurs unconsciously, whereas conscious (attended/aware) learning is shallow at best (e.g., Krashen, 1981). Clear and valid measurements of attention and awareness as they relate to any acquisition outcomes are therefore necessary when researching salience in the field of second language acquisition (SLA). Finally, any salience effect of properties of language features on attention, awareness, and/or acquisition will not exist in a vacuum, but interact with external factors, creating a complicated network of influences that must be considered.

To address these issues, the present article reports on an experiment aiming to distinguish a subset of salience properties of morphological forms as independent variables in an implicit learning task. The primary salience property of interest in this experiment is morphological boundedness: whether a morpheme is presented as an individual word (e.g., nouns, articles, determiners, etc.) or is attached to a base (e.g., tense markers, plural markers, derivative prefixes/suffixes, etc.) in written contexts. The novelty of this study lies in experimentally approximating boundedness as a local perceptual cue rather than an emergent corpus-level property as in previous research (e.g., Goldschneider and DeKeyser, 2001). We

look at the effects of boundedness on attention, awareness, and intake of L2 forms both individually and in interaction with morpheme orthographic length of the morphemes, using eye-tracking measures to investigate the effect of each property on attention and early-stage acquisition, and retrospective interviews to measure awareness. We also consider possible moderating external factors, including individual learner variables and learning condition.

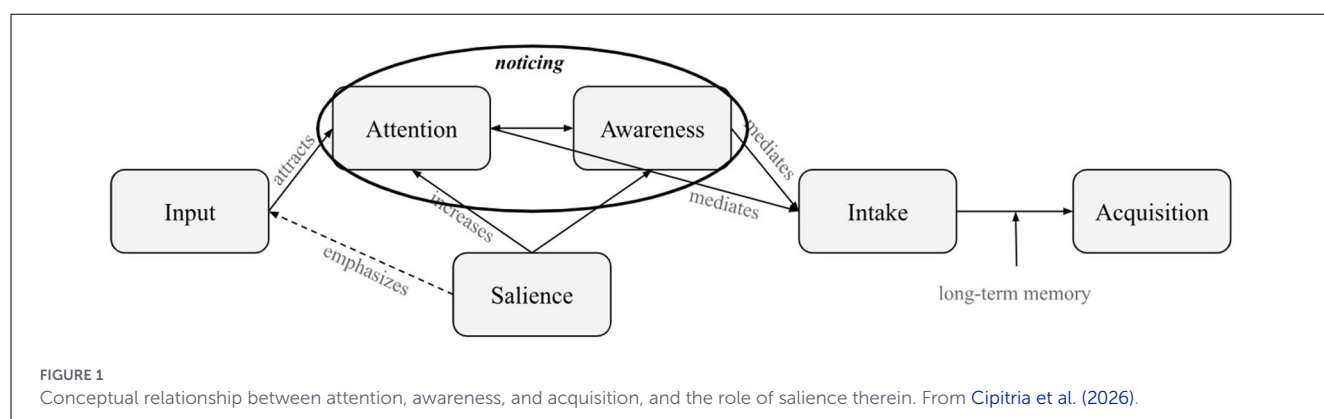
2 Background

2.1 Attention, awareness, and salience in L2 acquisition

Attention refers to any state of readiness to cognitively register information from the environment (Tomlin and Villa, 1994). In L2 acquisition, attention to aspects of linguistic input is a crucial step toward *intake* (the initial, and possibly temporary registration of input in short-term memory), which allows for further processing and eventual acquisition of that which is attended (see Robinson, 2003 for an in-depth discussion of attention in L2 acquisition). *Awareness*, meanwhile, remains theoretically more contested. Awareness refers to a broader cognitive state involving the conscious recognition of, or heightened experience with, stimuli. Such a state is usually, but perhaps not necessarily, the result of attending the given stimuli (Gass et al., 2003). Both attention and awareness are of critical importance to L2 acquisition according to Schmidt (1990, 2001) Noticing Hypothesis. *Noticing* is Schmidt's term for a state between attention and awareness that is necessary for the initiation of intake and, hence, to acquisition, emphasizing the crucial role of both phenomena in the acquisition process.

If attention to and/or (low-level) awareness of L2 forms equates to *noticing*, then salience might equate to a form's *noticeability*. Salient input is input that is more readily taken up by the cognitive system—that is, input with a higher probability of attracting attention (Taylor and Fiske, 1978). Thus, assuming that attention is crucial to acquisition, greater salience of L2 forms should make them easier to acquire (Figure 1).

Goldschneider and DeKeyser (2001) concluded this from a meta-analysis on observed orders of morpheme acquisition in L2 English. They identified five properties that together largely explained these orders: perceptual salience (operationalized as substance, syllabicity, and sonority), semantic complexity, morphophonological regularity, syntactic category, and frequency. Although they initially distinguished only one of the factors as “salience,” they later revisited their results to consider possible commonalities between them, and ultimately concluded that all factors might constitute aspects of a form's salience, asserting that “[i]t is possible...that just one variable, salience, is the ultimate predictor of the order of acquisition” (p. 36). Thereafter, numerous properties of linguistic forms have been theorized to manifest salience. This study focuses on two such properties: (1) morphological boundedness, operationalized as a comparison of bound vs. unbound morphemes, and (2) substance, operationalized as morpheme orthographic length in written input.



2.2 Substance and boundedness as salience

As evidenced by Goldschneider and DeKeyser (2001) categorization, substance (i.e., phonological and/or orthographic length) is among the most longstanding and widely acknowledged theorized salience properties. Empirical research largely affirms that longer forms positively correlate with better learning outcomes compared to shorter forms (e.g., Streefkerk, 2002; DeKeyser et al., 2017; Frigo and McDonald, 1998; but see, e.g., Carroll, 2012, for contrary findings). However, few studies link observed effects on learning outcomes to variations in attention to forms of different lengths—an essential step for establishing a causal role of salience in explaining the results. Simoens et al. (2017) aimed to do this by using eye-tracking to compare fixations to a one- vs. three-letter artificial morpheme in a grammaticality judgment task. They used a grammaticality sensitivity index (GSI; Godfroid, 2016; see Section 4.5 below for a detailed explanation) to measure intake of each morpheme. They found greater overall attention to the longer morpheme, as well as a small but significant positive effect of morpheme length on implicit learning. Cipitria et al. (2026) replicated the methods of Simoens et al. (2017) on a larger scale and also found that longer morphemes were more attended than shorter ones, but found no additional evidence of an effect of form length on implicit learning.

In contrast, the effect of boundedness as salience on attention and implicit learning has not yet been tested empirically. Boundedness has thus far only been invoked *post-hoc* as having a possible salience effect that would account for differences in acquisition order, or as one of several properties that yield a single salience differential between forms. Zobl and Liceran (1994), for example, found that unbound morphemes are acquired before bound morphemes after stratifying by syntactic category (lexical or functional). This inspired Goldschneider and DeKeyser (2001) inclusion of boundedness within their syntactic category factor in their meta-analysis. They, too, found that unbound morphemes were acquired earlier than bound within their respective syntactic category. In their reexamination of boundedness in the context of salience, Goldschneider and DeKeyser (2001) argued that greater salience of unbound morphemes was due to the emergent property of greater distributional variation in naturalistic input. Because bound morphemes are obligatorily attached to a base, their positional and contextual variability is inherently constrained,

whereas unbound morphemes can occur more independently across contexts. This increased variability, arising from the inherent property of boundedness, may increase the likelihood that learners notice unbound forms during processing, even when distributional variation itself is not directly manipulated.

In contrast, the present study adopts a local, stimulus-bound operationalization of salience, enabling experimental manipulation while holding broader frequency distributions constant. For example, there are clear perceptual differences between bound and unbound morphemes: In written input, unbound morphemes are demarcated as individual words via a space on either side, making them visually stand out relative to bound morphemes. Word recognition occurs early in reading development, which then automatizes the process of word-level language segmentation in a way that is “much more resistant to change than comparable phenomena in oral language” (Goodman, 1968, p. 1), priming the cognitive system to notice unbound morphemes more readily than bound, which makes the former more salient. Bound morphemes also tend to depend at least prosodically and often functionally on their stems compared to unbound morphemes (e.g., Ellis, 2006). However, an empirical verification of any direct effect of boundedness on attention, awareness, and acquisition remains wanting, perhaps because it is a particularly difficult property to isolate. Boundedness in natural language almost inextricably coincides with other possible salience properties, confounding any effect of the form’s boundedness specifically: Greater stress is more likely to be placed on unbound than bound morphemes, unbound morphemes are usually more syllabic/longer than bound, and are more likely to be lexical than functional (though Zobl and Liceran (1994) and Goldschneider and DeKeyser (2001) found that when accounting for syntactic category, the boundedness effect on acquisition order held). By using a semi-artificial language, our methodology aims to isolate the property of boundedness in order to test its individual effect on attention, awareness, and acquisition.

2.3 External factors

Any language-internal salience effect will likely be influenced by numerous language-external factors, including the learning conditions in which the input is encountered, as well as

individual learner variables influencing cognitive processes related to attention.

Regarding learning conditions, we distinguish for our purposes between incidental and intentional learning. Incidental learning involves the unconscious acquisition of information from the environment, occurring without the learner's awareness of the specific knowledge being gained. Applied to language learning, incidental learning usually focuses on meaning (semantics) rather than form (lexical, morphological, phonological or orthographic; DeKeyser, 2003; Hulstijn, 2003; Seger, 1994; Williams and Rebuschat, 2022). It typically takes place during natural language use, or communicative learning activities designed to replicate natural use. In contrast, intentional learning involves a conscious, goal-directed effort to acquire knowledge, often through structured approaches such as formal language courses (Williams and Rebuschat, 2022). In contrast to incidental learning, intentional learning focuses more on linguistic forms than on meaning, though the learning that takes place might still be considered implicit if specific focus-on-form methods are not part of the learning process. These different learning conditions are thus expected to guide attention to different aspects of the L2 input, impacting any salience effect the language itself might yield.

