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Understanding student errors in hydronym perception: a cognitive–pedagogical perspective

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ABSTRACT

Despite the cultural and linguistic significance of hydronyms, little empirical research has examined how university students cognitively conceptualize them and why systematic misinterpretations arise. This study aims to identify and classify the dominant cognitive mechanisms underlying student errors in hydronym perception. A descriptive quantitative design was employed, analyzing written responses from 120 university students using a seven-category error typology grounded in frame semantics, prototype theory, and psycholinguistic models of proper-name processing, with high inter-rater reliability (κ=0.87). The results show that cognitive errors occur significantly more frequently than inattentive or interpretative errors, indicating that students' difficulties stem primarily from incomplete activation of geographical, cultural, and historical conceptual frames rather than from surface-level inattention. Frequent reliance on phonological similarity further suggests that when conceptual knowledge is weakly integrated, learners' default to form-based processing strategies instead of semantic interpretation. These findings indicate the need for pedagogical approaches that explicitly connect hydronyms to broader cultural and conceptual frameworks, supporting more cognitively grounded instruction in linguistics and onomastics.

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1. INTRODUCTION

Place names constitute a distinctive category of linguistic units that encode cultural memory, geographical reference, and historically accumulated knowledge. Contemporary research increasingly emphasizes that their interpretation is not purely linguistic but fundamentally cognitive in nature, involving processes of conceptualization, categorization, and cultural inference [1]. Within this domain, hydronyms represent one of the most stable and conservative layers of toponymy, yet their interpretation requires the activation of complex conceptual, cultural, and ecological knowledge structures [2], [3]. International scholarship has demonstrated that hydronyms contribute to the formation of spatial identity and reflect long-standing interactions between linguistic communities, while studies in cultural and environmental linguistics show that such names crystallize ecological perception and social experience across generations.

Advances in cognitive linguistics and psycholinguistics have further highlighted the conceptual foundations of place-name interpretation. Research on proper-name processing indicates that comprehension involves the activation of semantic frames, retrieval of culturally anchored schemas, and the integration of linguistic form with conceptual representation [4], [5]. Interpreting hydronyms therefore presupposes sensitivity to prototypical features of water-related entities, awareness of historical and cultural associations, and the ability to distinguish surface-level phonetic similarity from meaningful semantic relatedness [6]. Cognitive onomastics, as an interdisciplinary field, investigates how individuals mentally represent, categorize, and interpret proper names by integrating insights from cognitive linguistics, psycholinguistics, and cultural studies.

Recent international research reflects a growing interdisciplinary interest in toponymy, including studies on cognitive mapping of place names [7], spatial categorization across cultures [8], and psycholinguistic processing of proper names in multilingual settings [9]. Collectively, these studies confirm that place names are cognitively meaningful units embedded in broader cultural and spatial systems. However, much of the existing hydronymic research remains focused on classification, etymology, historical development, or cartographic representation. As a result, the cognitive mechanisms through which learners interpret hydronyms—and, crucially, misinterpret them—remain insufficiently examined, particularly from an empirical and educational perspective.

The multilingual region of Western Kazakhstan provides a particularly relevant context for addressing this limitation. Hydronyms in this region reflect layered linguistic histories and diverse cultural traditions, yet university students often experience difficulty connecting linguistic forms with the geographical, historical, or cultural knowledge required for accurate interpretation. Preliminary observations suggest that learners frequently rely on surface-level cues such as phonetic resemblance, while deeper conceptual integration remains weak or inaccessible. These tendencies point to the need for research that combines cognitive-linguistic theory with systematic empirical analysis of learner errors.

Previous research in onomastics and cognitive linguistics has established that place-name interpretation is a cognitively mediated process involving semantic frames, cultural schemas, and spatial categorization. Existing studies have examined hydronyms from historical, etymological, cultural, and cartographic perspectives, as well as within broader investigations of place-name cognition, spatial identity, and multilingual toponymic landscapes. Collectively, this body of research demonstrates that hydronyms encode layered cultural and environmental knowledge and contribute to shaping spatial perception and identity.

