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以語料庫方式研究排灣語的使役結構

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摘要****

本研究從語料庫的角度探討排灣語中使役詞綴（*pa-Ø-*，*pa-ka-*和*pa-pe-*）的變異。在 Tang(295)的基礎上，本研究繼續探討排灣語使役結構中*Ø-*、*ka-* 和 *pe-* 詞綴的使用，並對從語料庫中提取的排灣語使役結構語料進行邏輯迴歸分析。我們的研究表明此三個使役結構之間存在認知上的區別（Verhagen & Kemmer)。迴歸模型的結果支持直接/間接致使二分法的理論，提供了對這些詞綴特徵及詞彙意義的合理解釋。具體而言，詞綴 *pa-Ø-* 與「直接致使」相關，通常用於涉及無生命參與者的事件中，且起因論旨角色直接導致受使役者的結果狀態。相反地，詞綴 *pa-ka-* 與「間接致使」相關，經常出現在有生命參與者的場景，且除了使動者之外，亦有其他一些驅動來源也導致使役事件的發生。詞綴 *pa-pe-* 則處於中間位置，偏好與不及物的結果謂語共同出現。此外，本研究亦對排灣語的三個使役前綴與荷蘭語的 *doen* 及 *laten* 以及中文的*使* 和*讓* 進行了跨語言比較。這些發現不僅使我們對排灣語的使役結構有更全面的認識，同時也為語言類型學中使役結構的普遍性和特殊性提供了更深刻的見解。

關鍵詞：語言變異、使役結構、語料庫語言學、R 統計

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**** 誌謝詞：本研究成果為作者群在第四屆中研語言學論壇會上發表之“基於語料庫的排灣語使役前綴的功能與語意分析”一文之延伸，會議上得到諸多專家學者之寶貴意見，特此致謝。此外，本文的撰寫與修改過程中，獲得中央研究院張永利研究員和陳彥伶研究員的許多指導與寶貴建議，在此一併致以深深謝意。

A Corpus-based Study of Causative Constructions in Paiwan

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Abstract****

This study examines the variation in causative affixes (*pa-Ø-*, *pa-ka-*, and *pa-pe-*) in Paiwan using a corpus-based approach. Building on Tang's (295) identification of the *Ø-*, *ka-*, and *pe-* affixes in Paiwan causative constructions, we apply logistic regression analysis to data extracted from corpora. Our research suggests a cognitive distinction among the three causative subtypes (Verhagen & Kemmer). The regression model results support the theory of a direct/indirect causation dichotomy, offering a plausible explanation for the characteristics and lexical meanings of the affixes. Specifically, the affix *pa-Ø-* is associated with "direct causation," typically used in events involving inanimate participants where the cause directly results in the state of the causee. Conversely, the affix *pa-ka-* is linked to "indirect causation," often found in contexts with animate participants and additional contributing forces. The affix *pa-pe-* occupies an intermediary position, showing a preference for intransitive effected predicates. Additionally, this study conducts a cross-linguistic comparison of the Paiwan causative affixes with the causative verbs *doen* and *laten* in Dutch, and *shi* and *rang* in Mandarin. These findings enhance our understanding of Paiwan causative constructions and offer insights into the universality and specificity of causative structures in linguistic typology.

Keywords: language variation, causative construction, corpus linguistics, R statistics

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1. Introduction

Causative constructions are a fundamental aspect of linguistic analysis, revealing the intricate relationship between a cause and its resulting effect. These constructions, characterized by the interaction between a causer and a causee, are pivotal in understanding how different languages encode causation. The Paiwan language, an Austronesian language spoken by the Paiwan people in southern Taiwan, presents an interesting case for exploring causative constructions due to its complex verbal morphology and diverse phonological system. This study investigates the variation in causative affixes (*pa-Ø-*, *pa-ka-*, and *pa-pe-*) in Paiwan from a corpus-based perspective. Building upon previous research and employing advanced statistical models, this study provides new insights into direct and indirect causation in the language. By examining these affixes, this research aims to contribute to the broader field of linguistic typology and deepen our understanding of the cognitive and pragmatic aspects of causative constructions in Paiwan.