Individual learner variables are also believed to crucially impact cognitive processes involved in [language] learning. SLA researchers attribute variation in L2 acquisition outcomes to individual differences in various cognitive abilities (Robinson, 2001). In this study, we focus on three such variables to consider their possible moderating effect on attention, awareness, and acquisition: L2 proficiency, implicit learning ability (ILA), and working memory (WM) capacity.

L2 proficiency—i.e., the degree of ability to use a given L2 as a communicative tool (Bulté et al., 2024)—affects how a learner processes L2 input. For example, in eye-tracking studies, lower-proficiency learners tend to read more slowly and make more regressions, whereas higher-proficiency learners exhibit more native-like reading behaviors, such as spending more time on ungrammatical sentences (e.g., Lim and Christianson, 2015; Sagarra and Ellis, 2013). This can be particularly relevant to morphological processing, as beginners often overlook verbal morphology (e.g., *-ed*) in favor of more salient markers like temporal adverbs (e.g., *yesterday*), while intermediate learners notice such morphological cues but might not analyze their function (Sagarra and Ellis, 2013). In general, proficiency level is expected to influence where a learner's attention is inherently drawn within L2 input.

ILA is a broad conceptualization of how readily an individual takes in information in an implicit learning context. SLA research has found evidence that ILA influences L2 acquisition. Granena (2013), for example, found a correlation between a serial reaction time (SRT) task performance and implicit grammar learning, suggesting that visual sequence learning ability is relevant to implicit L2 acquisition from written input. Godfroid and Kim (2021) similarly found that performance on an alternating SRT task predicted learners' performance on timed, accuracy-based language tests, indicating a positive relationship between implicit learning aptitude and implicit

acquisition. Such evidence suggests that any effect of salience might be moderated by an individual's ability to take in and retain information.

WM capacity refers to the ability to temporarily store and manipulate a limited amount of information while engaging in cognitive tasks (Baddeley, 1992). Research in SLA has extensively explored the connection between WM and attention, with WM capacity significantly affecting comprehension and processing skills, especially in explicit learning contexts (Robinson et al., 2012; Williams, 2015; Wen et al., 2015). Like ILA, differences in WM might moderate the effect of salience of L2 forms.

3 The present study

Despite increased theoretical interest in salience in the SLA field (e.g., Boswijk and Coler, 2020; Gass et al., 2017; Goldschneider and DeKeyser, 2001), there remains a paucity of empirical research on the subject. Specifically, much of existing SLA salience research assumes the salience of a given linguistic property and its effect on attention, awareness and learning, but rarely has this been empirically tested by isolating said property (cf. Knell et al., 2025). Moreover, to get a complete picture, the relationship between salience effects and the effects of relevant external factors must also be considered. The present experiment investigates the effect of morphological boundedness, which has yet to be investigated in isolation in empirical research, and its interaction with L2 form substance (here, orthographic length). Our experiment is conducted along the following research questions (RQs) and corresponding hypotheses (H):

RQ1: Does morphological boundedness as a manifestation of salience affect attention to L2 forms in written input, and [how] does orthographic length of the form impact any effects of boundedness on attention, as measured by eye movement measures?

H1: Given that greater salience is expected to relate to greater attention levels, we hypothesize that attention will be greater for the high-salient unbound forms compared to low-salient bound forms. This is expected to compound in interaction with length, i.e., the greatest attention levels are expected for long, unbound forms and the lowest levels for short, bound forms.

RQ2: Does level of attention to a form predict awareness of a form and/or intake of its associated grammatical rule?

H2: In keeping with most theories of the relationship between attention and awareness, we hypothesize that attention level will positively correlate with awareness level. Likewise, in keeping with the Noticing Hypothesis, we hypothesize that attention (and consequently awareness) will positively correlate with intake of the associated rule.

RQ3: [How] is the effect of boundedness and length on attention, awareness, and intake impacted by possible external influences, namely: an incidental vs. intentional learning condition and the individual learner variables of L2 proficiency, WM capacity, and ILA?

H3: We hypothesize that the intentional learning condition will yield greater learning outcomes than the incidental condition,

given the additional instruction to focus on the grammar in that condition which is more likely to instigate noticing of the target morpheme associations compared to the incidental condition. We also expect that any effects of the salience variables will be stronger among lower-proficiency learners (cf. Knell et al., 2025). WM capacity and ILA will most likely both reduce overall fixation times due to lower cognitive load and higher sensitivity to input pattern recognition, respectively, though whether and how these will interact with salience specifically cannot be predicted due to limited previous research relating these processes to salience.

4 Methods

4.1 Participants

Participants ($n = 126$) were L1 Dutch speakers aged 18–35 with high English proficiency. Proficiency was assessed in two stages: First, a self-reported proficiency measure was included as part of a background questionnaire to determine participant eligibility. An objective proficiency test (C-test, which could only be conducted in person during the experiment appointment to avoid the possibility of cheating) was administered to verify the validity of the self-reported measure, and the score received was the only proficiency measure used in the statistical analyses. All participants had normal or corrected-to-normal vision and no reported reading or attentional disorders (e.g., dyslexia or attention deficit [hyperactive] disorder, respectively). To avoid possible confounding interaction with other L2 knowledge, those with self-assessed L2 proficiency $\geq$ B1 in a language with features similar to the target morphemes (e.g., Spanish, Italian, and Portuguese which include a gender-related *-o* bound morpheme and an unbound morpheme “*o*”) were excluded. Participants received compensation for their time either via course credit or €20 monetary compensation. Ethical approval for participant recruitment and compensation was granted by the Ethics Committee for Humanities at the [affiliated university].

4.2 Target language

The target language was an English-based semi-artificial language called *Englishti*, originally developed by Simoens et al. (2017). Using a semi-artificial language served three purposes: First, a primary goal of our research is isolating the salience properties of interest to investigate their individual effect on L2 acquisition. Few, if any, comparable forms in natural language differ according to only one salience manifestation. Second, we wanted to control for previous exposure to the target forms due to the possible influence of prior linguistic experience on attention and salience (Ellis, 2006; Sagarra and Ellis, 2013), which is difficult to ensure when using a natural language. Finally, the large number of participants required for this experiment constrains the feasibility of using a natural language unknown to all participants or a fully artificial language given the time burden of grammar learning to sufficiently contextualize the target forms. The use of a semi-artificial language mitigates these issues while allowing us to maximally isolate the properties under investigation.

Englishti largely follows English vocabulary and morphosyntax, but replaces the possessive determiners *his* and *her* with either *[-julp]* or *[-jo]*, which serve as our target morphemes. These appeared either as unbound morphemes in the same phrasal position of the determiner, or as a bound suffix attached to the object of the possessive (see example below).

Example target-morpheme sentences in *Englishti*:

Bound: Last year Alan broke elbowulp in Austria.

Unbound: Last year Alan broke ulp elbow in Austria.

The sentential position of the unbound morpheme before rather than after the possessive object (as is the position of the bound morpheme) was done to prioritize ecological plausibility while otherwise maintaining tight stimulus control. The morpheme—determiner correspondence was counterbalanced between participants (i.e., for half of participants *[-julp] = his*, and half *[-julp] = her*, and vice versa for *[-jo]*).

The target morphemes were selected based on the following properties:

- 1) Monosyllabism with a vowel onset to match syllabicity and maximize attachability to English nouns ending in consonants,
- 2) Absence of ortho-phonological forms as existing morphemes in English or Dutch (and to the extent possible, other L2s with which participants might be familiar),
- 3) Phonotactic permissibility but infrequent [tri-]grapheme frequency in English and Dutch.

Englishti also includes numerous English pseudowords in its vocabulary, which serve as distractors to mask the focus of the experiment to participants. The distractor pseudowords were five to seven letters long and appeared syntactically to act as adjectives or adverbs (created using WordGen; Duyck et al., 2004).

Example distractor sentence:

Alan can sometimes be a pirye daredevil.

4.3 Stimuli

The experiment itself consisted of a learning phase (LP) and a testing phase (TP). The stimuli were presented as four-sentence stories in *Englishti* during the LP and individual sentences in the TP. Each story in the LP ($k = 40$; 160 total sentences) contained one target sentence, one distractor sentence, and two filler sentences in varying order. Target sentences included one of the two target morphemes and an associated noun as a possessive object as indicated by the target morpheme. These nouns were carefully selected according to the following properties:

- Five to seven letters long.
- Bisyllabic.
- Monomorphemic.
- Inanimate.
- Concrete (minimum 4.5/5 concreteness score; Brysbaert et al., 2014).

- High-frequency (Corpus of Contemporary American English [COCA]; Davies, 2015).
- Gender bias-controlled (via comparative his/her + noun bigram frequency per million; COCA).
- Non-zero his/her + noun bigram frequency per million (COCA).
- No exact Dutch cognates.
- Zero neighborhood density in English and Dutch to avoid misapprehension (CLEARPOND; Marian et al., 2012).

Target sentence structure was likewise carefully controlled. All sentences consisted of seven (bound condition) or eight words (unbound condition, see example sentences above). Each sentence included a four-letter-named human subject as possessor, with the possessive object in either the fifth (bound) or sixth (unbound) word position, and the target morpheme in either the fifth word position (unbound) or attached as a suffix to the possessive object in the fifth word position (bound). The possessive phrase was followed by either a two-word prepositional phrase starting with a two-letter preposition (e.g., as, in, of, etc.) or a two-word infinitive verb phrase starting with *to* for parafoveal structural consistency. Each possessive object noun was used in the target sentence of two stories, each appearing in a different block of the LP, once with *[-]ulp* and once with *[-]o*. The only difference between the two sentences in which each noun appeared was the subject (male or female proper name), the corresponding target morpheme, and the final word (to mask the repetition and maintain relevance within two different stories; final words in sentence pairs matched for orthographic length).