However, existing studies have largely focused on the origins, classification, or symbolic meanings of hydronyms, while limited attention has been given to how learners cognitively conceptualize hydronyms and why systematic misinterpretations arise in educational contexts. In particular, there is a lack of empirically validated models that classify student errors in hydronym interpretation and link these errors to established cognitive-linguistic mechanisms. This gap is especially pronounced in multilingual contexts, where hydronyms reflect complex layers of linguistic and cultural interaction, yet learner perception remains underexplored. Furthermore, this study addresses these limitations by contributing in three ways: i) it develops and empirically validates a seven-category typology of student errors in hydronym interpretation grounded in cognitive-linguistic theory; ii) it demonstrates that cognitive errors predominate over inattentive and interpretative errors, highlighting the central role of conceptual frame activation in hydronym perception; and iii) it extends international research on toponymic cognition by providing evidence from a multilingual educational context in Western Kazakhstan, offering a framework applicable to cross-regional and cross-linguistic studies.

2. RESEARCH METHOD

The study employed a descriptive cross-sectional quantitative design aimed at identifying and classifying the cognitive mechanisms underlying student errors in hydronym interpretation. This design was selected because it allows for the systematic analysis of error distributions across a defined cohort at a single point in time and is well suited for examining cognitive patterns of proper-name perception without manipulating instructional variables. Cross-sectional designs are widely used in cognitive and psycholinguistic research on place-name processing and conceptual categorization [10].

The participants were 120 undergraduate students majoring in humanities and philology at universities in Western Kazakhstan. A purposeful sampling strategy was applied, as all participants had prior coursework in linguistics and regional geography. This ensured a baseline familiarity with hydronyms and made it possible to attribute observed errors to cognitive and interpretative mechanisms rather than to a complete lack of subject knowledge. Participation was voluntary.

Data were collected using written interpretative tasks requiring students to interpret, compare, and categorize hydronyms from the regional onomastic landscape. The tasks were designed to elicit different

dimensions of hydronym perception, including phonological recognition, contextual interpretation, semantic association, etymological reasoning, and cultural-historical inference. Written responses were used instead of multiple-choice formats in order to capture students' underlying reasoning processes more explicitly.

The instrument was theoretically grounded in frame semantics, prototype theory, and psycholinguistic models of proper-name processing. Frame semantics provides a basis for understanding how hydronyms activate structured conceptual backgrounds related to water bodies and cultural associations [11]. Prototype theory accounts for learners' reliance on idealized representations when categorizing hydronyms [12], while psycholinguistic research explains the influence of phonological similarity and associative processing in name interpretation [13]. Together, these frameworks support the construct validity of the tasks.

A coding scheme consisting of seven error categories (GD1–GD7) was developed to classify student responses. Each category corresponded to a specific mechanism of misinterpretation, including inattentive, cognitive, and interpretative errors. While the categories were theoretically motivated, they were refined inductively through an initial review of student responses to ensure empirical relevance. This balance between theory-driven and data-informed categorization allowed the typology to capture recurring patterns without unnecessary fragmentation.

Instrument validity was ensured through alignment with established cognitive-linguistic theories of conceptualization and proper-name processing. To assess reliability, two trained coders with expertise in linguistics and onomastics independently classified all responses. Inter-rater reliability, calculated using Cohen's kappa, reached κ=0.87, indicating a high level of agreement and demonstrating that the error categories were clearly defined and consistently applied. Disagreements were resolved through discussion based on theoretical and empirical criteria, following established practices in linguistic error analysis [14].

The analysis focused on calculating the frequency and distribution of each error type across tasks. Descriptive quantitative analysis was used to identify dominant patterns and to compare the prevalence of inattentive, cognitive, and interpretative errors. The results were interpreted in relation to cognitive-linguistic theory and international research on place-name perception. Although the present study emphasizes descriptive analysis, the dataset structure allows for the application of inferential statistical techniques such as chi-square tests or one-way analysis of variance or ANOVA in future research. These methods could be used to examine potential differences in error distributions across task types or participant groups. The study was conducted in accordance with national research regulations and the principles of the Declaration of Helsinki. Informed consent was obtained from all participants prior to data collection, and ethical approval was granted by the relevant institutional review board.

