Native and Non-Native Speakers' Cue Integration in the Processing of the English *As*-Predicate Construction

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Abstract

Drawing on the principles of associative learning theory and positing a statistical foundation for language acquisition, this paper investigates the independent contributions of the predictive validities of verbal and constructional cues in English native and non-native speakers' mental representations of the English *as*-predicative construction. This is examined through two experiments: a sentence completion task targeting constructional outcome retrieval (Experiment 1), and a gap-fill schema task with a focus on verb retrieval (Experiment 2). The results demonstrate that both cues are integrated in parallel when eliciting a constructional outcome (Experiment 1), but only construction cue validity plays a role in eliciting verbal outcomes (Experiment 2). Verb frequency and voice additionally contribute to the retrieval of verbal and constructional information in distinct manners. The present study raises discussions about distributional cue integration in forward versus backward retrieval of linguistic information, in addition to emphasizing the importance of considering cross-linguistic factors in future research.

Keywords: cue validity; associative language learning; contingency; delta p; *as*-predicative; NS; NNS; constructions

Introduction

Associative learning theory suggests that outcomes can be inferred from cues available in the environment based on their predictive validities, and that these associations are unidirectional in nature (Rescorla & Wagner, 1972; Tversky, 1972). Contextualizing this in the realm of cognitive approaches to language learning, which ascribe a statistical basis to language acquisition (Isbilen & Christiansen, 2022; Saffran et al., 1996), scholars suggest that language users are intuitive statisticians (Peterson & Beach, 1967) who can tally the distribution of the linguistic information encountered in the input (Ellis, 2012). Though a proliferation of research has addressed both speakers' ability to integrate different cues in comprehension (Henry et al., 2017; MacDonald et al., 1994; MacWhinney, 1987) and speakers' ability to track distributional information (e.g., Ellis & Ferreira-Junior, 2009; Ellis et al., 2014) separately, there is little evidence of how speakers concurrently integrate distinct distributional cues which are asymmetrical in nature, such as cue validity information, in conjunction with frequency and context-specific information (e.g., voice) during the retrieval of different types of linguistic information. Therefore, the present study aims to investigate the independent contributions of the predictive validities of verbal and constructional information in English native and non-native speakers' mental representation of the *as*-predicative construction (e.g., *She saw this as a great opportunity*, see Gries et al., 2005) via two offline written completion tasks, one aimed at eliciting constructional outcomes (Experiment 1) and another focusing on verb retrieval. Additionally, we aim to examine the effects of verb frequency and voice in speakers' mental representations of the *as*-predicative construction. The reason we focus on this particular construction is because, though there exists some corpus-based evidence discussing its distributional properties (Gries et al., 2005), we have very little experimental evidence about speakers' knowledge of this structure. This is particularly important given its conceptual distinction from the thoroughly studied verb-argument constructions and its functional similarity to other structurally comparable constructions, where many of the same overlapping verbs are present (e.g., *She considered this a great opportunity; She considered this to be a great opportunity; She considered this as a great opportunity*).

Literature Review

Constructions are the building blocks of language, embodying conventionalized form-meaning pairings (Goldberg, 1995). In this constructionist viewpoint, language learning is seen as rational contingency learning (Ellis, 2006). This means that language users keep track of the distributional properties of the elements they encounter from the input in terms of how frequently these occur in particular contexts, and what other elements they co-occur with across contexts. In Construction Grammar, special attention has been given to studying the distributions of verbs across constructions and their associations (*collostructions*, Stefanowitsch & Gries, 2003), which, are deemed *unidirectional* in nature. For instance, in the case of the *as*-predicative construction, as discussed in Gries et al. (2005), there is a high association between the verb *regard* and this construction, suggesting that the presence of *regard* can be predictive of its usage. Therefore, when speakers encounter *The woman regarded the man*, there is a high probability that they might end the sentence with a *as NP* or *as AdjP* (e.g., *The woman regarded the man as a successful*