1.1. Background Information of Paiwan

Many "Philippine-type" languages exhibit elaborate systems of nominal and verbal morphology (Blust 343). In these languages, the functional load of verbal morphology typically surpasses that of nominal morphology, as key syntactic information such as voice, aspect, and mood is marked on verbs. As a prototypical Philippine-type language, Paiwan is an Austronesian language spoken by the Paiwan people, primarily located in the southern part of Taiwan. According to statistics from the Council of Indigenous Peoples, the Paiwan population stands at approximately 108,312, accounting for 18% of the total indigenous population of Taiwan, which numbers around 588,660. This makes the Paiwan the second-largest indigenous group in Taiwan. The geographical distribution of the Paiwan people is predominantly concentrated in Pingtung County, home to 49,926 individuals, followed by Taitung County with 17,096 residents, and Kaohsiung City with 10,080 residents (Council of Indigenous Peoples, Executive Yuan 2024).

As an integral part of the Formosan languages, Paiwan showcases a rich linguistic heritage that includes complex verbal morphology and a diverse phonological system. The language is considered endangered, with efforts being made to revitalize and document it for future generations. Paiwan's phonological system consists of 24 consonants and 4 vowels.

Distinct features include the use of epenthetic glottal stops in vowel-initial words and the presence of morphophonemic processes such as infixation and suffixation (Yeh 122). The language's syllable structure is predominantly CVCV(C), with stress typically falling on the penultimate syllable of a prosodic word.

In what follows, we will give a brief grammatical sketch of Paiwan before we delve into a corpus-based analysis of Paiwan causative constructions. It is worth mentioning that all tables and example sentences showcasing Paiwan linguistic knowledge throughout the paper are derived from the authors' own fieldnotes and original research findings, unless otherwise cited.

1.2. A Grammatical Sketch of Paiwan

Paiwan is characterized as a predicate-initial language, wherein the predicate typically precedes the subject and object in a sentence. For instance, in an equational construction, a noun serves as the predicate, as demonstrated in (1):

(1)

Noun as a predicate (equational construction):

uqaljay	*ti*	*Bali*
boy	NOM	Bali

'Bali is a boy.'

Conversely, in verbal constructions, a verb functions as the predicate, as shown in (2):

(2)

Verb as a predicate:

caqis=aken	*ta*	*itung*
sew<AV>=1S.NOM	OBL	clothes

'I often sew clothes.'

In both constructions, the predicate occupies the initial position in the clause. The most natural word order in Paiwan is Predicate/Verb-Subject-Object (VSO). However, an alternative grammatical structure, Predicate/Verb-Object-Subject (VOS), is also permissible, as illustrated in (3) and (4):

(3)

uri=k an ta ciqaw ti Bali
IRR=eat<AV> OBL fish NOM Bali
'Bali will eat fish.'

(4)

uri=kan ti Bali ta ciqaw
IRR=eat<AV> NOM Bali OBL fish
'Bali will eat fish.'

Additionally, negators can appear in the initial position, and nominative clitic pronouns function as second-position enclitics, as seen in (5):

(5)

ini=aken a na-kan ta ciqaw
NEG=1S.NOM LNK PFV-eat<AV> OBL fish
'I have not eaten fish.'

In topicalization constructions, the subject is moved to the initial position to serve as the topic of the sentence, as exemplified in (6):

(6)

a zua a tja=maca i tja-i- qayaw
NOM that LNK 1PL.GEN=eye be.at more-be.at-front
tua tja=ulu
OBL 1PL.GEN=head
'Our eyes, they are in the front of our head.' (Li 24)

This syntactic flexibility highlights the complex nature of Paiwan's sentence structure and its pragmatic use in conveying emphasis and topical information.

The voice system in Paiwan has four voices: Agent Voice (AV), Patient Voice (PV), Locative Voice (LV), and Beneficiary/Instrumental Voice (BV/IV), as outlined in Table 1. The verbal affixes corresponding to each voice type vary depending on the sentence construction.

