The Ecology of English Loanwords in Chinese: A Case Study of Cement
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Abstract
From an ecolinguistic perspective, this study focuses on five English loanwords in Chinese related to the field of cement, as defined in the Modern Chinese Dictionary. The research quantitatively examines the ecological dynamics of these loanwords using two indicators: lexical niche breadth and overlap. The goal is to uncover the evolutionary mechanism governing their adaptation. The findings show: (1) The emergence of English loanwords is intricately linked to specific social environments. As new concepts and items are introduced from abroad, the masses initially make new loanwords, which are later standardized by authoritative bodies. (2) The vitality of loanwords correlates with their niche breadth. The competition among lexical variants is influenced by niche overlap. The loanwords for cement, ranked by vitality in descending order, are ShuiNi (3.221), YangHui (2.350), ShuiMenTing (1.385), HongMaoNi (1.202), and ShiMinTu (0.879). (3) The endangerment of loanwords results from a combination of external (social environment) and internal (language system) factors. Intense competition arises due to the presence of multiple synonyms for the same entity, and localization challenges occur when the loanwords do not precisely fit the entity. Among the five loanwords for cement, the first two exhibit higher vitality and continue to develop sustainably, while the last three show lower vitality and are gradually becoming endangered. As these loanwords undergo continuous evolution, a lexical ecosubcontinuum emerges: extinct in the wild—ShiMinTu; critically endangered—HongMaoNi; endangered—ShuiMenTing; vulnerable—YangHui; least concerned—ShuiNi.

Keywords: English loanwords, lexical niche breadth, lexical vitality and metabolism, Cement, ecolinguistics

1. Introduction
Languages, like cultures, are rarely sufficient unto themselves. The necessities of intercourse bring the speakers of one language into direct or indirect contact with those of neighboring or culturally dominant languages (Sapir, 1985). Such interaction may be shaped by various influences, including trade, cultural exchange, war, conquest, and migration. Consequently, language undergoes evolution, with phonological and grammatical changes occurring gradually and imperceptibly, while lexical changes unfold rapidly and are easily observable. One fundamental influence among languages is the exchange of words, where a language can compensate for its shortcomings, enrich its vocabulary, and enhance its culture. The Chinese language, with its extensive history and cultural richness, demonstrates a remarkable adaptability in incorporating loanwords. Modern Chinese sees a significant presence of English loanwords, contributing not only to the enrichment of Chinese vocabulary and culture but also exerting a noteworthy influence on linguistic form, sound, meaning, and grammar. This paper, adopting an ecolinguistic perspective, endeavors to elucidate the ecology of English loanwords in modern Chinese, uncovering their metabolism and the driving factors across temporal, spatial, and functional dimensions.

2. Literature Review
2.1 Language Contact
Bloomfield (1933) categorized language contact into three types: cultural borrowing, intimate borrowing (borrowing from an inferior to a superior language), and interdialectal borrowing. Haugen (1950) defined linguistic borrowing as reproduction, assuming that every speaker seeks to reproduce previously learned linguistic patterns to navigate new linguistic situations. He also noted that due to changes in time or geography, a loan word for one concept may appear in two successive forms due to reborrowing. For instance, speakers acquired the Norwegian
word [whip] as /hyppa/ in the first generation but as /wippa/ in the second. Weinreich (1963) regarded language contact as a form of conflict where two different language systems exert an effect on each other. This conflict encompasses linguistic and cultural comprehensive conflict, phonological conflict, grammatical conflict, and lexical conflict. Both facilitating and hindering factors influence the process of language contact. Cannon (1988) explored borrowings based on authoritative dictionaries, focusing on etymological research, statistical analysis, and the borrowing process. In his study of Chinese Borrowings in English, he classified loanwords into four levels based on the degree of assimilation: Level 1: unassimilated; Level 2: partially assimilated; Level 3: deeply assimilated; Level 4: completely assimilated. Poplack et al. (1984) established three categories with 20 indexes to analyze the degree of incorporation of English-origin loanwords used by bilingual (English-Spanish) children and their parents in Puerto Rico. The degree of incorporation was found to be influenced by lexical frequency and phonological morphology. McArthur (1992) classified loanwords absorbed by English into three categories: local, national, and international. Zenner (2012), in the study of the degree of infusion of 149 English nouns in Dutch, identified characteristics of successfully incorporated English words into Dutch, including short word length, expression of low-frequency concepts, necessity borrowing, and derivation from Anglo-American culture. He highlighted factors affecting the integration of loanwords, such as economy of language, age of borrowing, source language, necessity vs. luxury borrowing, and geographical variants.