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businessman/successful). Conversely, if speakers encounter a constructional schema such as *The woman ___ the man as a successful businessman* and are asked to fill in the blank space, they might respond with the verb *regard*, or with the verb *know*, or even with the verb *see* (e.g., *The woman regarded/knew/saw the man as a successful businessman*). In this case, there are multiple lexical candidates competing for selection, each determined by its strength of association with the *as*-predicative, notwithstanding the subcategorization bias of the verb itself conditionalized on the constructional outcome. In construction learning, therefore, we distinguish between the predictive power of verbs towards constructional outcomes, or ΔP (construction|verb), which we refer to as *verb cue validity*, and the predictive strength of constructions towards verbal outcomes, ΔP (verb|construction), which we refer to as *construction cue validity*. Both types of cues provide distributional information that assist in the delineation of category boundaries, which subsequently affects the formation of constructional representations in the mental lexicon. However, to this date, we know very little about how speakers integrate these cues concurrently when eliciting a linguistic outcome.

The way various cues interact to conjure up a particular outcome holds paramount research objective and significance in domains of language acquisition (Chan et al., 2009; MacWhinney, 1987) as well as in human models of language processing (Gennari et al., 2012; Gennari & MacDonald, 2009). The research on cue competition has thus far underscored two key points: i) cues rarely occur in isolation, and ii) it is the speaker's task to determine which cue makes the most reliable information source for a given outcome. Regarding the second point, primarily two opposing positions prevail: i) speakers commit to integrating a single cue in comprehension, thus blocking out other redundant cues (Arnon & Ramscar, 2012; Siegelman & Arnon, 2015) or ii) speakers utilize multiple cues additively where redundancy facilitates the learning of outcomes (Henry et al., 2017; Juliano & Tanenhaus, 1994; MacDonald et al., 1994; Trueswell et al., 1994). Motivated by this scholarship, we place our foci on investigating speakers' integration of the *distributional* cues based on the ΔP contingency theory, across two linguistic tasks which necessitate the retrieval of different types of linguistic information through which the direct availability (observability) of the cues is varied. We ask different groups of Native Speakers (NSs) and Non-native Speakers (NNSs) to complete sentence fragments cued by verbs (Experiment 1) and to supply verbs to form a sentence cued by a construction (Experiment 2). We aim to examine whether the outcome retrieval is facilitated by a verb that is both a reliable predictor and a category member, when either verbal or constructional cues are available, or if only one type of distributional cue is considered based on its availability. We also explore between-group differences in speakers' cue integration.

Methodology

Experiment 1

Design and Procedure

Experiment 1 comprises a written production task in the form of sentence completion, aiming to elicit the *as*-predicative construction, conditioned by the verb cue validity and construction cue validity The target verbs were selected from the top 70 verbs that occurred in the *as*-predicative in the British National Corpus (BNC). We used the BNC to calculate the cue validity of each verb (the probability of encountering the *as*-predicative given the verb) and the constructional cue validity (probability of encountering a particular verb in the *as*-predicative) using the ΔP contingency metric (Allan, 1980). The participants in this task were first presented with a set of two sentences, which we refer to as a *contextual prompt*, that expressed the functions of labelling, identifying, perceiving, classifying, or utilizing an object noun phrase (NP). The prompt sentences all adopted the simple past tense. Following the prompt, participants were then presented with a fragment of the target sentence that appeared in either active or passive voice (counterbalanced across participants). The reason why this voice-related variation was added is because previous research has suggested that the as-predicative construction is more inclined towards passive contexts (Gries et al., 2005). Participants were instructed to complete the sentence fragment to form a meaningful English sentence that corresponds to the meaning of the contextual prompt (n=24 target; n=18 filler stimuli[1]).

Example of Experiment 1 task:

> Contextual prompt: *Cocoa beans were grown by different cultures. They were renowned for being a nutritious food.*
> Target sentence fragment: *Different cultures knew___. / Cocoa beans were known___.*

All the sentence stimuli were normed for plausibility and grammaticality by English native speakers (n = 7). The online experiment software Psytoolkit (https://www.psytoolkit.org/) was used to set up the task and collect data. Prior to the task, participants filled out a consent form and a demographics questionnaire The average task duration was 20 minutes.