Table 1. Voice System in Paiwan

Voice		voice forms	imperative	hortative
AV (Agent Voice)		** (*m-* or *<en>*); *Ø-*; *ma-*	*-u; -i*	
PV (Patient Voice)		*<in>*; *-in*; (*-en*)	*-u*; *-i*	*-av*; *-aw*; *-ay*
LV (Locative Voice)		*-an*	*-u*; *-i*	*-ay*
RV (Referential Voice)	BV (Beneficiary Voice)	*si-*	*-an*	*-ay*; *si-*; *-an*
	IV (Instrumental Voice)	*si-*	*-an*	*-ay*

The following examples illustrate the application of these voice forms. For instance, an infix ** is attached to the verb when the sentence is in Agent Voice (AV), see (7). On the other hand, a suffix *-en* is attached to the verb when the sentence is in Patient Voice (PV), see (8). Imperative forms are typically marked by the suffixes *-i* or *-u*, while hortative forms are marked by the suffixes *-aw* or *-ay*.

(7)

Agent Voice (AV):
[*'an ta vurati*]$_{\text{predicate}}$ [*ti pali*]$_{\text{subject}}$
eat<AV> OBL sweet.potato NOM Pali
'Pali eats sweet potatoes.'

(8)

Patient Voice (PV):
[*'an-en ni pali*]$_{\text{predicate}}$ [*a vurati*]$_{\text{subject}}$
eat-PV GEN Pali NOM sweet.potato
'The sweet potato is eaten by Pali.'

(9)

Locative Voice (LV):
[*'a-'an-an ni Pali ta vurati*]$_{\text{predicate}}$
RED-eat-LV GEN Pali OBL sweet.potato
[*a 'a'esan*]$_{\text{subject}}$
NOM kitchen
'This kitchen is where Pali eats sweet potatoes.'

(10)

Instrument Voice (IV):

[*si-'an ni Pali ta vurati*]$_{\text{predicate}}$

IV-eat GEN Pali OBL sweet.potato

[*a qecap*]$_{\text{subject}}$

NOM chopsticks

'Pali eats sweet potatoes with chopsticks.'

These examples demonstrate how different voice forms in Paiwan are used to indicate various syntactic roles and relationships between the agent, patient, location, and instruments or beneficiaries involved in the action.

Paiwan employs case markers to indicate the grammatical relations of nouns within sentences. These markers are categorized into nominative, genitive, and oblique cases, as in Table 2. The nominative (NOM) case typically marks the subject of a sentence, the genitive (GEN) marks possessors or agents in passive constructions, and the oblique (OBL) case often signals objects or locations. The form of the case markers varies depending on whether the noun is a personal noun or a common noun, and within these categories, the markers can further be classified as specific or nonspecific.

Table 2. Paiwan Case Markers

		Nominative	Genitive	Oblique
Personal noun	singular	*ti*	*ni*	*tjay / tji*
	plural	*tia*	*nia*	*tjia*
Common noun	Specific	*a*	*na~nua*	*ta~tua*
	nonspecific	*nu*	*nu*	*tu*

The personal pronoun system in Paiwan includes bound pronouns and free pronouns, as shown in Table 3. Bound pronouns attach to the verb as enclitics and vary based on nominative or genitive cases. Free pronouns stand alone and also vary by case and number.

Table 3. The Personal Pronoun System in Paiwan

		Bound form		Free form		
		Nominative	Genitive	Nominative	Genitive	Oblique
Sg	1st	*=a'en (=aken)*	*'u=*	*tia'en*	*nia'en*	*tjanua'en*
	2nd	*=sun*	*su=*	*tisun*	*nisun*	*tjanusun*
	3rd	-	-	*timadju*	*nimadju*	*tjaymadju*
Pl	1st Incl	*=itjen*	*tja=*	*titjen*	*nitjen*	*tjanuitjen*
	1st Excl	*=amen*	*nia=*	*tiamen*	*niamen*	*tjanuamen*
	2nd	*=mun*	*nu=*	*timun*	*nimun*	*tjanumun*
	3rd	-	-	*tiamadju*	*niamadju*	*tj(a)iamadju*

1.3. Causative Constructions in Paiwan

The field of linguistics has been deeply immersed in an ongoing dialogue concerning causative constructions, an intricate linguistic phenomenon that involves the interaction of two fundamental participants: the causer and the causee. In these constructs, the causer triggers the causal event, while the causee undergoes the resulting outcome, thus forming the essential components of causative sentences (Shibatani 14-16). Comrie ("The Grammar of") initially distinguished between causative verbs and their effects, laying the foundation for subsequent analyses, such as Verhagen & Kemmer (68), who further refined the categorization of causative verbs as "causal predicates" and the associated verb forms as "effected predicates," applicable to both transitive and intransitive variations.

