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Challenging the Monotonicity Universal Theory of Quantifiers: A Cross-Linguistic Analysis of Monomorphemic Quantifiers in English, Japanese, and French

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Abstract: The paper aims to criticize the monotonicity universal theory of quantifiers to question the universal applicability of the monotonicity theory. A qualitative analysis method was employed, focusing on counterexamples of monomorphemic quantifiers from English, Japanese, and French to critically evaluate the monotonicity universal theory by analyzing these quantifiers' behavior and examining the implications of findings on the theory's validity. The significant finding was that not all monomorphemic quantifiers, such as *few* in English, *peu* in French, and すこし in Japanese, are monotonic. Therefore, this result contradicted the existing claim that all monomorphemic natural language quantifiers are monotonic (upward monotonic, downward monotonic, or non-monotonic), challenging the universal of the monotonicity theory of quantifiers. The research concludes that the monotonicity universal theory of quantifiers does not universally apply to all monomorphemic natural language quantifiers and underscores the theory's one-sidedness and imperfections. Hence, this work highlights the need for a broader approach to understanding semantic universal and quantifiers' behavior in natural languages.

Keywords: semantic universal, monotonicity universal, monotonicity universal theory, quantifier, morphology

1. Introduction

In the diverse and intricate landscape of linguistic research, the exploration of semantics stands as a pivotal domain, endeavoring to decipher the intricate ways through which languages convey meanings. Within this realm, semantic universal emerges as a focal point of inquiry, reflecting linguists' endeavor to uncover the commonalities underlying the semantic dimensions of various languages. Moreover, in the realm of linguistic research, the exploration of quantifiers stands as a cornerstone for understanding the intricate mechanisms through which language encodes and manipulates quantities and relations, and at the heart of this exploration lies the concept of monotonicity, a principle governing the inferential properties of quantifiers that has garnered significant attention and debate within the linguistic community.

Current research on semantic universal and monotonicity in quantifiers explores how these aspects arise from a trade-off between simplicity and informativeness, often seen in function words like determiners. Central to this investigation is the theory which suggests that all monomorphemic

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natural language quantifiers are monotonic (Note that the universal only constrains monomorphemic quantifiers, and so doesn't concern complex quantifiers e.g., *exactly three*, *some but not all*) [1][2]—being either upward monotonic, downward monotonic, or non-monotonic. However, this assertion invites rigorous examination and debate, propelling this research to delve into counterexamples and comparative analyses across languages to critically evaluate the theory's validity.

Therefore, this paper will address one primary research question: Do all monomorphemic natural language quantifiers satisfy the theory of monotonicity universal? Also, more broadly, how do the counterexamples and comparative analyses challenge and inform our understanding of quantifiers' semantic universal?

This paper seeks to contribute to this ongoing discourse by systematically analyzing counterexamples from English, Japanese, and French, thereby questioning the universal applicability of the monotonicity theory. By engaging with qualitative analyses and drawing upon morphological insights, the study aims to shed light on the complexities and variances inherent in natural language quantifiers, offering a nuanced critique of the monotonicity universal theory.

At last, this paper, through its meticulous examination of counterexamples and its critical engagement with theoretical frameworks, aspires to contribute meaningfully to the discourse on semantic universal, pushing the boundaries of our understanding and opening new avenues for future research, offering new perspectives and insights into the complex world of quantifiers in natural language.

2. Literature Review

2.1. Semantic universal

Semantic universal is defined in the context of linguistic theory as properties or features that are common to all human languages, focusing on semantics—the meanings conveyed by language [3]. There have been many studies on semantic universal, and previous studies have combined semantic universal with many other aspects.

Majid, A. explores the semantic universal of perception and body parts across languages to provide an insightful exploration into the origins of meaning, the similarities in word meanings across communities, and the relationship between language and thought [4]. Conversely, [5] provides a comprehensive review of specific examples of semantic categories, such as color terms and kinship terminology, and the color terms and kinship terms are used to illustrate how different languages categorize these concepts in ways that reflect a balance between the need for specificity and the need to minimize effort in communication, and this balance is seen as a reflection of underlying principles of efficient communication.