2.2 Ecolinguistics

Ecolinguistics emerged in the 1970s as an interdisciplinary science that explores the interaction between language and ecology. Over the past few decades, it has developed distinct research frameworks and theoretical systems, particularly the Haugen Paradigm, which studies the impact of the environment on language, and the Halliday Paradigm, which investigates the impact of language on the environment (Fill, 2001). Haugen (1970, 1972) introduced the concept of the ecology of language, metaphorically illustrating the relationship between a language and its environment—social, natural, and psychological. He emphasized the dependence of linguistic ecology on learners, users, and transmitters. Halliday (1990) argued that language, as a form of social practice, is closely linked to the ecological environment. Language does not passively reflect reality, but actively creates reality. Li (1991) applied niche theory from ecology to study Chinese language, defining linguistic niche as the temporal and spatial distribution of language varieties and their environmental context. Dale and Lupyan (2011) proposed the linguistic niche hypothesis, suggesting that language variation correlates with the social environment, particularly language use and learning. Dale and Lupyan (2011) found in their study of over two thousand languages that
population size is related to the complexity of language structure. Xiao (2021, 2023) introduced the concept of an Ecolinguistic continuum, emphasizing that lexical and grammatical evolution represents an ecocontinuum, extending to corresponding contexts.

Zhang (1982) pointed out: “We should not only study where, when, why and how a loanword comes in, but also how it obeys or adapts to Chinese phonological system (syllable) and grammatical structure (morphology), what changes in its meaning, how these changes occur, and what impacts it exerts on target language. Only in this way can the study of loanword elucidate the law of lexical development, and the driving factors as well, revealing the relationship between words, people, and society” (Note 1). Fang (2008), Poplack and Dion (2012) noted that current research on loanwords is predominantly qualitative and lacks extensive statistical analysis. Despite fruitful research on Chinese loanwords, deficiencies exist in three key aspects: (1) an imbalance between static and dynamic research, with a predominance of static studies lacking dynamic examinations of loanword metabolism; (2) an overreliance on qualitative analysis, lacking scientific data due to limited large-scale corpus studies; (3) a focus on internal ecology rather than external ecology in factor analysis, neglecting the holistic study of the external environment’s impact on loanword evolution.

In the era of big data and cloud computing, there is a growing trend towards cloud computing lexical ecology. Adopting an Ecolinguistic perspective, this study aims to conduct a comprehensive analysis—synchronic and diachronic, quantitative and qualitative, internal and external—cloud computing the English loanwords in Chinese within the cement domain. The research questions include: 1) the birth of loanwords; 2) factors determining their vitality; 3) reasons for loanword endangerment.

3. Objective and Data

3.1 Research Objective

Loanwords are categorized into general and restrictive types, where general loanwords encompass transliteration and literal translation, while restrictive loanwords only involve transliteration. This study focuses on general loanwords, whether they are newly coined or existing words with new meanings, specifically examining English loanwords related to cement in the Modern Chinese Dictionary. The selected loanwords include ShuiMenTing, ShiMinTu, HongMaoNi, YangHui, and ShuiNi (Note 2). The first two are transliterations (translated by sound), and the last three are literal translations (translated by meaning). Among them, the first four are neologisms, and the last one represents an existing term with a new connotation. Taking cement as a case, this paper quantifies the ecology of English loanwords in Chinese by using two indices, namely niche breadth, and niche overlap, with the aim of exploring the following three points: (1) the environment in which English loanwords are born; (2) the size of the vitality of English loanwords; and (3) the reasons for the endangerment of English loanwords.

3.2 Data Source

Data for this study are drawn from various sources, including dictionaries, atlases, corpora, including: Modern Chinese Dictionary (1st–7th editions), Great Chinese Dictionary, Modern Chinese Standard Dictionary, Dictionary of Loanwords in Chinese, Xinhua Dictionary of Loanwords, Atlas of Chinese Dialects, Atlas of the Chinese Language, BCC by Beijing Language and Culture University, MLC by Communication University of China, CCL by Peking University, CCB by Shaanxi Normal University. The study incorporates text from BCC and MLC corpora to create diachronic corpora (T1/T2/T3/T4) for analyzing temporal ecological niches. It also categorizes survey spots from the Atlas of Chinese Dialects into seven dialect areas to build synchronic corpora (D1-D7) for analyzing spatial ecological niches. Additionally, five corpora of different genres (C1-Literature, C2-Science/Technology, C3-Blogs, C4-Newspaper, C5-TV/Broadcast) are created to analyze the functional ecological niche of Cement. Examples are primarily sourced from the Great Chinese Dictionary, CCB, and CCL.