Distractor sentences included a pseudoword from *Englishti* vocabulary in a position which suggested either an adjectival or adverbial form. Filler sentences were fully-English sentences. The position of each sentence type within the story was balanced across trials. All sentences during the LP were grammatical.

The TP sentences were either target or distractor sentences. Half of each ($k = 20$ each) were familiar sentences repeated from the LP, while half were unfamiliar to the participants, but with structures matching their respective LP counterparts. Half of each sentence type was grammatical and half ungrammatical. Ungrammatical target sentences had the incorrect target morpheme according to the subject's gender, while ungrammatical distractors (included to have an equal number of total grammatical and ungrammatical sentences in the TP) had the distractor word in a position that was not syntactically plausible for an adjective or adverb. To minimize potential stimulus-level effects, the grammaticality of each test sentence—and, for target sentences, the gender of the subject—was balanced across task conditions.

4.4 Procedure

Prior to the experiment, participants completed an online questionnaire including demographic and linguistic background information (Qualtrics, 2005), which determined eligibility to participate. Upon qualification, participants then completed two pretests programmed in Gorilla (gorilla.sc; Anwyl-Irvine et al., 2019): a serial reaction time task (SRT; adapted

from Kaufman et al., 2010) which measures ILA, and a reading span test (RST; adapted from van den Noort et al., 2008) which measures WM capacity (see Supplemental material for details of the procedure and analysis of the pretests). Participants were permitted to complete these tasks on their own time online prior to the experiment. If not completed beforehand the tasks were done in person during the appointment before the experiment proper.

For the experiment, participants were sorted into one of eight task conditions in a $2 \times 2 \times 2$ design according to the following three criteria: target morpheme boundedness, morpheme association (i.e., whether *[-]ulp* and *[-]o* represented a replacement for *his* and *her*, respectively, or vice versa), and learning condition (see Figure 2).

The incidental group only received instructions to read the stories for content, whereas the intentional group was instructed to focus on the grammar of *Englishti* in addition to the content, and were informed in advance of the test in the second task.

The experiment included three steps: the LP, the TP, and a retrospective interview. The LP consisted of two blocks, during which participants read four-sentence stories in *Englishti*, each of which was followed by a yes/no question related to the content of the story to ensure focus on the task. Each block contained 20 stories with one of 20 target-associated nouns. Half appeared with *[-]ulp* and half with *[-]o* in the first block, and the same 20 nouns appeared with the other morpheme in the second block (see Section 4.3). The TP likewise consisted of two blocks, wherein participants performed a grammaticality judgment task on 80 individual target and distractor sentences ($k = 40$ each) across the two blocks (40 per block, equally divided according to sentence type, familiarity, and grammaticality; see Section 4.3). The procedure of each phase is visualized in Figure 3.

The TP was followed by a voice-recorded retrospective interview of approximately 5–10 min, which probed participants' awareness of the two target forms and their meaning in *Englishti* following a general-to-specific questioning order (Koch et al., 2023; Simoens et al., 2017; see Supplemental material for the complete interview protocol). Finally, participants were debriefed about the purpose of the experiment, and thereafter conducted an English proficiency test (C-test; Keijzer, 2007).

The experiment was carried out individually in a quiet room. It was designed and displayed using Experiment Builder (v. 2.3.38), and eye movements were captured using an EyeLink Portable Duo (SR Research Ltd, n.d.b). A 13-point manual calibration was completed before beginning until the validation error was under one degree of visual angle. Screen resolution was set to 1920×1080 , and refresh rate was 120 Hz. A chinrest was used to minimize head movements and ensure accurate eye movement data collection. Only the participant's dominant eye was recorded, using a sample rate of 500 Hz and optimal participant distance fixed at 52 cm.

The reading task was presented in Courier New (20 pt), a monospace font with equal spacing between characters. The sentences were centered on the screen and displayed on a single line. Between trials, participants could only continue when their gaze was focused on the fixation dot, ensuring their attention was maintained and controlling for saccade length at each trial onset. A drift check was performed every four sentences to verify sustained recording accuracy.

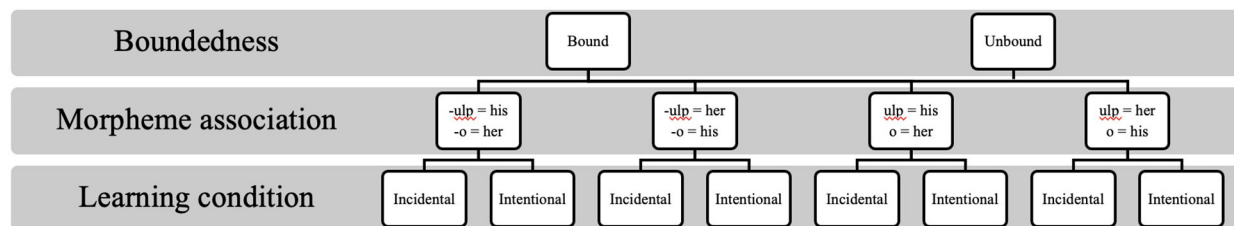


FIGURE 2
Experiment task conditions.

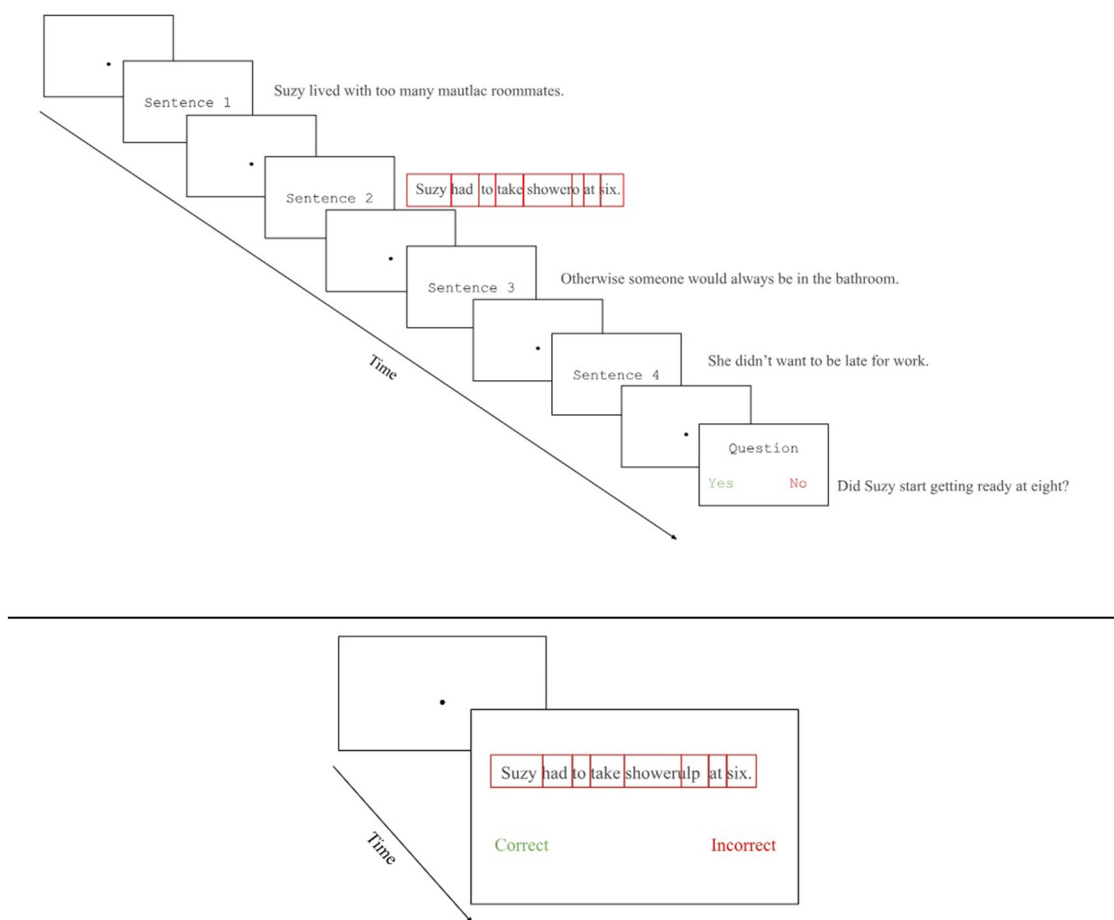


FIGURE 3
Trial procedure during LP (above) and TP (below). Example sentences are from the bound condition and association of -ulp = his/-o = her. The TP example is therefore an ungrammatical target sentence. The red-outlined boxes represent the interest areas of the sentence but were not visible to participants during the experiment.

4.5 Measures

4.5.1 Attention

Attention was measured by eye movement data captured via eye-tracking, namely fixation rates and durations. Eye-tracking is a well-established method for measuring attention (cf. Godfroid et al., 2013) given the close relationship between eye focus and cognitive focus in a given moment (i.e., the eye-mind link; Reichle et al., 2006; see also Rayner, 2009). Because

of possible differences of salience effects in early vs. late processing stages, we included an eye movement measure that represented each of these stages. In the first experiment in this series, a principal component analysis was conducted including numerous eye movement measures, and the two measures that each explained the most variance in the data for early and late processing measures were, respectively, First Fixation Duration (FFD), which captures the duration of the initial fixation on a target region upon first encounter, and Total Duration (TD), which sums all fixation durations within the target region during a given trial. For

consistency across all experiments, we use the same measures here and in all other experiments within the series. Before calculating FFD and TD, we also determined the skipping rates for each morpheme, which measure the absence of fixations during either the first-pass (hereafter FPS) or total reading (hereafter TS) of each target sentence. This served two purposes: (1) the skipping rate clarifies what percentage of the data was used to calculate fixation durations, and (2) skipping rate itself can act as an additional attention measure, specifically the initial drawing of attention to the form, though this is qualified by the possibility of skipping due to parafoveal pre-processing, predictability, and/or pre-programmed saccades. We therefore include skipping rates as coarse detectability indices, while fixation durations more clearly indicate prolonged attention and possibly further processing.