Meanwhile, the modal expressions were focused by Matthewson, and she explores the semantic underpinnings of modal expressions, including their interaction with the context in which they are used, the influence of conversational backgrounds, and the distinctions between different types of modality, she also offers a comprehensive overview of current research and debates in the field of modal semantics, highlighting the complexity of modality as a linguistic phenomenon and the need for further research to unravel its intricacies [6]. Similarly, a proposed universal constraint on the possible denotations of clause-embedding predicates across languages was discussed, and they mainly focus on the relationship between the meaning of a clause-embedding predicate when it takes an interrogative complement and its meaning when it takes a declarative complement. Moreover, this proposal is intended to better capture the nuances of how different languages handle the semantics of clause-embedding predicates, offering a more refined framework for understanding their behavior across linguistic contexts [7].

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2.2. Semantic universal of quantifiers

The methodology used by Steinert-Threlkeld and Szymanik involves using a learning model based on recurrent neural networks (RNN), specifically Long Short-Term Memory (LSTM) networks, to investigate the learnability of quantifiers about semantic universal. Also, they concluded that quantifiers adhering to semantic universal were indeed easier to learn for the neural network models, supporting the hypothesis that semantic universal may reflect cognitive efficiencies in language learning and processing, which suggests that the properties making quantifiers easy to learn could be fundamental to understanding the universal of certain semantic features across languages [3], while Van de Pol et al. used the method of generating a large collection of quantifiers using a logical grammar to analyze their complexity and adherence to semantic universal like monotonicity, quantity, and conservativity, and this process included defining minimal expression lengths and utilizing logistic regression models to examine the relationship between these properties and simplicity. They found that quantifiers satisfying semantic universal are generally simpler, having shorter minimal description lengths, and this supports the hypothesis that semantic universal in quantifiers can be explained by cognitive preferences for simpler semantic properties, suggesting that simplicity may underlie the prevalence of certain semantic features across languages [8].

Two experiments were designed to explore the relationship between quantifiers in natural language and efficient communication, particularly focusing on the degrees of semantic universal such as monotonicity and conservativity. These experiments measured how well languages balance simplicity and informativeness, using information-theoretic measures to analyze the properties of quantifiers. Moreover, it is concluded that while artificial languages that closely resemble natural languages are more optimal, the degrees of semantic universal like monotonicity and conservativity are not directly correlated with optimality, which suggests that efficient communication shapes the semantic typology of languages, and that semantic universal might not require independent explanations beyond these communication efficiencies [9].

Van de Pol et al. used the methodology involved in conducting two experiments using algorithmic information theory to measure the complexity of quantifiers with the semantic universal. Experiment 1 used a minimal pair approach comparing pairs of quantifiers for properties of monotonicity, quantity, and conservativity. Experiment 2 involved generating a large set of quantifiers using logical grammar to study their complexity and relation to universal properties on a larger scale. Also, they concluded that monotone quantifiers are simpler (having lower complexity) than non-monotone ones, supporting the hypothesis that simpler semantic properties are more likely to become universal. However, results for conservativity and quantity were less definitive, suggesting a complex relationship between complexity, simplicity, and universal in quantifiers [10].

2.3. Monotonicity universal of quantifiers

Ben-Avi and Winter used the methodology involving analyzing the monotonicity behavior of plural determiners in collective quantification contexts, using a determiner fitting operator that respects existential quantification and monotonicity properties, and it integrates generalized quantifier theory and type shifting operators to systematically derive collective determiners from standard ones. Moreover, they concluded that the count operator, a key component of the determiner fitting process, preserves the monotonicity properties of determiners in their second argument, but the preservation of monotonicity in the first argument depends on its direction in the second argument, and the result demonstrates that collective quantification’s monotonicity properties follow from standard assumptions on quantification in natural language, emphasizing the central role of the conservativity principle in understanding collective determiners [11].