3.3 Research Method

This study presents the concept of Lexical Niche, which explores the temporal and spatial distribution of words in the lexical system and their functional relationships. Temporal lexical niche examines the evolution of loanwords over different time periods, spatial lexical niche assesses their distribution across Chinese dialectal areas, and functional lexical niche evaluates their frequency in various genres. Applying ecolinguistic principles, the study quantifies the ecology of loanwords using two indicators—lexical niche breadth and niche overlap—aiming to uncover the driving factors behind the metabolism of English loanwords in Chinese. The computations are performed using R 4.2.2.

The lexical niche breadth is calculated by Levins formula:

\[ B_i = -\sum_{j=1}^{r} \left( P_{ij} \ln P_{ij} \right) \]
where $B_i$ represents the niche breadth of loanword $i$, and $r$ is the total number of lexical resource (period, area, genre); $P_{ij} = n_{ij}/N_i$, that is, the ratio of the number of species $i$ in resource $j$ to the total number of species $i$. When calculating the temporal, spatial, and functional niche breadth of loanwords, $j$ represents period $j$ of Chinese history, area $j$ of Chinese dialect, corpus $j$ of different genres respectively. The value of $B_i$ is $[0, r]$, the wider of the niche breadth, the stronger its vitality is, and greater sustainability.

The lexical niche overlap is calculated by Pianka formula:

$$O_{lk} = \frac{\sum_{j=1}^{r}[P_{ij}P_{kj}]}{\sqrt{\sum_{j=1}^{r}P_{ij}^2 \sum_{j=1}^{r}P_{kj}^2}}$$  \hspace{1cm} (2)

Where, $O_{lk}$ is the niche overlap index between loanword $i$ and loanword $k$ under the same lexical resource (period, area, genre). The range of niche overlap index is $[0,1]$, when $O_{lk} = 1$, it indicates that loanword $i$ and loanword $k$ are completely overlapped and the competition is intense, which is good for their sustainability; when $O_{lk} = 0$, it means the two loanwords are not overlapped at all, without any competition.

4. Result and Analysis

Prior to the introduction of cement, the Chinese language lacked both the material and the concept. When cement was introduced, the need arose for an appropriate name, resulting in the creation of different terms through reborrowing in various ages and regions. Words compete, survival of the fittest, endangerment of the weak.

4.1 Birth of English Loanwords in Chinese

Our research, encompassing various books and corpora, identified a total of 37 translated words within the Cement domain, classified into three groups, as detailed in Table 1.

<table>
<thead>
<tr>
<th>Mandarin: 1</th>
<th>ShuiNi (水泥)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialects: 24</td>
<td>YangHui (洋灰), YangNi (洋泥), YangNiBa (洋泥巴), YangHuiHui (洋石灰), YangNiHui (洋泥灰), YangMuHui (洋木灰), YangMaoHui (洋毛灰), YangMaoNi (洋毛泥), DaYingNi (大英泥), YingNi (英泥), DeGuoNi (德国泥), FanNanHui (番囝灰), HongMaoHui (红毛灰), HongMaoNi (红毛泥), HongNiTu (灰泥土), WuHui (乌灰), NiJiang (泥浆), BaTu (霸涂), BaHui (霸灰)</td>
</tr>
<tr>
<td>Loanwords: 12</td>
<td>SaiMenDunShiHui (赛门敦石灰), SaiMenDun (赛门敦), SaiMenDeTu (赛门得土), SeMenDeTu (塞门德土), SeMenDe (塞门德), CuiMenTu (崔门土), HuoNiXiMenTu (火泥西门土), XiMenTu (西门土), XiMianTu (细棉土), ShiMinTu (士敏土), ShuiMenTing (水门汀), SiMenTing (四门町)</td>
</tr>
</tbody>
</table>