Participants

A total of 67 adult participants (NSs = 26, NNSs = 41) recruited from a large public university in Australia took part in this experiment. Nearly all NSs originated from Australia, whereas half of the NNSs originated from China with Mandarin Chinese as their first language (n = 21). We

[1]In order to keep the experiment time under 30 minutes, we opted for a slightly smaller number of fillers.

collected NNSs' English proficiency scores in the past 3 years (Tests: IELTS, PTE Academic, and TOEFL iBT) and converted them to an IELTS scale (https://www.ets.org/). Their converted mean proficiency score on an IELTS scale was 7.19 (SD = 0.69).

Data Analysis

We adopted a Bayesian approach instead of a frequentist one (e.g., see Kruschke & Liddell, 2018 for a discussion of practical and theoretical advantages to adopting a Bayesian perspective) for data analysis. We fit a Bayesian mixed effects logistic regression model using the *brms* package version 2.20.4 in R (Bürkner, 2016). First, we sum-coded (-1, 1) two categorical predictors: speaker (NS and NNS) and voice (active and passive) and scaled three continuous predictors with SD=1: verb cue validity, construction cue validity, and log-transformed verb frequency to facilitate model interpretability. The binary response variable was coded as 0= *the as-predicative was not supplied* and 1= *the as-predicative was supplied*. All predictors described above were defined as fixed effects, with interaction terms added for speaker and a) verb cue validity, b) construction cue validity, c) verb frequency, and d) voice, and maximal random effects structure for item and participant with random slopes and intercepts to account for the repeated measures design. All priors were *weakly informative* (Gelman et al., 2008) with a normal distribution located at zero with SD=2.5 for the fixed effects and student t's distribution with df=3 and SD=2.5 for the intercept and random effects. The model converged with all chains mixing well and yielding stable estimates. Posterior predictive checks confirmed the model's ability to generate predictions that accurately capture the existing data (Bayesian R^2=0.38).

Results

We found that both speaker group were more likely to provide the target construction when the predictive validity of verbs was higher (estimate=0.61, est. error=0.38, 95%CI=-0.11–1.39) and when the verbs were better representative category members of the construction (estimate=0.51, est .error=0.29, 95%CI=-0.06–1.09), the NSs being more strongly affected by the latter as opposed to the NNSs. Higher frequency verbs led to smaller odds of supplying the target structure (estimate=-0.97, est. error=0.35, 95%CI=-1.67–-0.27), with stronger effects for the NSs. The target structure was more likely to be provided in passive as opposed to active contexts (estimate=0.48, est. error=0.19, 95%CI=0.10–0.86), suggesting a contextual relationship between the *as*-predicative and passive-voice frames. Our Region of Practical Equivalence (ROPE) analysis, however, suggested that the only parameter value for which we can reject the null with certainty is verb frequency (1.35% within ROPE[2]). For all other parameter values, we cannot neither reject nor accept the null value, therefore, we remain undecided (although see Figure 2 for demonstration of which effects have minimal distribution within ROPE versus effects falling almost entirely within ROPE).