4.5.2 Awareness

Awareness of each target morpheme was gauged based on responses to a retrospective interview. Participants' awareness level was calculated separately for each target morpheme on a scale from 0 to 4: 0 = participant was entirely unaware of the form; 1 = aware of the form after receiving a prompt of possible options, 2 = aware of the form without prompt but either no or inaccurate awareness of meaning, 3 = aware of approximate meaning of the form, and 4 = aware of both the form and its exact meaning. This scale was adapted from similar protocols used to distinguish groups of aware and unaware participants in previous studies (e.g., Koch et al., 2023) such that awareness of the form's presence and structure (score of 2) and partial or total awareness of the form's meaning (score of 3 and 4, respectively) could also be distinguished (Andringa, 2020; Simoens et al., 2017). Any disagreement in scoring was resolved through discussion between the two primary researchers until consensus was reached.

4.5.3 Intake

Because of the brief time period encompassed in the task, we measure *intake* rather than full acquisition of target forms (see Section 2.1) by assessing participants' sensitivity to ungrammatical target sentences in the TP following repeated exposure to grammatical target sentences in the LP. Intake was measured by calculating a Grammatical Sensitivity Index (GSI), a method of measuring implicit knowledge of a grammatical rule (Godfroid, 2016; Granena, 2013; Lim and Christianson, 2015). The GSI was derived by subtracting fixation durations for all grammatical sentences per participant from those for ungrammatical sentences. Given the expected increase in processing time for an item that is to some degree recognized as ungrammatical, longer fixation times on morpheme-gender mismatches are interpreted as an indication of early-stage intake of the grammatical rule. Most participants will likely not be able to explicitly articulate the grammatical rule associated with the target morphemes by the end of the relatively brief experimental task. Using a GSI shows whether and to what extent the rule is being taken in implicitly. Additionally, the GSI calculation based on eye-movement measures also allows for finer-grained temporal insight into the processing of the forms compared

to other common GSI bases such as reaction times or self-paced reading segmentation (e.g., Godfroid et al., 2015). While the effects detectable by the GSI might be clearer in learning tasks taking place over longer periods of time or with more exposure to the target forms, previous research has found effects in some conditions in similarly short tasks (cf. Simoens et al., 2017).

4.6 Data processing

Pretest scores were calculated according to the procedures described in their original publications (C-test: Keijzer, 2007; SRT: Kaufman et al., 2010; Reading Span Test: van den Noort et al., 2008; see [Supplementary material](#)).

Eye-tracking data were pre-processed using Data Viewer (SR Research Ltd, n.d.a, v. 4.2.1.). Only target sentences were analyzed, with filler and distractor sentences excluded. Data quality checks indicated minimal fixation loss. A four-stage cleaning process merged or removed fixations following established research practices (e.g., Godfroid, 2020). Key eye-tracking measures commonly used in reading research were extracted using Get Reading Measures (SR Research Ltd, n.d.c). The analysis focused on only the target morpheme interest area (IA). For the unbound condition, this corresponded with IA5 (the fifth word in the sentence), whereas in the bound condition this corresponded with IA6 (the suffix region of the fifth word in the sentence; see [Figure 3](#) above for a visual example of the interest area outlines in the bound condition).

LP and TP sentences were considered separately, with TP sentences further differentiated according to grammaticality (target-subject gender [dis]agreement) and familiarity (either repeated from the LP or new in the TP).

4.7. Analysis

4.7.1 Attention

Using R (R Core Team, 2025) via RStudio (Posit Team, 2025), we fitted multiple mixed-effects linear and logistic regression models for both the LP and TP data. For eye fixation measures (FFD and TD), we fitted the following models ("c" indicates a centered variable; all categorical variables are sum coded):

Learning phase:

- $\log(\text{FFD}) \sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length} * \text{Boundedness} * \text{Learning condition} + (1|\text{Participant}) + (1|\text{Item})$.
- $\log(\text{TD}) \sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length} * \text{Boundedness} * \text{Learning condition} + (1|\text{Participant}) + (1|\text{Item})$.

Training phase:

- $\log(\text{FFD}) \sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length} * \text{Boundedness} * \text{Grammaticality} + \text{Length} * \text{Boundedness} * \text{Familiarity} +$

- Length*Boundedness*Learning condition + AwarenessO*AwarenessULP + (1|Participant) + (1|Item).
- $\log(\text{TD}) \sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length*Boundedness*Grammaticality} + \text{Length*Boundedness*Familiarity} + \text{Length*Boundedness*Learning condition} + \text{AwarenessO*AwarenessULP} + (1|\text{Participant}) + (1|\text{Item})$.

The outcome skip (“yes” vs. “no”) was created based on zero-values for both FFD and TD, with skip defined as “yes”, when FFD/TD measurements were equal to zero (i.e., an interest area was skipped when there was no fixation). For skipping we fitted the following models:

Learning phase

- Skip (based on FFD) $\sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length*Boundedness*Learning condition} + (1|\text{Participant}) + (1|\text{Item})$.
- Skip (based on TD) $\sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length*Boundedness*Learning condition} + (1|\text{Participant}) + (1|\text{Item})$.

Testing phase

- Skip (based on FFD) $\sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length*Boundedness*Grammaticality} + \text{Length*Boundedness*Familiarity} + \text{Length*Boundedness*Learning condition} + \text{AwarenessO*AwarenessULP} + (1|\text{Participant}) + (1|\text{Item})$.
- Skip (based on TD) $\sim \text{Proficiency.c} + \text{SerialReactionTime.c} + \text{ReadingSpan.c} + \text{Length*Boundedness*Grammaticality} + \text{Length*Boundedness*Familiarity} + \text{Length*Boundedness*Learning condition} + \text{AwarenessO*AwarenessULP} + (1|\text{Participant}) + (1|\text{Item})$.

In total, then, eight different models were fitted. For the LP, we evaluated the three-way interaction between Length, Boundedness and Learning condition, because we were interested in possible interaction effects (for instance, Short length might have a different effect depending on Boundedness and Learning condition). For the TD, we additionally included interactions with Grammaticality and Familiarity. We always included the (mean-centered) individual features Proficiency, SerialReactionTime, ReadingSpan, to control for individual differences. As to the random effects, we always included Item and Participant as random intercepts. Random slopes for various significant fixed effects were tested but not retained due to reasons of extremely low variance (singularity). All categorical predictors were also sum coded (e.g., Length, short vs. Long = −1 vs. 1), which enhances interpretability of the estimates.

We used the functions `lme4::lmer()` and `lme4::glmer()` (Bates et al., 2015) to fit our models. Our model-building strategy was informed by theoretical and linguistic considerations rather than by any attempt to capture a minimally adequate model, i.e., the smallest possible model with the best prediction accuracy. However, we did compare the models fitted below with smaller models without interactions to verify the consistency of the observed significant effects. All the significant effects proved to

be robust in these smaller models (i.e., they remained significant, and the parameter estimates remained largely the same). See [Supplementary material](#) for full modeling details.

4.7.2 Awareness

Awareness was measured as an ordinal categorical variable with five levels (0–4). Awareness levels for *O* and *ULP* were analyzed separately. First, we conducted a bivariate analysis of the relationship between awareness levels and boundedness using the Cochran–Armitage trend test [via `DescTools::CochranArmitageTest()`]. Next, we fitted simple regression models with awareness level as the dependent variable and average LP TD or average LP TS as predictors, to assess potential effects of eye-tracking measures. Finally, to evaluate how awareness levels related to eye-tracking measures (average total duration and skipping rate), while controlling for participant characteristics and boundedness, we used conditional inference trees [`partykit::ctree()`]. The following models were fitted (see [Supplementary material](#) for further details):

- AwarenessO $\sim \text{Proficiency} + \text{SerialReactionTime} + \text{ReadingSpan} + \text{Boundedness} + \text{AVE_TD}$.
- AwarenessO $\sim \text{Proficiency} + \text{SerialReactionTime} + \text{ReadingSpan} + \text{Boundedness} + \text{AVE_SKIP}$.
- AwarenessULP $\sim \text{Proficiency} + \text{SerialReactionTime} + \text{ReadingSpan} + \text{Boundedness} + \text{AVE_TD}$.
- AwarenessULP $\sim \text{Proficiency} + \text{SerialReactionTime} + \text{ReadingSpan} + \text{Boundedness} + \text{AVE_SKIP}$.

4.7.3 Intake

Grammatical sensitivity index (GSI) was calculated from the testing phase data. For each participant, GSI for both total duration (TD) and first fixation duration (FFD) was computed as the difference between responses to ungrammatical and grammatical items. As a starting point, we tested whether the mean GSI differed significantly from zero using a one-sample *t*-test and a non-parametric sign test. To examine potential bivariate effects of Boundedness and Learning condition, we used the Wilcoxon rank-sum test. To assess multivariate effects of Length, Boundedness, and Condition, we fitted linear regression models using `lm()`, beginning with the full three-way interaction:

- $\text{GSI} \sim \text{Learning condition} * \text{Length} * \text{Boundedness}$.

5 Results

Results were calculated for each salience variable (boundedness and length) according to measures of attention, awareness, and acquisition, as well as any independent or interactional effect of our selected external variables (learning condition, proficiency, ILA, and WM capacity). At all stages, data from each

TABLE 1a C-test and RST scores.