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Sippel and Szymanik used the methodology involved refining and extending a natural logic model proposed by Geurts to better predict human performance in reasoning tasks with quantifiers, including iterated quantifiers, and this was achieved by assigning weights to inference rules and operationalizing the complexity of a reasoning pattern as the weighted length of proof in the logic. Moreover, the model uses a cost-based system to account for the cognitive cost of reasoning tasks to align with variations in cognitive difficulty observed in experiments. It is concluded that the refined model successfully predicts human performance in reasoning tasks with quantifiers and iterated quantifiers, showing good predictive capacity, and also suggests that the logic and its complexity measure, while grounded in semantic relationships and psychological evidence, could benefit from further empirical testing [12][13].

The universal of monotonicity, quantity, and conservativity was focused on by Steinert-Threlkeld and Szymanik, performing computational experiments to train the network to learn to verify quantifiers, and they proposed the idea that certain properties of natural languages, like monotonicity and quantity, might be shaped by cognitive biases inherent in the process of language learning and transmission [3].

Developing and applying an iterated learning model with neural networks as agents to investigate the emergence of monotone quantifiers in language, focusing on the evolution of such quantifiers through cultural transmission and learning processes was used by Carcassi et al., and they manipulated variables such as bottleneck size and the number of epochs to observe their effects on the evolution of quantification. Also, they concluded that monotone quantifiers consistently evolved in the iterated learning model, suggesting that the propensity for monotonicity in natural language quantifiers could be explained by the iterated learning process. Moreover, they found that these evolved quantifiers often did not rely on the identity of specific individuals, aligning with another semantic universal, the universal of quantity [14]. Therefore, this outcome supports the hypothesis that certain properties of natural language quantifiers, like monotonicity and quantity, may arise from the cognitive biases of learners and the dynamics of cultural transmission.

2.4. Controversy on the monotonicity universal theory of quantifiers

The argument can be concluded into a theory about the monotonicity universal of quantifiers: All monomorphemic natural language quantifiers are monotonic (Note that the universal only constrains monomorphemic quantifiers, and so doesn't concern complex quantifiers, e.g., *exactly three, some but not all*) [1][2], which means all monomorphemic natural language quantifiers are upward monotonic, downward monotonic or non-monotonic. However, linguists have rarely questioned or refuted this theory. Based on this theory and references from previous studies, two questions are raised. Moreover, the current study adopts a case study approach and a quantitative methodology is employed in this study.

Research question:

Do all monomorphemic natural language qualifiers satisfy the theory of monotonicity universal?

3. Methodology

A common example of quantifiers from English, Japanese, and French in natural languages was used to challenge the monotonicity universal theory of quantifiers to recognize the commonalities and differences of natural languages and to rethink this theory. Qualitative analysis was the main research method used in this article, mainly including the justification of counterexamples and how they were used to question the theory.

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3.1. Justification of counterexamples

The definition of the monotonicity universal theory of quantifiers is that all monomorphemic natural language quantifiers are monotonic (Note that the universal only constrains monomorphemic quantifiers, and so doesn't concern complex quantifiers e.g., exactly three, some but not all). According to the definition, the most basic condition required for a counterexample is a mono morpheme word, and based on the morphological field in linguistics, a morpheme refers to the smallest grammatical unit in a language that carries meaning, and a mono morpheme is similar to the free morpheme, which means the morpheme that can stand alone as words [15]. Therefore, the quantifier expressing "a small number of something" is a mono morpheme word in English, French, and Japanese:

English: *few*
French: *peu*
Japanese: *すこし*

3.2. Counterexamples used to question theories

3.2.1. Upward and downward monotonicity

The monotonicity of quantifiers can be divided into three categories: upward monotonic, downward monotonic, and non-monotonic. A quantifier Q is upward monotonic if the following is true: (for every A, B, and B'):

$$\text{If } [[Q]](A)(B)=1 \text{ and } B \subseteq B',\ [[Q]](A)(B')=1 \qquad (1)$$