3. RESULTS

The analysis revealed clear and systematic patterns in the ways students interpreted hydronyms. Rather than focusing on individual numerical values, the results section highlights overall tendencies and relationships between error types, while detailed quantitative data are presented in Tables 1–5. Across all task types, cognitive errors consistently predominated, indicating that students' difficulties were primarily conceptual rather than attentional or purely interpretative in nature. This pattern suggests that learners experienced challenges in activating appropriate geographical, cultural, and historical frames when interpreting hydronyms. The classification procedure identified seven distinct error categories grouped into inattentive, cognitive, and interpretative mechanisms, as in Table 1. This typology illustrates that most errors were not random but followed identifiable cognitive patterns linked to frame activation, associative reasoning, and semantic integration.

Table 1. Summary of error types in hydronym interpretation

Error type	Code	Description	Example
Inattentive error	GD1	Phonetic similarity overlooked	"Kaspiy" and "Zhaiyk" classified as unrelated
	GD2	Lexical origin misread as unrelated	"Tengiz" and "Tengis" treated as unrelated
Cognitive error	GD3	Geographical relations misinterpreted	"Irtysh" and "Shagalaly" seen as unrelated
	GD4	Historical or cultural link disregarded	"Ural" and "Zhaiyk" interpreted as separate names
Interpretative error	GD5	Lexical similarity misinterpreted semantically	"Karasai" understood as related to "Karagai"
	GD6	Cultural context misinterpreted	"Arkalyk" associated with "Tarkhan"
	GD7	Symbolic or etymological root misinterpreted	"Tobol" associated with "Turan"

3.1. Errors related to hydronymic similarity

Tasks involving similar-sounding hydronyms revealed a clear tendency for students to rely on formal phonological resemblance rather than on etymological or semantic relationships. As shown in Table 2, cognitive errors were the dominant error type in these tasks. This indicates that phonetic similarity often triggered incorrect conceptual associations when deeper semantic knowledge was not readily available.

Table 2. Errors in perceiving similar hydronyms

Error type	Percentage (%)	Example of student response
Inattentive error	6.5	Confusion between GD1 and GD2 categories
Cognitive error	18.3	Incorrect etymological or cultural interpretation (GD3–GD4)
Interpretative error	5.1	Misunderstanding semantic aspects (GD5–GD7)

3.2. Errors related to contextual interpretation of hydronyms

When hydronyms were presented in contextualized tasks, errors were primarily associated with overlooking cultural and historical cues necessary for accurate interpretation. Table 3 demonstrates that cognitive errors remained predominant, while inattentive and interpretative errors occurred less frequently. This pattern suggests that contextual information alone was insufficient when students lacked well-integrated conceptual frameworks.

Table 3. Errors in context-based hydronym interpretation

Error type	Percentage (%)	Example of student response
Inattentive error	5.2	Contextual distinctions ignored (GD1–GD2)
Cognitive error	12.7	Historical or cultural cues overlooked (GD3–GD4)
Interpretative error	1.1	Local semantic meanings confused (GD5–GD7)

3.3. General errors in hydronym perception

In tasks requiring broader semantic classification and comparison, students again demonstrated a dominance of cognitive errors, as seen in Table 4. These errors reflected difficulties in defining the semantic scope of hydronyms and distinguishing between geographically or culturally related names. The recurrence of this pattern across different task types points to a stable underlying cognitive mechanism rather than task-specific misunderstanding.

Table 4. General errors in hydronym perception

Error type	Percentage (%)	Example
Inattentive error	5.6	Inconsistent classification (GD1–GD2)
Cognitive error	13.2	Misunderstanding semantic scope (GD3–GD4)

3.4. Errors in associating hydronyms

A different distribution emerged in tasks based on associative reasoning, as presented in Table 5. Inattentive errors increased in frequency, indicating a stronger reliance on superficial similarity when students were required to group hydronyms freely. Nevertheless, cognitive errors remained present, suggesting that even associative tasks did not fully compensate for weak conceptual integration. Interpretative errors were consistently rare across all task types. Overall, the results show a robust and recurrent pattern: cognitive errors dominate hydronym interpretation across similarity-based, contextual, general, and associative tasks. Inattentive errors increase only in tasks that encourage surface-level grouping, while interpretative errors remain marginal. These findings establish a clear empirical foundation for the discussion of cognitive mechanisms and pedagogical implications presented in the following section.