Test	N	Mean (SD)	Median
C-test	126	82 (10)	84
RST	124	39 (10)	40

TABLE 1b SRT scores

Test	0	1	2	3	4	5	6
SRT	5 (4%)	14 (11%)	18 (15%)	29 (23%)	25 (20%)	18 (15%)	15 (12%)

The C-test measured English proficiency and was scored out of 100; the RST measured WM capacity and was scored out of 60; the SRT measured ILA and was scored 0–6, with 6 indicating the highest ILA performance relative to the sample.

TABLE 2 FPS and TS during each experiment phase.

Variable	LP (%)	TP (%)
FPS	68	65
TS	52	36

experiment phase were treated separately. We report below on the most informative results. Complete analysis and results can be accessed at <https://dataverse.no/dataset.xhtml?persistentId=doi:10.18710/33MERR>.

5.1. Participant features

Table 1 summarizes participants’ scores for the three tested individual learner variables.

Each of these variables were included in each model, but no significance ($\alpha = 5\%$) was found in relation to measures of attention, awareness, or acquisition other than those which reflect expected behavior patterns (e.g., a slight but significant negative correlation between TD and proficiency, which likely reflects faster reading times and/or less rereading for higher-proficiency participants, but is not of note otherwise). Possible reasons for this are discussed in Section 6.

5.2 Attention

Attention was measured using eye movement data, namely first pass and total skipping rates (hereafter FPS and TS, respectively), FFD, and TD.

5.2.1 Skipping rate

The average skipping rate was relatively high for both the LP and TP (68% and 65% FPS, respectively). This is as expected for short items in reading input (Rayner, 1998). The mean TS was 52% during the LP and 36% during the TP (Table 2). The lower TS (and to a lesser extent FPS) during the TP is not surprising, given the requirement of the task to focus on the grammar of each sentence compared to the content focus during the LP.

TABLE 3 FPS and TS by experimental variables for each experiment phase.

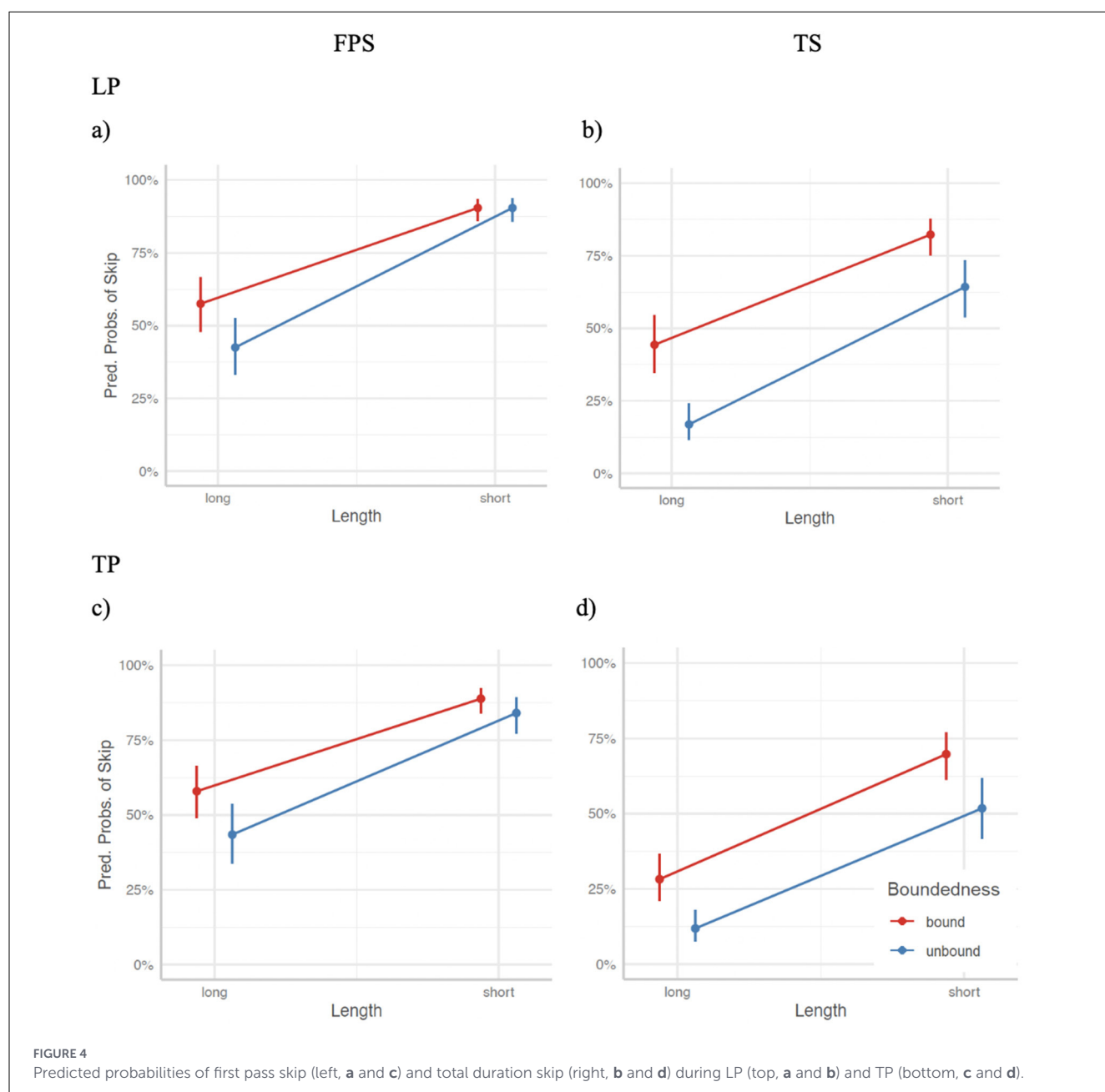
Variable	LP		TP	
	FPS (%)	TS (%)	FPS (%)	TS (%)
Length				
Short	86	70	81	54
Long	50	34	49	19
Boundedness				
Bound	70	61	68	42
Unbound	65	42	61	30
Learning condition				
Incidental	69	53	67	37
Intentional	67	52	63	36
Grammaticality*				
Grammatical	–	–	65	37
Ungrammatical	–	–	65	35
Familiarity*				
Familiar	–	–	66	40
Unfamiliar	–	–	63	33

*Not examined during LP.

Table 3 summarizes the bivariate results of both skipping rates according to each experimental variable.

In both phases, stark differences emerged between the skipping rates of bound vs. unbound and long vs. short morphemes, with consistently higher skipping rates for bound and short morphemes, respectively, though this effect was stronger for length than boundedness overall.

Figure 4 shows the predicted probabilities for the significant effects found in the four models. In the LP, an interaction of length*boundedness was found for both skipping rates, wherein boundedness had a larger effect for [-]ulp (58% predicted probability long*bound – 43% long*unbound = 15% FPS, Figure 4a; 27% TS, Figure 4b), possibly evident of a compounding effect of the two higher-salience properties on skipping rates. In the TP, a main effect of length and boundedness was found for FPS (31% and 15%, respectively, Figure 4c), and an interaction of length*boundedness was found for TS, wherein boundedness had a slightly stronger effect for the shorter morpheme (17%; Figure 4d).



5.2.2 First fixation duration

FFD was selected as an early processing measure. Table 4 summarizes the sample distributions of FFD in relation to each experimental variable.

We interpret significance in the model results in terms of marginal means (predicted FFD) using the ggeffects package (Lüdtke, 2018; see also <https://strangejacke.github.io/ggeffects/articles/ggeffects.html>). During the LP, a main effect of boundedness was found, with bound forms fixated longer than unbound forms (26ms), opposite to attentional effects of boundedness according to skipping rate. An interaction of length*condition was found in the LP, with longer fixations on the short form in the intentional condition (20ms; Figure 5), and a main effect of length was found in the TP, with longer fixations on the long than short form (28ms). FFD rates for both salience variables are visualized in Figure 6.

5.2.3 Total duration

TD was selected as a late processing measure. Table 5 summarizes the bivariate results of TD according to each experimental variable.

During both experiment phases, a main effect of length was found, with longer total fixations of long vs. short forms (LP: 165 ms; TP: 128 ms; Figure 7). No effect of boundedness was found in either phase.

5.3 Awareness

Awareness was measured using a scaled score of 0–4 for each target morpheme based on participant responses during the retrospective interview (see Section 4.5). Table 6 shows the

participant number with each score for each morpheme, stratified by boundedness.

For both morphemes, the unbound form showed higher awareness levels (cf. the larger number of participants scoring 3). For *[-]ulp*, this trend was significant based on a Cochran-Armitage test ($Z = -5$, $\text{dim} = 5$, $p\text{-value} < 0.001$).

Because most participants reported noticing the forms early in the experiment, and given the theorized bidirectional relationship between attention and awareness (e.g., Gass et al., 2003; see also Figure 1), we considered awareness as an outcome variable of LP attention patterns, and as a predictor variable of TP patterns. In

the TP, no significant relationship between any attention measures and awareness was found. In the LP, to explore potential effects of other variables on awareness, we performed two classification tree analyses, one for each morpheme (Figure 8). Results showed higher awareness scores for *[-]o* among those with higher mean TD (Figure 8a), suggesting an effect of overall attention on awareness

TABLE 4 FFD by experimental variables for each experiment phase.

Variable	Mean (SD)	Median	Mean (SD)	Median
Length				
Short	207 (82)	178	220 (85)	190
Long	233 (95)	201	241 (93)	216
Boundedness				
Bound	245 (103)	216	244 (95)	214
Unbound	208 (76)	181	227 (86)	202
Learning condition				
Incidental	231 (93)	200	231 (89)	204
Intentional	223 (93)	190	239 (93)	210
Grammaticality*				
Grammatical	–	–	233 (88)	208
Ungram.	–	–	238 (94)	208
Familiarity*				
Familiar	–	–	236 (93)	310
Unfamiliar	–	–	234 (90)	208

*Not examined during LP.