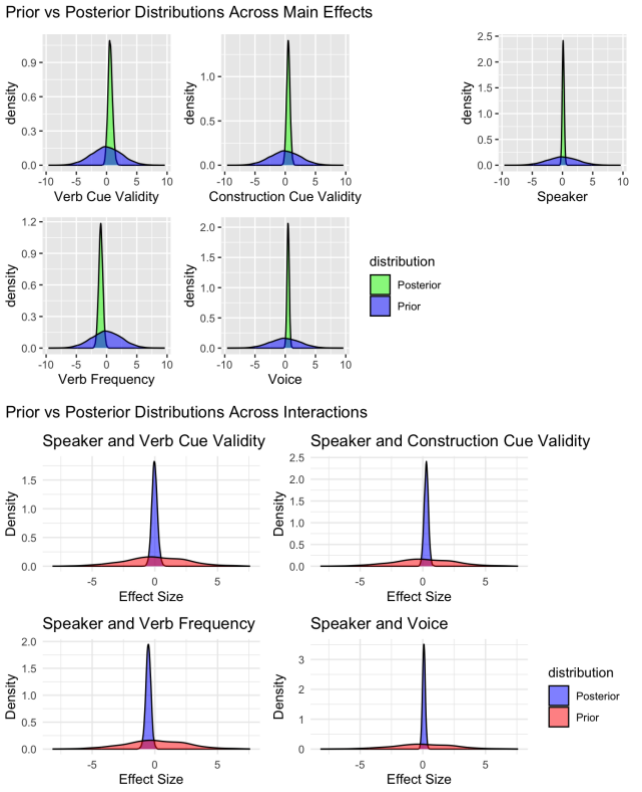

Figure 1: Prior and Posterior Distribution for Main Effects (top) and Interaction Effects (bottom).

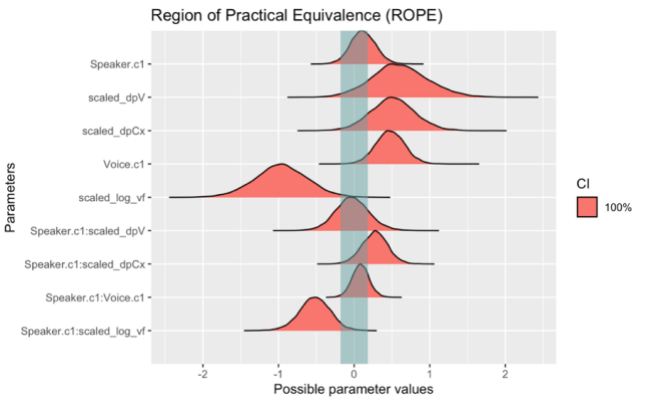

Figure 2: Region of Practical Equivalence for Parameters in Experiment 1.

[2] ROPE threshold: the HDI within ROPE is less than 2.5% for rejection or over 97.5% for acceptance of null value, otherwise, we remain undecided (Krushke, 2018).

Experiment 2

Design and Procedure

In Experiment 2, we also used a sentence completion task. We selected 12 out of the 24 target stimuli from Experiment 1, which consisted of both contextual prompts and target sentence fragments. We removed the main verb from the second sentence of the prompt, and from the target sentence fragment, to avoid lexical priming stemming from the verb in the prompt. We also created 12 additional fillers which targeted various prepositions except *as*. Akin to Experiment 1, two versions of sentence stimuli for Experiment 2 were created where the target fragments were counterbalanced between active and passive structures (see the example below).

Example of Experiment 2 task:

Target contextual prompt: *Maria was a singer. Her family ___ she was a very talented girl.*
Target fragment: *Maria's family ___ her as ___. / Maria was ___as ___.*

Filler contextual prompt: *The teacher prepared some printed tasks. She ___ the prints all around the classroom.*
Filler fragment: *The teacher ___the prints across ___. / The prints were ___ across ___.*

Participants were instructed to fill in the first two gaps (one in the prompt, one in the fragment) with the first verb that comes to mind for the given context, and to then complete the fragment so that it makes up a meaningful and logical English sentence. We used the online platform Qualtrics (https://www.qualtrics.com/au/) to set up the task and collect data. Prior to the task, participants filled a consent form and a demographics questionnaire. The average task duration was 20 minutes.

Participants

We recruited a total of 107 adult participants (NSs = 52, NNSs = 55). The NS participants were recruited from the United Kingdom via the online research platform Prolific because not enough NSs from Australia registered for participation. The NNS participants (dominant origin China and L1 Mandarin speaking, n = 21) were recruited from a large public university in Australia. Their mean English proficiency was 7.28 (SD = 0.71) as measured on an IELTS scale (all scores were converted to an IELTS scale according to https://www.ets.org/.)

Data Analysis

To examine and compare the frequency distributions between the corpus and the experimental data, we downloaded the BNC Sampler (BNC Consortium, 2007) which is a 2-million-word subset of the BNC. We first performed a full-corpus annotation which includes tokenization, part-of-speech tagging, lemmatization, and dependency parsing using the *UDPipe NLP Toolkit* from the udpipe package in R (Wijffels et al., 2018). We retrieved all instances of the *as*-predicative construction in the corpus that matched the following criteria:

1. All structures where a verb is followed by the preposition "as" which is then followed by either an adjectival phrase or a noun phrase.
2. All structures where a verb is followed by a noun in an object position, followed by the preposition "as", which is then followed by either an adjectival phrase or a noun phrase.