Within the context of Paiwan, Chang elucidates three distinct strategies for constructing causative sentences (87). The first strategy involves inherently causative verbs like *veneciq*, signifying 'to slaughter' (i.e., 'to cause [an animal] to die'). The second strategy employs morphological tools, such as *pa'an* (formed by combining the causative prefix *pa-* with the root *'an*), conveying 'to make eat; to feed'. The third approach encompasses syntactic structures, exemplified by sentence patterns led by words like *papaqadilj*, meaning 'force', combined with other verbs. This study primarily focuses on the second method.

In Paiwan, the causative affixes *pa-Ø-*, *pa-ka-*, and *pa-pe-* play a pivotal role in forming causative constructions (cf. Tang 295), as illustrated in (11)-(13) respectively.

(11)
pa-v<in>(e)celaq-en a qipu na qadav
CAUS-crack<PFV>-PV NOM soil GEN sun
'The sun causes the soil to crack.'

(12)
pa-ka-lingdjelj-en=aken ni kama
CAUS-KA-stand-PV=1S.NOM GEN father
'My father will make me stand as punishment.'

(13)
pa-pe-qaca-in=anga 'u=itung ni 'ina
CAUS-PE-big-PV=COS 1S.GEN=clothes GEN mother
'It's time that Mom make my clothes wider!'

In (11), the causative prefix *pa-* is used in combination with the perfective aspect marker *<in>* and the patient voice suffix *-en* to convey the meaning that the sun (the causer) causes the soil (the causee) to crack. The nominative case marker *a* indicates the subject (soil), while the genitive case marker *na* indicates the agent (sun). Example (12) demonstrates the use of the causative prefix *pa-* combined with *ka-* and the patient voice suffix *-en* to indicate that the father (the causer) causes the speaker (the causee) to be punished by standing. The nominative pronominal clitic *=aken* indicates the first person singular subject, while the genitive case marker *ni* indicates the agent (father). Example (13), on the other hand, demonstrates the use of the causative prefix *pa-* combined with the morpheme *pe-* to convey a request for alteration, in which the perfective aspect marker *anga* indicates the completed action, and the genitive pronominal clitic *'u=* indicates the first person singular possessive (my clothes).

This study employs a quantitative perspective to explore the affinities of these affixes with verbs, building on existing research in Paiwan and other languages. We contend that causative constructions using the affix *pa-Ø-* are closely associated with direct causation, while those employing the causative affix *pa-ka-* lean towards instances of indirect causation. In

general, direct causation tends to emphasize interactions involving non-human elements more prominently than indirect causation. This quantitative approach allows us not only to investigate the prevalence of the affixes *pa-Ø-*, *pa-ka-*, and *pa-pe-* but also to gain fresh insights into their tendencies regarding direct or indirect causation. This study pioneers a data-driven angle, adding a quantitative dimension to the analysis of these causative affixes and their associations with verbs.

The subsequent sections of this paper are organized as follows: Section 2 provides a concise review of relevant literature. Section 3 elaborates on the selected methodologies. Section 4 presents the findings, advocating for a direct/indirect dichotomy and conducting a comparative analysis of causative predicates across Paiwan and other languages. Finally, Section 5 encapsulates the study's main findings and concludes the investigation.

2. Literature Review

2.1 A Model of Causation Types

The architecture of causative constructions often reflects how speakers mentally conceptualize the relationship between a cause and its resulting effect. This facet of language has sparked extensive discourse, spanning both typological and cognitive dimensions. Typologically, causatives often find themselves classified into three distinct forms: (i) lexical causatives, (ii) morphological causatives, and (iii) analytic causatives (Comrie "Language Universals," 166). On the cognitive front, Croft (20) introduced the concept of the Idealized Cognitive Model (ICM), building upon Lakoff's framework. Within Croft's framework, causative constructions depict singular events classified into three primary categories: (i) causative, (ii) inchoative, and (iii) stative (20). It's noteworthy that both Comrie's ("Language Universals,"166) and Croft's taxonomies are conceived as continua, acknowledging that linguistic expressions often fall within the spectrum between adjacent categories (20), rather than neatly fitting into a single one.pacin

In his influential work, Croft visually illustrated the typologies of causation proposed by Talmy ("Semantic causative types," 47, 62; "Force dynamics," 54), as depicted in Figure 1(167). This illustrative framework employs two primary dimensions to delineate four causation categories.