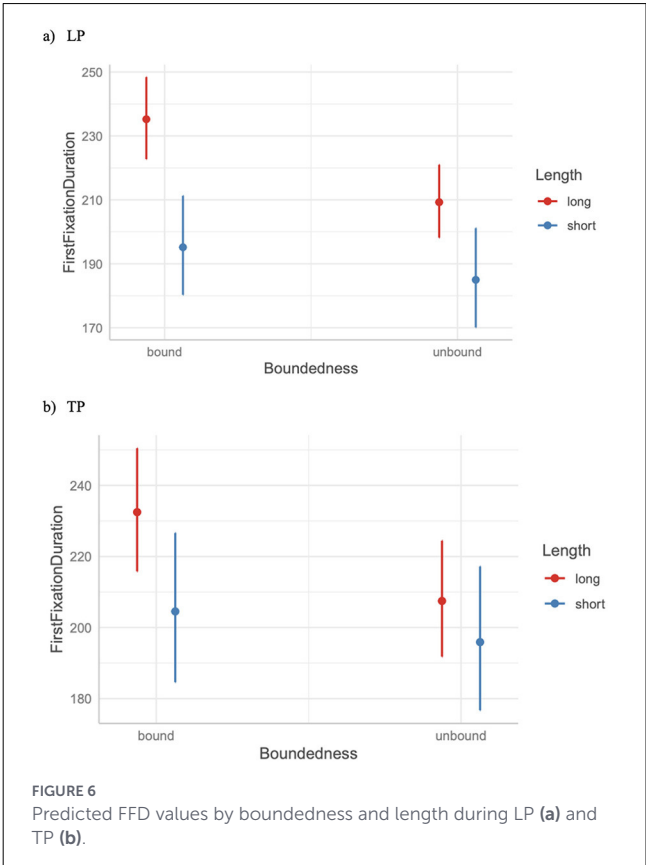


FIGURE 6 Predicted FFD values by boundedness and length during LP (a) and TP (b).

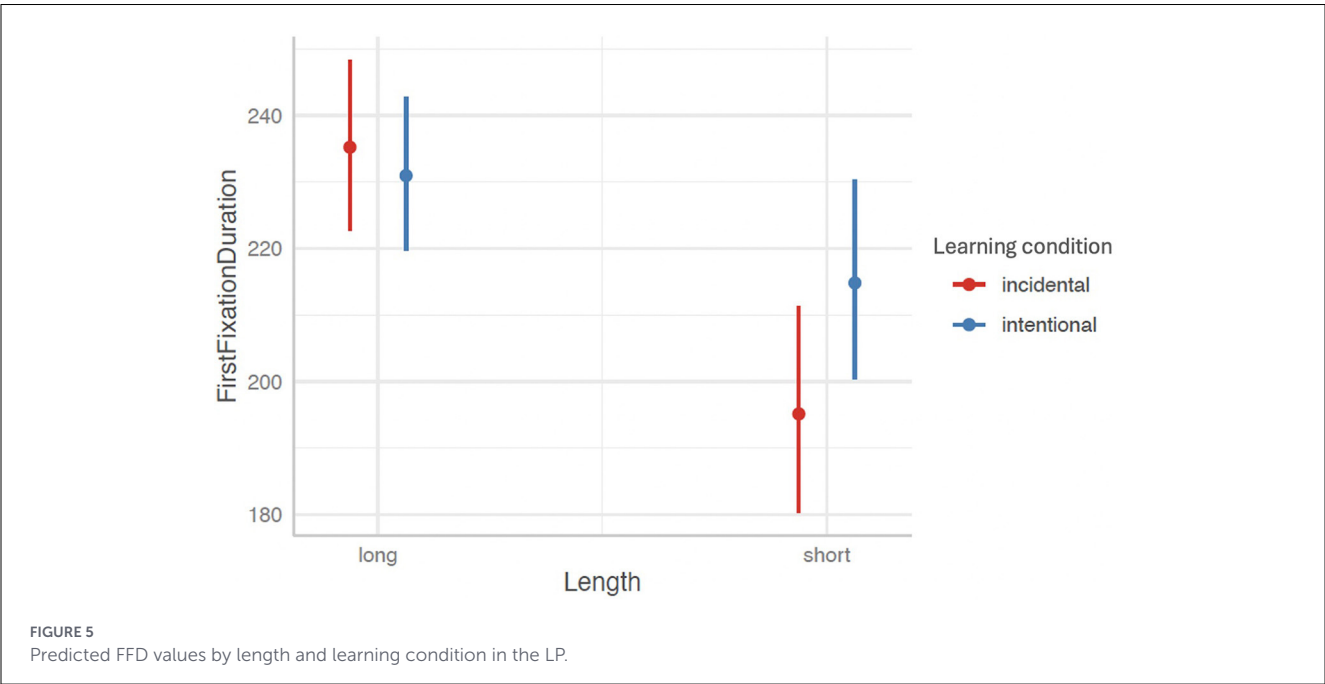
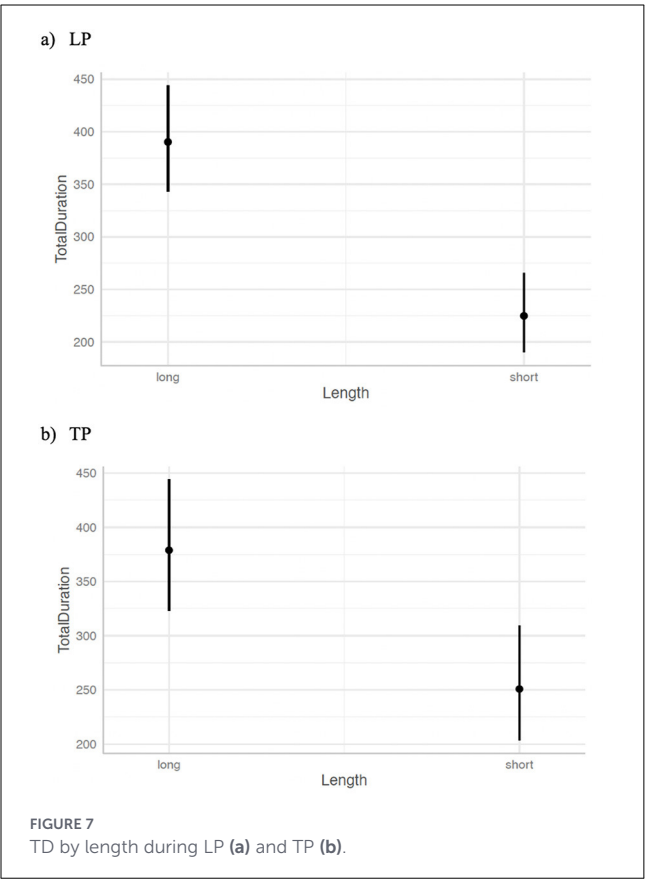


FIGURE 5 Predicted FFD values by length and learning condition in the LP.

TABLE 5 TD by experimental variables for each experiment phase.

Variable	Mean (SD)	Median	Mean (SD)	Median
Length				
Short	307 (246)	214	357 (261)	258
Long	499 (369)	388	545 (408)	428
Boundedness				
Bound	467 (367)	341	463 (368)	338
Unbound	444 (341)	358	491 (384)	380
Learning condition				
Incidental	445 (352)	340	470 (361)	364
Intentional	466 (357)	358	483 (384)	360
Grammaticality*				
Grammatical			482 (383)	362
Ungram.			472 (363)	362
Familiarity*				
Familiar			455 (364)	337
Unfamiliar			496 (380)	382

*Not examined during LP.



of [-]o, whereas for [-]ulp, higher awareness scores were found for unbound than bound morphemes, and for higher-proficiency participants in the unbound condition. Note that, given the

exploratory nature of this particular analysis, the strength of these findings is limited.

5.4 Intake

Early-stage implicit knowledge (intake) of the target morphemes' meaning was measured by calculating a GSI for each participant according to FFD and TD (see Section 4.5). For each measure, longer fixations on ungrammatical forms compared to grammatical (GSI score > 0) suggests implicit learning of the associated rule. Figure 9 plots participant fixation durations for grammatical and ungrammatical trials according to length, boundedness, and learning condition. Using regression modeling, no evidence was found for any effect of Boundedness, Length, or Instruction on GSI (neither for FFD nor for TD).

Generally, no evidence of implicit knowledge of either morpheme was found within the sample based on GSI scores. No GSI score was significantly different from zero (based on one sample *t*-test; an additional sign test affirmed roughly as many positive as negative GSI scores). Likewise, no difference was evident in GSI scores according to length nor boundedness of the form for either fixation measure, nor among any external variables.

6 Discussion

This study presented an investigation of morphological boundedness as salience and its interaction with morpheme length as salience, and the effect of each on attention, awareness, and intake of L2 input. We further considered how any observed salience effect interacts with external factors assumed to mediate these processes: namely learning condition (incidental or intentional) and three individual learner variables (ILA, WM capacity, and L2 proficiency).