This search returned 309 tokens with the predetermined search criteria, all of which were manually checked to ensure they were accurate representations of the *as*-predicative construction. We discarded 81 instances which were not representative of the target structure (e.g., comparative forms such as "as many as four million experts are facing…", or parallel temporality structures such as "balloons were released as flags were waved…"). From the experimental data, all the verbs supplied in the gaps were manually lemmatized and corrected for spelling prior to the analysis.

Data analysis was performed by fitting a Bayesian mixed effects negative binomial regression model using the *brms* package version 2.20.4 in R (Bürkner, 2016). The negative binomial distribution is an extension to the Poisson distribution for over-dispersed non-negative integer data (see Winter & Bürkner, 2021). As in Experiment 1, we sum-coded the two categorical predictors: speaker (NS and NNS) and voice (Active and Passive) and scaled the three continuous predictors: ΔP(construction|verb), ΔP(verb|construction) and log-transformed verb frequency. The categorical response variable (verb) was transformed into a count variable by levels of speaker and voice. The model comprised main fixed effects for speaker, voice, verb cue validity, construction cue validity, and verb frequency, and interactions between speaker and the remaining variables, and between voice and the remaining variables. We included random effects with random intercepts for verb and random slopes for speaker and voice, indicating that each verb may have a separate effect for NSs vs NNSs and active vs passive structures. The fixed effects were assigned a normally distributed prior with a location parameter 0 and scale 2.5, whereas the intercept and the random effects were allotted a student_t prior. Convergence metrics returned reliable estimates, and posterior predictive checks indicated good model performance which accounted for a significant variance in the data (Bayesian R^2 = 0.87).

Results

In Experiment 2, we found that increasing verb cue validity adversely affected verb retrieval, however, construction cue validity and verb frequency positively influenced verb retrieval, which means the expected verb count grew as the values of these predictors increased. Namely, for every one-standard deviation increase in verb cue validity, the expected

count of verbs decreased by a factor of 0.87 (95% CI =-0.42–0.15), however, for every one-standard deviation increase in construction cue validity, the expected count of verbs increased by a factor of 2 (95% CI=0.43–0.99). Similarly, for a standard deviation increase in verb frequency, the expected verb count increased by a factor of 1.18 with a 95% probability that the true value of the parameter lies between -0.10 and 0.44. NSs were slightly more inclined towards these predictor trends as opposed to the NNSs. Passive contexts in general negatively affected verb retrieval, where expected count of verbs decreased by 0.91 (95% CI=-0.21–0.02). However, verb retrieval was facilitated in passive contexts as a function of increasing construction cue validity (estimate=0.02, 95%CI=-0.09–0.13 and verb frequency (estimate=0.05, 95%CI=-0.09–0.18), but not verb cue validity (however, see Figure 3 below demonstrating effects nearly practically equivalent to 0). The ROPE analysis indicated that the single parameter for which we can with certainty reject the null value is construction cue validity (0% within ROPE), whilst remaining undecided for the other parameters (Figure 3).

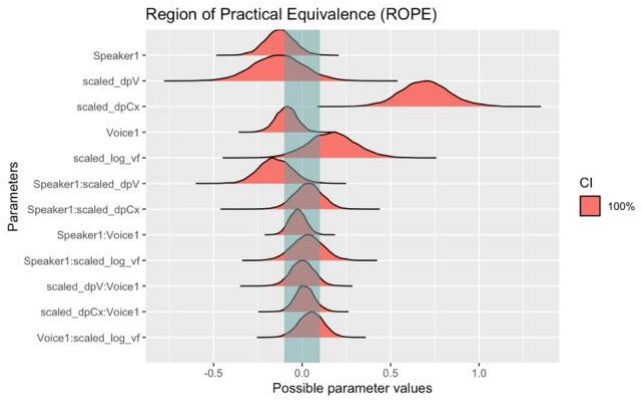

Figure 3: Region of Practical Equivalence for Parameters in Experiment 2.