[making B bigger doesn't falsify the statement]

A quantifier Q is downward monotonic if the following is true: (for every P, Q, and Q'):

$$\text{If } [[Q]](A)(B)=1 \text{ and } B' \subseteq B,\ [[Q]](A)(B')=1 \qquad (2)$$

[making B smaller doesn't falsify the statement]

3.2.2. The monotonicity of counterexamples

If a quantifier is neither upward nor downward monotonic, it is classified as a non-monotonic quantifier:

Q: *few*
S1: *Few* boys are good at cooking Western food.
A B
S2: *Few* boys are good at cooking.
A B'

$[[Q]](A)(B')=1$ only iff the few boys who are good at cooking Western food are good at cooking lots of meals and make it taste good (at least as much as most people would agree and as good as they would agree). However, this situation is not necessarily true.

$\because [[Q]](A)(B)=1,\ B \subseteq B',\ [[Q]](A)(B') \neq 1$

$\therefore$ few is not an upward monotonic.

Q: すこし
A: すこしの男の子は料理が得意しません。
A B
B: すこしの男の子は西洋料理が得意しません。
A B'

$[[Q]](A)(B')=1$ only iff the *few* boys who are good at cooking are good at cooking Western food and are generally recognized as delicious meals. However, this situation is not necessarily true.

∵ [[Q]](A)(B)=1, B'⊆B, [[Q]](A)(B')≠1
∴ すこし is not a downward monotonic.

French *peu* is much the same. Therefore, the quantifiers *few*, すこし, *peu* expressing "a small number of something" in English, French, and Japanese are monomorphemic non-monotonic quantifiers, justifying that there are certain quantifiers that do not adhere to this theory.

4. Results

From the short review above, key findings emerged that *few*, すこし, *peu* were not monotonic but monomorphemic quantifiers. Therefore, this was an important finding in the understanding of the monotonicity universal theory of quantifiers.

5. Discussion

The results indicate that in some languages, certain quantifiers are monomorphemic but not monotonic quantifiers. Therefore, the results contradict the claims that all monomorphemic natural language quantifiers are monotonic (Note that the universal only constrains monomorphemic quantifiers, and so doesn't concern complex quantifiers e.g., *exactly three*, *some but not all*) [1][2]. Also, the counterexamples provide a new insight into the relationship between semantic universal and morphology. However, the generalizability of the results is limited by the amount of examples of the quantifiers violating the theory. Moreover, the previous researchers who proposed this theory and the linguists who supported it can refer to this article because when studying semantic universal we should consider as many situations as possible, and this article only uses a counterexample to disprove this theory. Therefore, further studies should comprehensively take into account more counterexamples to modify and refine this theory further.

6. Conclusion

This research aims to question the monotonicity universal theory of quantifiers, exposing its one-sidedness and imperfections. Based on a qualitative analysis of the counterexamples of the same quantifier in different natural languages, it can be concluded that not all monomorphemic natural language quantifiers are monotonic. This research clearly illustrates that the generality of this theory is not completely universal and correct, but it also raises the question of whether it is proper to analyze the universal of monotonicity at the semantic level of quantifiers from a morphological perspective. Although this study raises doubts about this theory, it does not further improve this theory. To better understand the implications of these results, future studies could consider whether the quantifier monotonicity universal could be analyzed from other perspectives in linguistics, and a new generalization could be found that can account for the counterexamples, and why the universal holds. Moreover, this study analyzes counterexamples from the perspective of truth conditions and then questions the monotonicity universal theory of quantifiers. Previous studies did a lot on the semantic universal and monotonicity universal of quantifiers. Still, this theory focuses on filling the gap that previous researchers did not question this theory from the perspective of truth conditions, and makes a slight contribution to the research in the field of semantic universal.

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