RQ1 focused on the effect of morphological boundedness on attention and called for the comparison of the effect of boundedness on attention with that of orthographic length. Both first-pass and total skipping rates of the target morphemes indicated greater initial attention levels to the long vs. short morpheme, consistent with results of previous experiments (Cipitria et al., 2025, 2026; Simoens et al., 2017), and to a lesser extent to unbound vs. bound morphemes, which is in line with expectations based on the difference in salience for each variable. While it should be noted that skipping can also occur for other reasons, including sufficient parafoveal pre-processing of the form and/or general oculomotor functions (e.g., Brysbaert and Vitu, 1998; Drieghe et al., 2005), evidence suggests that skipped words are not always processed to the same degree as fixated words (Eskenazi and Folk, 2015), making the difference still relevant when measuring overall attention levels. However, skipping rates did not predict fixation durations for boundedness specifically. For both fixation measures during each experiment phase, the longer morpheme was fixated longer than the short. For bound forms, meanwhile, longer FFD was found for bound forms during the LP and to a lesser extent in the TP. This leveled out to a null effect of boundedness on TD.

TABLE 6 Participant awareness scores by morpheme and boundedness.

Morpheme	Boundedness	Score				
		0	1	2	3	4
[-]o	Bound	1 (1%)	6 (9%)	56 (80%)	5 (7%)	2 (3%)
	Unbound	0 (0%)	4 (7%)	40 (74%)	10 (19%)	0 (0%)
[-]ulp	Bound	2 (3%)	17 (24%)	45 (64%)	3 (4%)	3 (4%)
	Unbound	0 (0%)	1 (2%)	20 (37%)	25 (46%)	8 (15%)

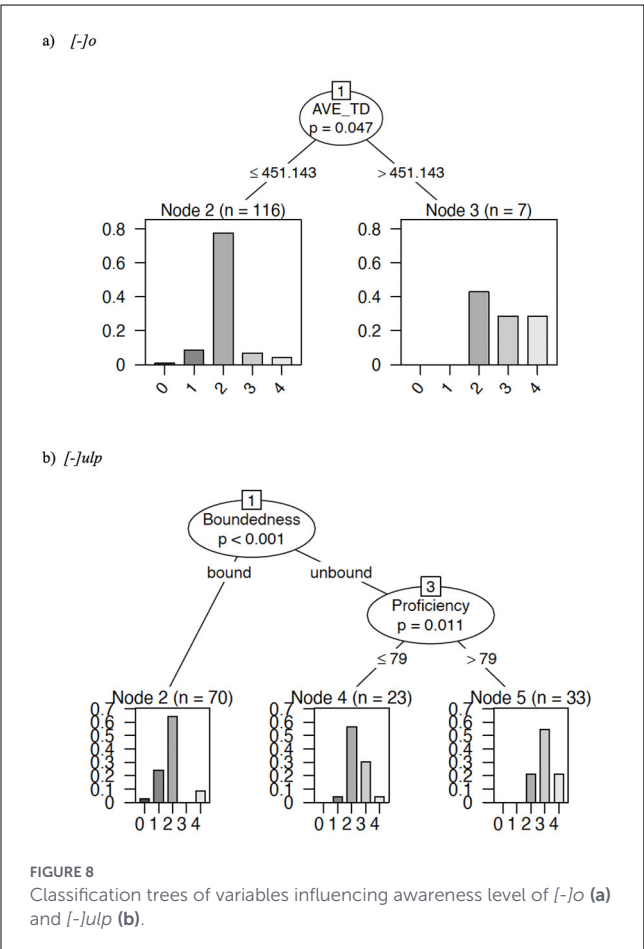


FIGURE 8 Classification trees of variables influencing awareness level of [-]o (a) and [-]ulp (b).

This contrasts with expectations regarding the effect of salience on early vs. late attentional processes, where greater salience, especially perceptual salience, is expected to increase early attention in particular (Skinner et al., 2018). The divergence in fixation patterns in these results might be due to the functional differences between bound and unbound forms that are absent in the length manipulation. For example, attachment of a bound artificial morpheme creates a morphologically-complex pseudoword. If the bound morpheme is fixated as part of reading the base to which it is attached, this might trigger automatic decomposition of the complex word, according to most theories of novel complex [pseudo]word processing (cf., Rastle and Davis, 2008; Schreuder and Baayen, 1995), leading to longer processing times as reflected in the fixation durations. Additionally, neither Dutch

nor English tend to add functional morphemes as suffixes on object nouns apart from plural and genitive markers, whereas both include auxiliary functional unbound morphemes such as possessive determiners. This might, therefore, yield a surprisal effect for the bound morphemes compared to unbound, which can also yield greater salience (e.g., Boswijk and Coler, 2020; Ellis, 2017). Importantly, positional predictability is itself one of the distributional cues through which boundedness has been argued to operate in natural language (Dube et al., 2019; Sundara et al., 2011). Thus, while the present design cannot fully separate position and boundedness, it captures an ecologically plausible constellation of cues that jointly instantiate boundedness in written input. In general, the divergence between skipping patterns and fixation durations underscores that early detectability and later processing effort may reflect partially distinct attentional mechanisms. These findings might also affirm a possible hierarchy of salience properties concerning their relative attention allocation, where length seems to operate as a primary cue while boundedness only has a secondary role.

RQ2 asked, in part, if attention level predicted awareness. Although some correlational trends could be seen between attention and awareness levels, few were significant. For both [-]ulp and [-]o, most participants were rated with an awareness score of 2, meaning they were aware of the form itself without prompting but had either no knowledge or an incorrect theory of the form's meaning, while comparatively few scored on either far end of the spectrum. This low variance might account for the limited findings regarding awareness. This notwithstanding, our results indicate that awareness is not necessarily an automatic result of attention, nor does it automatically trigger further attention, at least in the context of this experimental design. That said, a significant effect was found for awareness of [-]ulp specifically according to boundedness, with higher awareness in the unbound group, in keeping with expectations regarding salience. It should be noted, however, that a possible confound with regard to boundedness and awareness emerged during data collection: for unbound forms, many participants articulated in their retrospective interviews the visual and syntactic similarity between *o* and the English indefinite article *a*. Although participants saw *o* and *ulp* in the exact same sentential context throughout the LP (apart from the subject gender change), this visual association might have obfuscated the rule learning of *o* by creating an assumption that it was intended as a replacement for *a* (or even a typo), whereas rule learning of *ulp* was not affected by this association. Since more participants were able to associate *ulp* with possession without the possible confounding of the formal similarity of *o* and *a*, this might account for the greater awareness levels of unbound *ulp* vs. *o*, rather than

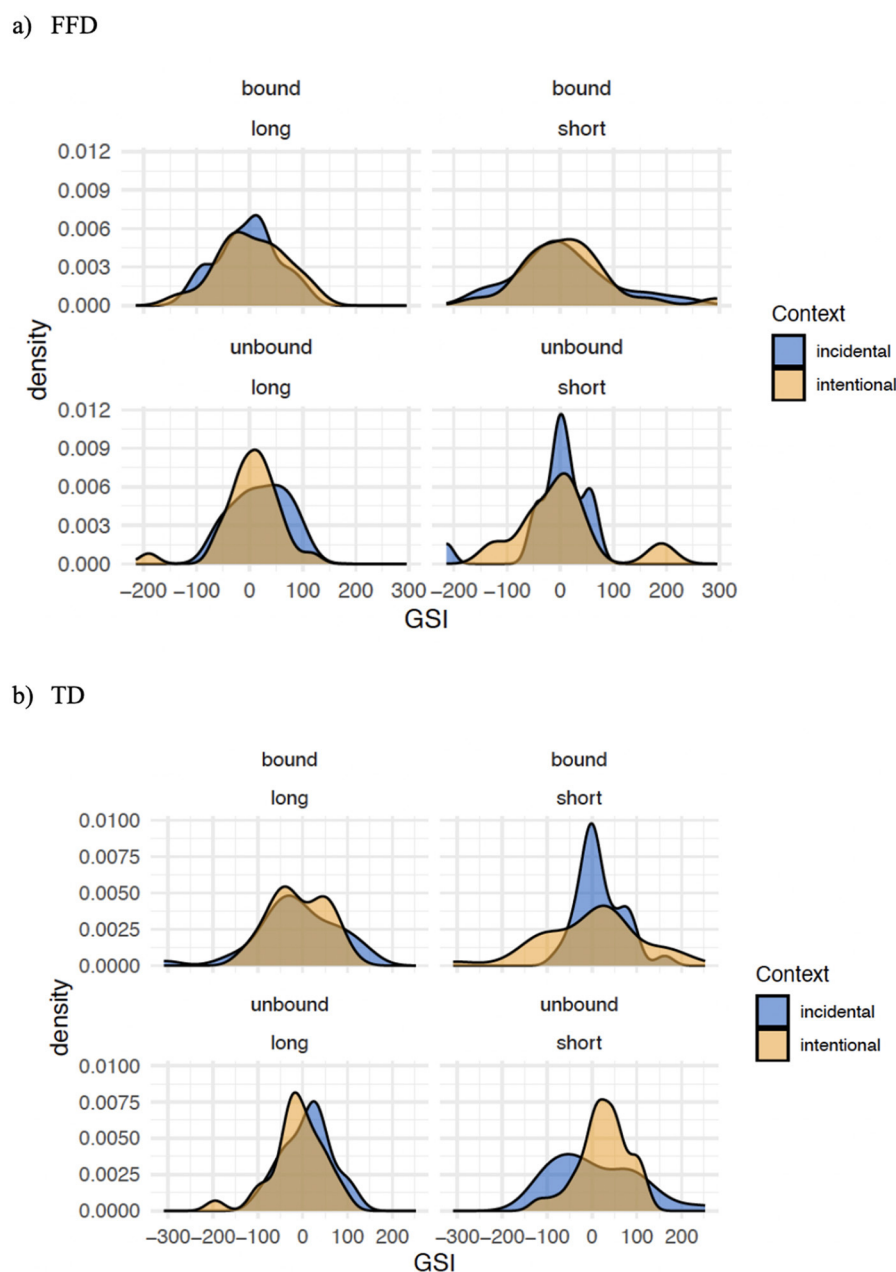


FIGURE 9

GSI score distributions by length, boundedness, and learning condition for FFD (a) and TD (b).

a difference in salience according to length. This interpretation is bolstered by the finding that the bound group—which would have no such visual association, being presented as bound suffixes—had an almost identical number of participants scoring 3 or 4 for each morpheme (see Table 6). This possibility therefore somewhat limits any conclusions to be drawn between boundedness as salience and awareness within our experiment.