Discussion

In Experiment 1, we found that both speaker groups integrated verb cue validity and construction cue validity in their construction retrieval, when they were explicitly only shown the verbal cue. This means that speakers considered both the predictive validity of the verb and the verb's category membership, being affected to a slightly greater degree by the former. Though we cannot with certainty reject the null value for these parameters, we believe that the small portion of the HDI within ROPE was indicative of some real effect for these predictors and we therefore engage in a tentative discussion about potential implications. The integration of both distributional cues in our study aligns well with constraint-based models of sentence processing, according to which, cue processing is additive in nature (Henry et al., 2017). In ambiguity resolution of main vs relative clauses, for example, cues like the verb subcategorization bias conditioned on the construction are activated. This, along with the activation of associated thematic roles and syntactic structures, aids in resolving ambiguities by evaluating the potential fit of arguments against alternatives (Juliano & Tanenhaus, 1994; MacDonald et al., 1994). Similarly, in child language acquisition, comprehension is enhanced when cues like word order and animacy align, as opposed to when they are conflicting or presented separately (Chan et al., 2009). In the present study, we found evidence that both NSs and NNSs' elicitation of the *as*-predicative construction is aided when the predictive validity of the verb is high and when the verb itself is a representative category member of the construction, which supports an assumption of joint integration of distributional cues. The NNSs in Experiment 1, however, showed a slightly higher sensitivity to the verb cue validity as opposed to NSs, but not to the construction cue validity.

The fact that NNSs are sensitive to distributional information is unsurprising (Ellis et al., 2014; Gries & Wulff, 2005, 2009) however, it is important to note their preference for one distributional cue over the other. NNSs' overreliance on one cue over the other suggests that they may not consider both the verb's predictive validity and its category membership to an equal extent; instead, they rely more on the cue that was made available – in this case, the verb cue validity. Previous work has pointed to differences in predictive processing between NSs and NNSs (Kaan, 2014) as a result of differences in lexical access (Hopp, 2013), verb subcategorization biases (Dussias & Cramer Scaltz, 2008), or ability to generate predictions given a 'noisier' L2 environment (Tachihara & Goldberg, 2020). Our results indicate that differences in constructional retrieval might also be due to the extent to which speakers are able to activate and integrate multiple distributional cues in real-time. A key limitation to the present study, however, is the fact that we did not account for any potential cross-linguistic influence that may have contributed to different NSs and NNSs approaches to cue integration. As we know, the perception and integration of L2 linguistic cues can be attenuated to various extents by learners' L1 (MacWhinney, 1992). Considering that many NNSs in both studies were native Mandarin speakers, we briefly outline a cross-linguistic comparison. Namely, while there is not a direct equivalent to the English *as*-predicative, Mandarin often expresses similar meanings through verbs that inherently bear meaning of *considering* or *regarding*, or through phrases denoting the sense of "as". From these verbs, there are some that are closer in meaning to the *as*-predicative than others. For example, compound verbs like "当作" (dàng zuò), which means *to treat as* or *to regard as* and "视为" (shì wéi), which means *to view as* are closer in meaning to the *as*-predicative as opposed to, for example, the verb 认为" (rènwéi), which means *to consider/think*. The first two directly link the object with the state or quality ascribed, much like saying "as" in English, and are also more restricted in use, especially shì wéi. 认为 (rènwéi), on the other hand, is a more frequently attested verb, focusing more on the opinion rather than on the attribute ascribed to the object. It is therefore possible that differences

in meaning in addition to distributional differences between the L1 and L2 could contribute to cross-linguistic influence and should be systematically addressed in future research.