The presence of these 37 words in the Chinese language system can be attributed to the invention of cement and its introduction to China. In 1824, Joseph Aspdin, an English builder, invented Portland cement by combining limestone and clay in specific proportions, calcining the mixture, and grinding it into powder. Named after the color resembling Portland stone, Aspdin patented his invention, marking the advent of genuine cement worldwide. Our investigation across different corpora (BCC, CCL, CCB) did not reveal any records of these 37 words before 1824. The earliest example of the term “cement” appeared in Notes of European Travel (1882), as indicated in Table 2. Thus, we can infer that the introduction of cement to China occurred not earlier than 1824 and likely around the 1880s.
Table 2. Earliest examples of loanwords for cement

<table>
<thead>
<tr>
<th>Earliest example</th>
<th>Source</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>SaiMenDunShiHui</td>
<td>seven to eight marks per barrel for this SaiMenDunShiHui</td>
<td>Notes of European Travel</td>
</tr>
<tr>
<td>YingNi</td>
<td>Green Island YingNi Factory</td>
<td>Factory name</td>
</tr>
<tr>
<td>XiMianTu</td>
<td>Tangshan XiMianTu Factory</td>
<td>Factory name</td>
</tr>
<tr>
<td>ShuiNi</td>
<td>the powder built will iron is named ShuiNi</td>
<td>Collection of Zheng G.Y.</td>
</tr>
<tr>
<td>YangHui</td>
<td>YangHui kiln is not a shelter, it is urgent to find another.</td>
<td>News (ShenBao)</td>
</tr>
<tr>
<td>HongMaoNi</td>
<td>the center is built with HongMaoNi and gravel.</td>
<td>News (ShenBao)</td>
</tr>
<tr>
<td>ShiMinTu</td>
<td>loading barrels with rifles, taking them as ShiMinTu for customs declaration.</td>
<td>The Flower of Evil</td>
</tr>
<tr>
<td>ShuiMenTing</td>
<td>all the way to the corridor, all paved with the famous ShuiMenTing</td>
<td>The Thunderbolt</td>
</tr>
</tbody>
</table>

The Westernization Movement (1860s–1890s), which sought to strengthen China, introduced advanced Western science and technology on a large scale, and organized industries, laying the foundation for the birth of cement in China. The following are the earliest cement factories established in China (Note 3):

- 1886, Green Island YingNi Factory (Macau)
- 1887, Kowloon YingNi Company (Hong Kong)
- 1889, Tangshan XiMianTu Factory (Hebei)
- 1907, Onoda YangHui Manufacturing Co., Ltd. (Liaoning).
- 1907, Guangdong ShiMinTu Factory (Guangdong)
- 1907, Hubei ShuiNi Factory (Hubei)
- 1920, Huashang ShuiNi Company (Shanghai)
- 1921, China ShuiNi Company (Jiangsu)

The period when cement became entrenched in China aligns with the emergence of the aforementioned 37 words. Consequently, we can deduce that these words surfaced in the social context of the introduction of British cement to China in the 1880s. With the introduction of something new, the birth of a corresponding name is inevitable. Among the 37 translated words, only five have found a place in the Modern Chinese Dictionary (MCD), namely ShuiNi, YangHui, HongMaoNi, ShiMinTu, and ShuiMenTing. Their entries in the MCD (1st–7th editions) are presented in Table 3.

Table 3. Loanwords for cement in Modern Chinese Dictionary

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ShuiNi</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>YangHui</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>HongMaoNi</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>ShiMinTu</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>ShuiMenTing</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Loanwords, shaped by the masses, find their standardization in the hands of lexicographers. The inclusion of five words in MCD stems from their high generality and representativeness, spanning an official term (ShuiNi), two dialectal words (YangHui, HongMaoNi), and two loanwords (ShiMinTu, ShuiMenTing). Figure 1 illustrates the names of cement used in 930 dialect sites, roughly falling into five main groups: 1) YangHui/YangNi; 2) HongMaoHui/HongMaoNi; 3) ShuiMenTing/SiMenTing; 4) BaHui/WuHui; 5) ShuiNi. The five words recorded in MCD are essentially derived from these five major groups.
Addressing the first research question, our findings reveal that the birth of loanwords is a product of the social environment. During the Westernization Movement from the 1960s to the 1990s in China, the influx of foreign technologies and industrial development introduced new loanwords to align with these advancements. Cement, introduced from Britain in the 1880s, led to the creation of 37 borrowings in the Chinese language due to diverse borrowing ages and areas. Five of these variants found a place in MCD: ShuiMenTing, ShiMinTu, HongMaoNi, YangHui, and ShuiNi.