Table 5. Errors in associative interpretation of hydronyms

Error type	Percentage (%)	Example
Inattentive error	15.2	Grouping based on phonetic similarity
Cognitive error	7.4	Misinterpreting cultural or semantic links
Interpretative error	1.0	Symbolic or historical context overlooked

4. DISCUSSION

This discussion interprets the findings in relation to the research question concerning the cognitive mechanisms underlying students' errors in hydronym perception. This study shows that cognitive errors predominate across all task types, indicating that students' difficulties arise primarily from incomplete conceptual integration rather than from inattentiveness or superficial misunderstanding. The findings indicate that the core difficulty in hydronym interpretation lies in incomplete activation of conceptual frames rather than inattentiveness. This is consistent with psycholinguistic evidence showing that proper-name processing depends on semantic frame activation and culturally anchored schemas [15], [16]. Cognitive errors consistently outnumbered inattentive and interpretative errors across all task types, which suggests that the core challenge is rooted in the processes through which students activate semantic frames, retrieve cultural knowledge, and form associations between hydronyms and the geographical or historical realities they denote. This pattern aligns closely with international research on the cognitive processing of place names, where difficulties tend to arise when learners must establish meaningful connections between linguistic form and conceptual representation [17].

This may be explained by insufficient activation of geographical, cultural, and historical semantic frames, which aligns with frame-semantic and psycholinguistic models of proper-name processing. The consistency of these distributions suggests that, if examined through inferential procedures such as Chi-square or ANOVA, the predominance of cognitive errors would be expected to demonstrate statistical robustness. This reinforces the interpretative validity of the descriptive results. Students' reliance on phonological resemblance reflects a well-documented mechanism in name processing, where form-based strategies dominate when semantic structures are weakly encoded [18], [19]. Such studies show that individuals often default to phonological similarity when semantic or cultural knowledge is weakly encoded or insufficiently accessible [20]. The tendency to treat phonetic resemblance as evidence of semantic relatedness indicates that students did not consistently activate the conceptual background associated with hydronyms. Because hydronyms frequently preserve archaic elements, culturally encoded metaphors, or region-specific environmental features, accurate interpretation requires the recognition of non-obvious semantic and cultural cues—skills that were inconsistently demonstrated by participants.

These findings are consistent with previous international studies and have been documented across different linguistic and cultural contexts. European studies report that learners fail to identify environmental and cultural motivations underlying hydronyms [21], while research in East Asia shows that opaque etymology leads to form-based misinterpretation [22]. Studies in African contexts likewise demonstrate that learners often treat hydronyms as arbitrary labels when cultural context is not activated [23]. International studies in cultural linguistics and geographical semantics have emphasized that hydronyms often function as repositories of sociohistorical knowledge, reflecting settlement patterns, resource use, or cultural symbolism associated with local landscapes [24]. When students fail to recognize such associations, their interpretations tend to reduce hydronyms to isolated lexical items rather than culturally grounded linguistic signs. This lack of integration appears to have contributed to the erroneous classification of names such as "Ural" and "Zhaiyk," where the historical continuity of naming practices was not recognized.

The predominance of cognitive over inattentive errors also indicates that these misunderstandings are not simply the result of carelessness or insufficient attention to detail. Instead, they reflect underlying limitations in the conceptual organization of hydronymic knowledge. Inattentive errors, although present, were comparatively infrequent, which suggests that even when students focused on task instructions, they often lacked robust semantic frameworks for interpreting hydronyms accurately. This finding is consistent with international research demonstrating that place-name comprehension depends not only on linguistic awareness but also on the availability of structured conceptual schemas that link names to culturally meaningful categories [25]. Without such schemas, learners may default to pattern-matching strategies that prioritize phonetic similarity over semantic relevance.

The results also reveal that interpretative errors were the least common across all task types. Although infrequent, these errors are important because they indicate difficulties in recognizing symbolic, figurative, or context-dependent meanings embedded in hydronyms. Interpretative challenges of this type have been documented in research on conceptual metaphor and figurative naming practices, which shows that proper names often encode metaphorical mappings that require cultural or experiential knowledge to decode [26]. For instance, the confusion between "Karasai" and "Karagai" illustrates the inclination to associate meaning based on lexical resemblance rather than symbolic or etymological origins.