RQ2 further asked if attention and/or awareness predicted intake of the grammatical rule associated with the form. According to the GSI results, and despite the differences in awareness of meaning according to boundedness, there was no indication of intake of form meaning to suggest early stages of acquisition

for the overall sample (see Figure 9). There are several possible explanations for this. First, even with the differing degrees of salience between the target forms, the overall salience of all target forms might still be relatively low. Salience is a complex construct likely composed of numerous properties that together determine the overall [degree of] salience of a form (DeKeyser et al., 2017; Gass et al., 2017; Knell et al., 2025). In a systematic review of empirical research on salience in SLA, Knell et al. (2025) noted that among a sample wherein a large majority of studies saw a positive effect of salience on L2 learning outcomes, studies that found no effect often had a low overall degree of salience in target forms and/or small differences in salience between them. Previous

experiments using the same experiment design (Cipitria et al., 2025, 2026) have similarly found no indication of implicit learning. It is possible that the forms in this study are not salient enough, in themselves and/or as part of the LP task, to yield implicit intake. Second, it is possible that the LP task is not sufficiently conducive to the initiation of intake of the target forms' meaning. By design, participants receive little to no indication of which *Englishti* forms are being targeted, nor are they given explicit guidance regarding their meaning—beyond what can be inferred from the story context and sentence repetition. This intentional lack of direction prevents the application of external attention, which could otherwise confound the interpretation of salience as the source of any observed effects. Additionally, also by design to avoid excessive external attention to the target forms, the LP task did not necessarily require understanding the rule associated with the target forms to be completed successfully. Even if this were not an issue, there might be insufficient exposure to the target forms over the course of the experiment to initiate sample-wide intake of the rule. While implicit intake remains possible, it might be that a greater amount and/or variety of input is necessary for intake to occur. Finally, it is possible that even if salience impacts attention and/or awareness of a given form as seen here, it is not ultimately an important factor in acquisition, as some assert (e.g., Carroll, 2012; Lardiere, 2017; O'Grady et al., 2017), meaning that acquisition outcome differences as a result of differences in salience would be unlikely from the start. Lardiere (2017), for example, posits that while salience might play a role in L2 acquisition, what is more critical is whether the learner's developmental stage is such that features of the input can be integrated with their current knowledge, concluding that “detectability of grammatical feature contrasts is not limited to, and is likely only peripherally related to, the notion of ... salience” (p. 57). Similarly, Carroll (2012) argues that salience is an outcome rather than a cause of acquisition, given that certain L2 knowledge is necessary before salience becomes relevant to the learner. The continuation of our experimental series and other future research might elucidate the reason for these findings regarding intake (and ultimate acquisition).

RQ3 focused on whether and to what extent external factors—namely an incidental vs. intentional implicit learning condition and the individual learner variables L2 proficiency, WM capacity, and ILA—affected attention, awareness, and intake of the target forms and/or interacted with salience variable effects. A significant interaction of learning condition was found for FFD during the LP wherein the short morpheme *-u* was fixated significantly longer in the intentional than incidental condition (see Figure 5), suggesting that attention specifically to the otherwise low-salient form was bolstered by the additional overall attention to the L2 grammar imposed by the intentional condition. This is consistent with previous findings that increased focus on form in an instructional context differentially affects attention patterns, including often increasing attention allocation to otherwise lower-salient forms (e.g., Cintrón-Valentín and Ellis, 2015; Sagarra and Ellis, 2013; Simoens et al., 2017). The lack of a consistent effect of learning condition is most likely due to the subtlety of differences between the two conditions, which were ultimately both implicit, as well as an imposed focus on grammar in the TP in both conditions that likely leveled out the differences found in the LP.

Regarding the individual learner variables, the only significant findings were those that align with the relationship between these variables and general reading patterns, e.g., a slight but significant relationship between L2 proficiency and total duration, with lower fixation times as proficiency increased, as expected of higher-proficiency learners who tend to have faster reading times and make fewer regressions. Although some research has found a relationship between L2 proficiency and salience effects, findings on the relationship thus far are inconsistent and can depend on the L2 aspect at issue (cf. Knell et al., 2025). Moreover, all participants in this experiment had high English proficiency, and while individual levels varied from B2 to C2 according to the C-test results, significant differences in the relationship between proficiency and salience have usually been found between participants with greater proficiency variation and/or among participants at lower proficiency levels overall. As to WM capacity, while there is some precedent for an expected effect of this variable on attention (e.g., Wen et al., 2015), its effect on acquisition has mainly been found in processing and comprehension, and is especially prominent in explicit learning contexts and earlier learning stages (Robinson et al., 2012; Skehan, 2016; Williams, 2015), whereas this was an implicit learning task with high-proficiency participants. Given our findings that even early-stage acquisition of the forms did not result from this learning task, it is perhaps unsurprising that WM was not a factor. Similarly, regarding ILA, even less is known about its relationship to attention specifically, and research has found that this learner variable is most relevant at later stages of acquisition of a particular form than this task captures (e.g., Hamrick, 2015, who found that ILA predicted performance on a delayed but not an immediate recognition task). For both variables, little to no research has compared their effects on learning outcomes, let alone attention and awareness, to those of salience (Knell et al., 2026; but see Zalbidea and Sanz, 2020, who compared effects of WM on learning of forms of different degrees of salience, and found a positive effect of WM capacity on learning outcomes regardless of salience differences). There is a great deal of potential, therefore, for continued exploration of the relationship between these learner variables and L2 form salience.

7 Conclusion

This study used eye-tracking to examine how individual properties affecting the salience of L2 forms, namely morphological boundedness and orthographic length, influence attention, awareness, and intake of those forms. Our results showed via a comparison of skipping rates that both salience properties show differences in attention consistent with predictions from theoretical literature. Long forms compared to short further showed greater attention levels via both FFD and TD eye-movement measures in both experiment phases, whereas boundedness yielded no effect on TD rates while bound forms yielded longer FFD rates in both phases, in contrast to expectations of effects of greater salience on early attention processes in particular, and suggesting a difference in early processing of each form type. Certain attention

measures showed modest associations with awareness levels for individual salience variables; however, these patterns were neither sufficiently robust nor consistent to support a linear attention–awareness relationship, and the overall impact of salience differences on awareness proved limited. No evidence of intake was found, either generally or according to differences in salience or any external factors considered, such as learning condition or individual learner variables. This might suggest either that the salience level of the target morphemes was still too low to facilitate intake, that the learning conditions were not sufficiently conducive to early-stage implicit acquisition, or that salience does not impact acquisition despite many arguments to the contrary. More broadly, our findings showed that attention does not automatically lead to awareness or intake, and that these constructs might, in this context, be empirically separated from one another as distinct phenomena rather than causally linked processes.

Like all empirical research, this study is not without limitations. As noted earlier, our experimental paradigm might not have been ideally suited to fostering implicit intake of the target forms. Additionally, because bounded and unbound morphemes necessarily occupied slightly different positional configurations in the sentence, the present design cannot fully disentangle morphological boundedness from position-based expectancy effects. The findings should therefore be interpreted as evidence for boundedness under tightly controlled but not fully position-neutral conditions. This might have led to an additional experiential salience effect either of the surprisal of the bound morpheme and/or greater similarity of the unbound morpheme to participants' L1 and to English, upon which *Englishti* is based. It might also have caused the possible association of the *o* target morpheme with the *a* article in English, which appears to have led to garden path theories of the function of *o* in *Englishti*. Future replications of this research should consider either changing the short morpheme to another form and/or moving the unbound morphemes to after the possessive object to more closely match the position of the bound morphemes in order to avoid possible confounds. With respect to awareness, firm conclusions were difficult to draw, as most participants received a score of 2 for both morphemes, with only a small minority scoring at either extreme of the scale. Although this distribution is not entirely unexpected, the limited dispersion across awareness levels warrants caution in generalizing the findings to a broader population. Moreover, while the use of a semi-artificial target L2 was methodologically necessary to isolate the property under investigation with maximal control, this design choice entails some reduction in ecological validity and therefore calls for careful consideration when extending the results to naturalistic L2 learning contexts.

Taken together, the present findings provide a first systematic empirical examination of morphological boundedness as an independent salience property in early L2 input processing, and of its interaction with orthographic length. While the effects observed are primarily located at the level of attentional allocation rather than intake, they delineate more precisely where

salience appears to operate—and where it does not—within the attention–awareness–acquisition continuum. By refining the design in light of the methodological insights gained here (e.g., minimizing formal confounds and manipulating overall salience strength), future research can build on this foundation to test whether boundedness exerts a more sustained influence under conditions of increased exposure, enhanced task demands, or at later developmental stages. In this way, the present study contributes not only initial empirical evidence, but also a clearer research agenda for disentangling how specific salience properties shape the trajectory from input processing to acquisition.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee for Humanities at the Vrije Universiteit Brussel. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

GK: Writing – review & editing, Writing – original draft, Conceptualization, Funding acquisition, Methodology, Data curation, Investigation, Visualization, Formal analysis. SC: Writing – review & editing, Formal analysis, Methodology, Data curation, Investigation, Conceptualization. LD: Visualization, Methodology, Supervision, Formal analysis, Writing – review & editing. AH: Funding acquisition, Project administration, Supervision, Writing – review & editing, Methodology, Conceptualization. ES: Writing – review & editing, Supervision, Project administration.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/flang.2026.1736089/full#supplementary-material>

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