4.2 Vitality of English loanwords in Chinese

Based on the mean value of niche breadth, loanwords for cement can be categorized into three types: narrow niche \((1.5 > B_i > 0)\), medium niche \((3 > B_i ≥ 1.5)\), wide niche \((B_i ≥ 3)\). Table 4 illustrates the three-dimensional niche breadth of the five loanwords: ShuiNi \((3.221)\), YangHui \((2.350)\), ShuiMenTing \((1.385)\), HongMaoNi \((1.202)\), and ShiMinTu \((0.879)\). ShuiNi occupies a wide niche, signifying great vitality, while YangHui holds a medium niche with moderate vitality. ShiMinTu, HongMaoNi, and ShuiMenTing occupy narrow niches and display limited vitality. The vitality of these five loanwords aligns with the systematic rules for MCD word collection: all five words were included in the 1st edition, ShiMinTu was excluded from the 3rd to 7th editions, and HongMaoNi and ShuiMenTing were excluded from the 5th to 7th editions. We predict that the YangHui will also disappear from the next latest edition of MCD, and that eventually only ShuiNi will survive.

Table 4. Lexical niche breadth of loanwords for cement

<table>
<thead>
<tr>
<th></th>
<th>ShuiMenTing</th>
<th>ShiMinTu</th>
<th>HongMaoNi</th>
<th>YangHui</th>
<th>ShuiNi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal Niche Breadth</td>
<td>1.044</td>
<td>1.495</td>
<td>2.314</td>
<td>1.788</td>
<td>2.874</td>
</tr>
<tr>
<td>Spatial Niche Breadth</td>
<td>1.034</td>
<td>0.000</td>
<td>1.293</td>
<td>2.497</td>
<td>5.505</td>
</tr>
<tr>
<td>Functional Niche Breadth</td>
<td>2.075</td>
<td>1.142</td>
<td>0.000</td>
<td>2.765</td>
<td>1.283</td>
</tr>
<tr>
<td>Mean Value of Niche Breadth</td>
<td>1.385</td>
<td>0.879</td>
<td>1.202</td>
<td>2.350</td>
<td>3.221</td>
</tr>
</tbody>
</table>
As illustrated in Table 5, HongMaoNi exhibits minimal frequency across all Chinese periods, indicating negligible vitality. The frequencies of ShuiMenTing, ShiMinTu, YangHui, and ShuiNi notably increased from 1912 to 1949 (the founding of China), correlating with the democratic and scientific environment ushered in by the May Fourth Movement. Post-1950, ShuiMenTing, ShiMinTu, and YangHui experienced declines, and after the initiation of the Reform and Open policy in 1978, ShiMinTu, HongMaoNi, ShuiMenTing, and YangHui saw minimal usage, while ShuiNi became predominant. In terms of temporal ecological niche, ShuiNi boasts the largest value (2.874), with strong vitality, while ShuiMenTing has the smallest value (1.044), with weak vitality.

Table 5. Diachronic frequency of loanwords for cement

<table>
<thead>
<tr>
<th>Year Range</th>
<th>ShuiMenTing</th>
<th>ShiMinTu</th>
<th>HongMaoNi</th>
<th>YangHui</th>
<th>ShuiNi</th>
</tr>
</thead>
<tbody>
<tr>
<td>1872–1912</td>
<td>110</td>
<td>32</td>
<td>5</td>
<td>252</td>
<td>147</td>
</tr>
<tr>
<td>1913–1949</td>
<td>6654</td>
<td>356</td>
<td>3</td>
<td>3227</td>
<td>18910</td>
</tr>
<tr>
<td>1950–1978</td>
<td>29</td>
<td>48</td>
<td>1</td>
<td>1046</td>
<td>13938</td>
</tr>
<tr>
<td>1979–2022</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>30</td>
<td>24265</td>
</tr>
</tbody>
</table>

Table 6 reveals that ShiMinTu is extinct in the wild, absent from any of the 930 survey sites, validating its exclusion from the third edition of MCD in 1996. ShuiMenTing, a loanword translated from the Wu dialect, survives only in that area, indicating weak vitality. HongMaoNi, a Cantonese term referring to Westerners or Englishmen, persists mainly in the Cantonese-speaking area, with sporadic occurrences in the Official, Min, and Hakka dialectal zones, likely attributed to language contact through immigration or exchange. YangHui covers more dialectal points than ShuiNi but has a smaller spatial niche breadth due to uneven distribution, mainly in the Official dialect area (regional loanword). ShuiNi, defined as a national loanword, exhibits uniform distribution in all seven dialect areas, making it the widest in terms of spatial niche (5.505) and possessing the greatest vitality, while ShiMinTu shows no vitality with a spatial niche breadth of 0.000.