Although the region-specific context of Western Kazakhstan shapes the particular hydronyms students encounter, the error patterns observed in this study mirror tendencies documented in research conducted in other cultural and linguistic settings. European studies on river-name interpretation show that students frequently fail to identify the cultural or environmental motivations underlying hydronyms, especially when these motivations are historical or no longer transparent to speakers [27]. Research from

East Asia similarly highlights the prevalence of form-based misinterpretation when learners confront hydronyms with historically opaque or culturally marked structures [28]. In African contexts, studies have shown that misunderstandings of water-related place names often arise because learners treat such names as arbitrary labels, overlooking their cultural embeddedness and environmental symbolism [29]. These parallels reinforce the conclusion that the cognitive difficulties documented in this study reflect broader cross-cultural tendencies in the interpretation of place names rather than anomalies specific to the Kazakhstani context.

The present findings also contribute to the theoretical understanding of how hydronyms function within cognitive onomastics. The frequent reliance on surface cues and the difficulty in connecting hydronyms to relevant cultural or historical frames suggest that students' mental representations of these names remain fragmented or insufficiently structured. Such fragmentation is consistent with models proposed in cognitive ethnography, which emphasize the need for culturally grounded schemas to mediate the interpretation of environmental terminology [30]. Moreover, the error patterns observed here illustrate the consequences of what Fillmore described as incomplete frame activation: without access to the full conceptual structure associated with a hydronym, learners rely on partial or misleading cues.

Pedagogically, the findings underscore the importance of instruction that fosters deeper conceptual engagement with hydronyms. Approaches based solely on memorization or superficial classification are unlikely to address the conceptual gaps revealed in this study. Instead, educational practices that incorporate contextualized learning, narrative-based approaches to place-name history, and visualization of hydronymic networks may help students develop more integrated and culturally informed representations. Although the development of pedagogical recommendations was not the primary objective of this research, the observed error patterns offer clear insight into areas where learners require additional conceptual scaffolding.

Taken together, the results of this study contribute to ongoing discussions within cognitive onomastics about the mechanisms underlying the interpretation of place names. By demonstrating that cognitive errors predominate in student interpretations of hydronyms, the study highlights the central role of conceptual integration and cultural knowledge in the comprehension of toponymic systems. The correspondence of these findings with international scholarship strengthens the validity of the error typology developed here and suggests that the cognitive mechanisms identified in this study may be relevant for research in other multilingual or culturally heterogeneous settings.

This study has several limitations that should be considered when interpreting the findings. First, the research was conducted within a specific regional and educational context and employed a cross-sectional design, which may limit the generalizability of the results to other linguistic or cultural settings. Second, the analysis relied primarily on descriptive statistics; future studies could apply inferential and longitudinal methods to examine differences across learner groups, task types, or instructional conditions. These limitations do not undermine the contribution of the study but rather highlight directions for future research aimed at extending and refining the proposed cognitive error typology in diverse multilingual contexts.

5. CONCLUSION

This study provides an empirically grounded classification of the cognitive, inattentive, and interpretative errors that arise in students' interpretation of hydronyms. The results show that cognitive errors predominate, suggesting that successful hydronym comprehension depends on activating geographical, cultural, and historical conceptual frames rather than on phonological recognition alone. Unlike descriptive hydronymic research, this study applies quantitative error analysis informed by cognitive-linguistic theory, offering a model that may be adapted for comparative work in other multilingual regions.

For educators and practitioners, these findings suggest that instruction in linguistics and onomastics should move beyond memorization and formal classification of hydronyms toward cognitively grounded teaching approaches. Integrating contextualized analysis of place names, narrative exploration of hydronym origins, and visual mapping of hydronymic networks may support deeper conceptual integration and reduce learners' reliance on surface-level phonological cues. For curriculum developers and educational policymakers, the results highlight the importance of embedding regional onomastic material and cognitive-linguistic principles into higher education curricula. Policies that encourage the integration of cultural, historical, and environmental knowledge into language and geography programs can strengthen both linguistic competence and cultural awareness, particularly in multilingual educational contexts. From a research perspective, the validated error typology proposed in this study provides a framework for future comparative and longitudinal investigations. It may be used to examine how different instructional interventions influence conceptual frame activation in hydronym perception and to explore the generalizability of the identified cognitive mechanisms across diverse linguistic and cultural settings.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [AD], upon reasonable request.

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