In stark contrast to Experiment 1, in Experiment 2, both speaker groups solely relied on construction cue validity for verb retrieval. Consequently, scholarship predicated on cue coalescence cannot fully explain our findings, primarily due to the underlying foundation of information processing as a forward-manner prediction generation that enables comprehension. In the present study, it appears that multiple cues assist in generating predictions about the target constructional outcome only when there is a type of forward-activation of information involved (Experiment 1), but not when linguistic elements need to be elicited from memory given a constructional context in a backwards manner (Experiment 2). The latter procedure hinges more closely on the nature of recall tasks underpinned by memory retrieval processes discussed widely in the cognition literature (Kahana, 1996; Raaijmakers & Shiffrin, 1981; Rickard & Bajic, 2004). The scholarly consensus suggests that the retrieval process encompasses a type of parallel search mechanism whereby once a cue is encountered, all associative pathways are activated in parallel, and they compete to elicit a response. Memory retrieval is therefore rendered to be a cue dependent process (Tulving, 1974) and also noisy and probabilistic (Raaijmakers & Shiffrin, 1981). A key insight from recall tasks is that, when instructed to recollect a previously presented item list in "in any order", subjects tend to retrieve items that are related either categorically or associatively in adjacent positions (Kahana, 1996). Importantly, Kahana (1996) empirically demonstrated that "the probability of adjacent forward recalls is about twice that of adjacent backward recalls." (p. 105). It is therefore possible that multiple distributional cues can be more easily integrated in a forward-retrieval modality which follows natural adjacent linguistic patterns underlying the *as*-predicative such as *V+as (*e.g., *regarded as, seen as, etc.)*, as opposed to backward-retrieval modality where the *as*-schema is provided and the verb needs to be retrieved in the empty verb slot (e.g., *__ the girl as__).* Therefore, the direction in which information must be retrieved could motivate the extent to which different distributional cues are considered. More research is nonetheless needed to probe into the intricacies and asymmetry of the integration of distributional cues across various modalities of linguistic information retrieval.

In Experiment 1, the results also revealed that both speaker groups were negatively affected by verb frequency. This finding seems to be in line with the nature of ΔP conditional probabilities, given that high-frequency verbs are much more likely to be encountered in a myriad of different constructions, very likely themselves more frequent than the *as*-predicative itself. Therefore, it is less probable for high frequency verbs to be tied exclusively to the *as*-predicative construction, rendering this cue less reliable in constructional retrieval. Though both NSs and NNSs were affected by this distributional cue, NSs have demonstrated a stronger integration of this type of distributional information in this manner. In Experiment 2, verb frequency appeared to positively affect the retrieval of verbs, which, again, would be expected, given that more representative category members of a construction are likely to be of higher frequency and therefore better entrenched. Consequently, we highlight a key yet distinct role of verb frequency in the retrieval of linguistic information. Namely, we suggest that verb frequency has either a positive or a negative effect on the retrieval, depending on the direction of retrieval and the type of linguistic information that warrants elicitation. Furthermore, passive contexts facilitated speakers' retrieval of the *as*-predicative construction in Experiment 1, particularly for the NSs, which illustrates an acute sensitivity to context-specific constructional distributions. In contrast, verb retrieval in Experiment 2 appeared to be facilitated in active contexts, pointing to a relationship between either voice and the direction of information retrieval, or voice and the type of outcome that is being retrieved (verb or construction). Though the *as*-predicative construction appears to itself favour passive contexts, this may not the case with all its verb members, which again, points to a gap that should be considered more thoroughly in future research.

Conclusion

Drawing on principles from associative learning theory, this study investigated how English native and non-native speakers integrate conditional probability distributional cues to i) retrieve the *as*-predicative construction when the available cue is a verb (Experiment 1), and ii) retrieve verbs when the available cue is a construction schema (Experiment 2). Experiment 1 findings revealed a parallel integration of verb and construction cue validity, supporting the notion of cue coalescence in construction retrieval and suggesting that constructional categories are partially formed through distributional information hinging on normative ΔP theory. Experiment 2 highlighted that speaker exclusively relied on construction cue validity for verb retrieval, raising discussions about cue integration in forward versus backwards retrieval of linguistic information. The study also found different trends of verb frequency, on one hand, affecting construction retrieval negatively (Experiment 1), on the other, facilitating the elicitation of verbs (Experiment 2). Voice, likewise, demonstrated distinct trends in construction versus verb retrieval. The present study underscores the need for further research, particularly considering cross-linguistic differences and addressing the tentative outcomes from our Bayesian ROPE analysis, which neither fully rejected nor confirmed the null value for most parameters.

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