Table 6. Dialectal distribution of loanwords for cement

<table>
<thead>
<tr>
<th>Dialectal Area</th>
<th>ShuiMenTing</th>
<th>ShiMinTu</th>
<th>HongMaoNi</th>
<th>YangHui</th>
<th>ShuiNi</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1-Official Dialect</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>323</td>
<td>55</td>
</tr>
<tr>
<td>D2-Wu Dialect</td>
<td>58</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>D3-Gan Dialect</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>47</td>
<td>23</td>
</tr>
<tr>
<td>D4-Xiang Dialect</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>43</td>
<td>37</td>
</tr>
<tr>
<td>D5-Min Dialect</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>41</td>
<td>14</td>
</tr>
<tr>
<td>D6-Cantonese Dialect</td>
<td>0</td>
<td>71</td>
<td>24</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>D7-Hakka Dialect</td>
<td>0</td>
<td>2</td>
<td>18</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 7 indicates that HongMaoNi has zero frequency in each corpus, signifying non-usage. ShiMinTu exclusively appears in C1-Literature, implying its disuse in spoken language and extinction in the wild. ShuiMenTing and YangHui are primarily found in C1-Literature with minimal frequency and function. ShuiNi, although frequent in all corpora, has a smaller functional niche breadth than YangHui, mainly occurring in C2-Sci/Tech, indicating highly uneven distribution. YangHui boasts the widest functional niche (2.765), displaying the greatest vitality, while HongMaoNi has the narrowest (0.000), indicating no vitality.

Table 7. Frequency of loanwords for cement in different genres

<table>
<thead>
<tr>
<th>Genre</th>
<th>ShuiMenTing</th>
<th>ShiMinTu</th>
<th>HongMaoNi</th>
<th>YangHui</th>
<th>ShuiNi</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1-Literature</td>
<td>72</td>
<td>28</td>
<td>0</td>
<td>85</td>
<td>2638</td>
</tr>
<tr>
<td>C2-Sci/Tech</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>41</td>
<td>96200</td>
</tr>
<tr>
<td>C3-Blogs</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>2097</td>
</tr>
<tr>
<td>C4-Newspaper</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>22</td>
<td>6024</td>
</tr>
<tr>
<td>C5-TV/Broadcast</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>2168</td>
</tr>
</tbody>
</table>

Addressing the second research question, our findings reveal a direct proportionality between the vitality of loanwords and the breadth of the niche they occupy. This relationship is significantly influenced by three key factors: time, space, and function. ShuiNi, with a wide niche, exhibits strong vitality; YangHui, occupying a
medium niche, demonstrates moderate vitality; whereas ShiMinTu, HongMaoNi, and ShuiMenTing, with narrow niche breadths, display limited vitality. The competition and subsequent survival of the fittest among lexical variants are driven by niche overlap.

4.3 Endangerment of English loanwords in Chinese

Each word has its own history (Yakov 1967), undergoing a metabolic process from birth to growth to eventual obsolescence. The broader a loanword’s lexical niche, the greater its vitality. Statistical results indicate niche breadths for the five cement-related loanwords: ShiMinTu (0.879), HongMaoNi (1.202), ShuiMenTing (1.385), YangHui (2.350), and ShuiNi (3.221). Due to insufficient vitality, ShiMinTu, ShuiMenTing, and HongMaoNi were successively removed, leaving only YangHui and ShuiNi in the 7th edition of MCD. When a word is deleted and ceases to appear in dictionaries, it becomes endangered. Societal, political, economic, scientific, technological, and cultural factors continually impact people's lives and psychology, influencing the selection of loanwords. Borrowing and reborrowing across different periods and regions result in various variants of the same loanword, leading to competition among synonyms. The niche overlap index in Table 8 illustrates the intensity of competition among the loanwords for cement.