The first dimension differentiates between the initiator and the endpoint within a causative construction. Simultaneously, the second dimension highlights distinctions between animate and inanimate entities, with animates representing the mental realm and inanimates representing the physical realm.

As showcased in Figure 1, the arrows stemming from physical entities—specifically, affective and physical causation—follow a linear and direct trajectory. This underscores the profound direct influence that physical entities wield over other entities. In contrast, arrows originating from mental entities trace a more intricate path. The arrow representing mental-on-mental causation, or inducive causation, takes on a curved trajectory. Furthermore, the arrow corresponding to mental-on-physical causation, identified as volitional causation, displays a subtle bend. This pattern emphasizes that mental entities lack the direct influence over others that characterizes physical entities.

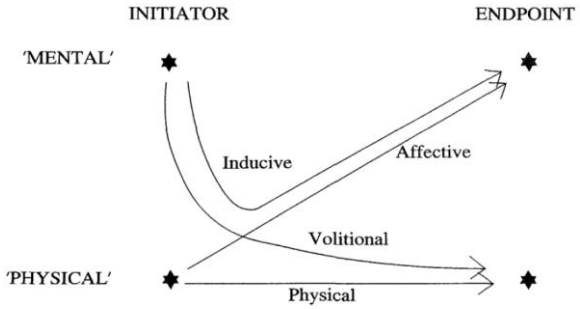

Figure 1. A Model of Causation Types (Croft 167)

The model of causation types has been harnessed in the research conducted by Verhagen & Kemmer to explore causative constructions in modern standard Dutch, employing the verbs *doen* and *laten* (Croft 167, cf. Talmy, "Semantic causative types," 47, 62; "Force dynamics," 54; "Toward a," 414). According to the authors, *laten* is anticipated to convey inducive (mental-on-mental) causation and exhibit a higher prevalence of animate causers compared to inanimate ones, due to its association with indirect causation. Conversely, *doen* is projected to involve more inanimate causers, aligned with its role in direct causation.

Following a similarly refined methodological trajectory, Shih et al.

conducted a logistic regression analysis to delve into the Chinese causative auxiliary verbs *shi* 'cause' and *rang* 'let'. Their outcomes from the regression model have demonstrated the applicability of the theory of direct/indirect causation in comprehending the attributes and lexical meanings of these verbs. The authors posit that the verb *shi* is intrinsically linked to "direct causation," predominantly employed when inanimate participants are involved. In such scenarios, the initiating force leads directly to the resulting state of the causee. In contrast, the verb *rang* is associated with "indirect causation," commonly used when animate participants are engaged, and an additional force beyond that of the causer contributes to the causal event.

2.2 Definition of Transitivity

Transitivity is a core grammatical concept that refers to the relationship between a verb and its arguments, particularly how the verb interacts with its object(s). Linguists typically explore transitivity from two primary perspectives: the syntactic view and the functional (semantic) view. These perspectives offer different criteria for defining and analyzing transitivity, which impacts how linguistic data, including causative constructions, are interpreted.

In formal syntactic theories, Chomsky's generative framework defines transitivity as the relationship between a verb and its internal argument, where transitive verbs require a complement (Chomsky 45). Radford expands on this idea by illustrating the VP structure that hosts direct objects for transitive verbs (Radford 123). Similarly, Carnie emphasizes that the projection of arguments determines the syntactic complexity of transitive versus intransitive verbs (Carnie 89).

In functional view, on the other hand, valency, a key aspect of transitivity, is discussed by Tesnière, who views it as the number of arguments a verb can take, reflecting its functional role (Tesnière 34). Dixon analyzes transitivity as a function of valency, observing how verbs are classified based on the number of participants involved (Dixon 112). Comrie provides a cross-linguistic perspective, showing that valency patterns vary widely across languages (Comrie "Language Universals," 78).