<table>
<thead>
<tr>
<th>Temporal Niche</th>
<th>ShiMinTu</th>
<th>ShuiMenTing</th>
<th>HongMaoNi</th>
<th>YangHui</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlap Index</td>
<td>0.98894</td>
<td>0.52172</td>
<td>0.95106</td>
<td>0.56234</td>
</tr>
<tr>
<td>Spatial Niche</td>
<td>0.00000</td>
<td>0.00024</td>
<td>0.11520</td>
<td>0.31132</td>
</tr>
<tr>
<td>Functional Niche</td>
<td>0.94897</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.33541</td>
</tr>
</tbody>
</table>

The overlap indexes in time, space, and functional niche delineate competition among the words in different temporal periods, geographic regions, and genres, respectively. A higher overlap index signifies stronger competition, while a lower index indicates weaker competition.

In terms of temporal niche (Table 8), the largest overlap index is between ShiMinTu and ShuiMenTing (0.98894), suggesting intense competition between these contemporaneous words. Conversely, the smallest overlap index is between HongMaoNi and ShuiNi (0.35736), indicating a generation gap and limited competition. Analyzing the earliest examples of these loanwords in the corpus and the history of cement factories in China, the evolution of cement-related loanwords follows an Ecological continuum: HongMaoNi/YingNi → XiMianTu/ShiMinTu/ShuiMenTing → YangHui → ShuiNi. The names of the first national cement enterprises in different eras (1889 Tangshan XiMianTu Factory → 1906 Qixin YangHui Company → 1954 Qixin ShuiNi Factory) demonstrate the continuum from XiMianTu to YangHui and finally to ShuiNi, as the transliterated term (XiMianTu) eventually gave way to the semantically translated word (ShuiNi).

In terms of spatial niche (Table 8), the overlap values of ShiMinTu with ShuiMenTing, HongMaoNi, and ShuiNi are all zero, indicating no competition. This lack of competition is attributed to ShiMinTu being phonetically transliterated by the Cantonese dialect in the 1880s (an early regional loanword). When the Chinese dialect survey was conducted in the 21st century, ShiMinTu was no longer in use at any of the 930 sites (Figure 1), suggesting its extinction in the wild. Both ShuiNi and YangHui, originating from the official dialect, have the largest spatial overlap index (0.84197), indicating fierce competition. ShuiNi is an elegant term, while YangHui is colloquial, contributing to the competition between the two words.

In terms of functional niche (Table 8), the overlap indexes between HongMaoNi and the other four words are all zero. HongMaoNi, a Cantonese loanword, is playful and derogatory, originating from the nickname for Westerners (Englishmen). HongMaoNi has zero frequency in various corpora, signifying its uselessness. Both YangHui and
ShuiMenTing are prevalent in different corpora (high richness) and occur evenly (high evenness), resulting in the highest spatial niche overlap index (0.98263) and intense competition.

Words compete, survival of the fittest. The fittest loanwords are those capable of localization and integration into the Chinese system. The introduction of the loanword for cement was a necessary borrowing since, before its introduction, there was no such substance or concept in China. The five loanwords for cement included in the MCD emerged in the 1880s during the Westernization Movement. Due to borrowing and reborrowing in different ages and areas, various lexical variants have appeared. However, HongMaoNi, ShiMinTu, and ShuiMenTing do not follow the principle of least effort, as they have three syllables, contrary to the mainstream of modern Chinese vocabulary, which favors two-syllable words. These three-syllable loanwords are out of trend. Additionally, the different borrowing modes have resulted in sound, formation, and meaning differences among these five words, as shown in Table 9. ShuiMenTing and ShiMinTu clone the sound but not the meaning, while ShuiNi, YangHui, and HongMaoNi make sense but not the sound. Moreover, all five words have morphemes leading to ambiguity, hindering their localization into the Chinese system.

Table 9. Linguistic statistics of loanwords for cement

<table>
<thead>
<tr>
<th>Loanwords</th>
<th>Mode of Translation</th>
<th>Length</th>
<th>Source</th>
<th>Dialectal Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>ShuiNi</td>
<td>literal translation</td>
<td>2 syllables</td>
<td>Native old word/new meaning</td>
<td>Official Dialect</td>
</tr>
<tr>
<td>YangHui</td>
<td>liberal translation</td>
<td>2 syllables</td>
<td>Native new word</td>
<td>Official Dialect</td>
</tr>
<tr>
<td>HongMaoNi</td>
<td>liberal translation</td>
<td>3 syllables</td>
<td>Native new word</td>
<td>Cantonese Dialect</td>
</tr>
<tr>
<td>ShiMinTu</td>
<td>transliteration</td>
<td>3 syllables</td>
<td>Loanword</td>
<td>Cantonese Dialect</td>
</tr>
<tr>
<td>ShuiMenTing</td>
<td>transliteration</td>
<td>3 syllables</td>
<td>Loanword</td>
<td>Wu Dialect</td>
</tr>
</tbody>
</table>

To assess the degree of localization of the five loanwords for cement, we evaluate four aspects: meaning, sound, formation, and character. Each aspect carries a full score of 8, 6, 4, and 2, respectively, totaling 20. As depicted in Table 10, ShuiNi attains the highest degree of localization (13 points) because it is a native old word in the Chinese lexical system. Being an old word with a new meaning for cement, ShuiNi seamlessly integrates into the Chinese language. On the other hand, ShuiMenTing scores the lowest degree of localization (6 points) as it clones the sound but not the meaning, making the domestication process challenging. Additionally, ShuiMenTing is translated from the Wu dialect (regional borrowing), posing difficulties in national acceptance.

Table 10. Degree of localization of loanwords for cement

<table>
<thead>
<tr>
<th>Loanwords</th>
<th>meaning</th>
<th>sound</th>
<th>formation</th>
<th>character</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>ShuiNi</td>
<td>7</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>YangHui</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>HongMaoNi</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>ShiMinTu</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>ShuiMenTing</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

Addressing the third research question, our findings indicate that the endangerment of loanwords arises from both external (social environment) and internal (language system) factors. The social environment fosters various variants, leading to competition among synonyms. Linguistic localization significantly influences the metabolism of loanwords, contributing to the survival of the fittest. Due to their lack of vitality, ShiMinTu, HongMaoNi, and ShuiMenTing have been removed from MCD, leaving only ShuiNi and YangHui. We anticipate that YangHui will also vanish from the next edition of MCDChinese, leaving the fittest word, ShuiNi, to endure. The vitality scores of the five loanwords for cement are as follows: ShiMinTu (0.879), HongMaoNi (1.202), ShuiMenTing (1.385), YangHui (2.350), and ShuiNi (3.221). Considering vitality and disappearance, the endangered category of loanwords for cement forms an ecological continuum: extinct in the wild—ShiMinTu; critically endangered—HongMaoNi; endangered—ShuiMenTing; vulnerable—YangHui; least concerned—ShuiNi.

5. Conclusion

Words serve as mirrors reflecting social life and encapsulating the evolving facets of language and society. The dynamics of social change, economic progress, scientific advancements, and the introduction of novel concepts find expression in the lexicon. The birth of a loanword coincides with its adoption, marking the commencement of its lifecycle, ultimately subject to metabolic changes. In the 1880s, when China embraced cement from Britain,
a competition of 37 loanwords ensued, resulting in the selection of five by authorities for inclusion in the MCD. Over time, ShiMinTu, HongMaoNi, ShuiMenTing, and YangHui faced endangerment due to narrow niche breadth (vitality) and niche overlap (competition), while ShuiNi emerged as the most adaptive and resilient.

Ecolinguistics, as an interdisciplinary field, delves into the intricate relationship between the environment and language. This paper adopts the lexical niche theory to specifically focus on the environmental impact on vocabulary within the realm of Ecolinguistics. Theoretically, employing cloud computing to analyze lexical niche and overlap offers a more scientific quantification of the ecology of English loanwords in Chinese, mitigating the subjectivity associated with qualitative research. Moreover, the lexical niche theory contributes to vocabulary teaching by providing a holistic understanding of lexical metabolism across temporal, spatial, and functional dimensions for teachers and students. However, it is important to note the limitation of this study, as the sample data is relatively small and biased, concentrating solely on cement loanwords. A more extensive analysis covering all the loanwords could potentially serve as an exceptional eco-project within the Chinese language.

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Authors’ contributions
Ruifeng Mo wrote, edited and reviewed the manuscript; Hao-zhang Xiao conceptualized, edited and reviewed the manuscript.

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Data sharing statement
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**Notes**


Note 2. ShuiMenTing=水门汀, ShiMinTu=士敏土, HongMaoNi=红毛泥, YangHui=洋灰, ShuiNi=水泥.


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