This study will adopt a semantic (functional) view of transitivity in the annotation scheme of our dataset. There are several reasons. First, Paiwan

causative constructions often exhibit complex relationships between the verb and its arguments that cannot be fully captured by a purely syntactic analysis. By focusing on the semantic roles of the causer and causee and examining how verb valency interacts with causative markers, this approach provides a more accurate representation of how transitivity operates in Paiwan.

Moreover, adopting a semantic view allows for meaningful cross-linguistic comparisons with other studies of causation, as this view parallels previous research in cognitive linguistics and linguistic typology, which often treats transitivity as a gradient rather than a strict binary (Croft; Hopper and Thompson). While a syntactic analysis could offer insights into the structural patterns of transitivity, the semantic approach offers greater flexibility in analyzing causative constructions in Paiwan. It is particularly useful in understanding the interaction between meaning, argument structure, and causative morphology.

3. Research Methods

To comprehensively explore the multifaceted contexts in which the three causative affixes operate, we carefully curated a Paiwan dataset. The dataset was assembled from a variety of sources, including dictionaries (e.g. Ferrell), textbooks (e.g. Chang, Hsieh et al., among others), example sentences from prior studies (e.g. Ho, Early & Whitehorn, Huang, Li, among others), Bible passages, and the authors' own field notes. The inclusion of Bible translations is justified by their accessibility and the structured linguistic data they provide, particularly for an endangered and under-documented language like Paiwan. Although these texts may not fully reflect contemporary spoken Paiwan, they offer a valuable source of consistent grammatical structures that are essential for the statistical analysis of causative constructions. To mitigate any limitations, the Bible data were supplemented with spontaneous speech and field-collected examples, ensuring a balanced and comprehensive corpus for analysis.

We collected a total of 10,012 Paiwan sentences containing the causative prefixes *pa-Ø-*, *pa-ka-*, and *pa-pe-*. Of these, 9,185 sentences feature the prefix *pa-Ø-*, 560 sentences contain *pa-ka-*, and 267 sentences include *pa-pe-*. The dataset was systematically categorized into three distinct groups: *pa-Ø-*, *pa-ka-*, and *pa-pe-*. From each category, a random sample of 220 items was selected for in-depth analysis. After a screening

process to exclude sentences with ambiguous causer-causee relationships or those that did not convey a clear causative meaning, we retained a total of 566 instances, which formed the basis for subsequent annotation.[1]

The initial annotation phase involved the detailed determination of whether the causer and causee within each data instance could be classified as either mental or non-mental entities.[2] When the causer, often a human or a human-operated institution, exhibited the ability to consciously initiate the causing event, it met the criteria for being a mental causer. Conversely, an inanimate causer was designated as non-mental. Similarly, a mental causee was identified when it underwent the caused event spontaneously; otherwise, it was labeled as non-mental.

The distinguishing attributes of the causative affixes were extracted through a meticulous analysis of the causers and causees present in causative constructions. Instances featuring both a mental causer and a mental causee were categorized as "inducive," as illustrated in (14), repeated from (12).

(14)
pa-ka-lingdjelj-en=aken ni kama
CAUS-KA-stand-PV=1S.NOM GEN father
'My father will make me stand as punishment.'
(lit.) 'My father will cause me to stand as punishment.'

[1] It is noteworthy to mention that this paper does not take dialectal variation into consideration. We acknowledge that there are distinct dialects within the Paiwan language, each with variations in voice marking and the pronominal system. However, based on our data and previous studies, the semantics of causer and causee remain relatively consistent across these dialects. Thus, while some morphological or syntactic differences may exist, they do not significantly impact the semantic interpretation of causative constructions as analyzed in our study.

[2] For consistency with previous studies that emphasize cognitive and pragmatic factors in causative constructions (e.g., Verhagen & Kemmer), we employ a mental vs. non-mental distinction in this study. Nevertheless, we recognize the broader relevance of the animate vs. inanimate hierarchy in linguistic typology. We appreciate the anonymous reviewer for highlighting this potential perspective, and we will leave incorporating distinctions of animacy and more nuanced verb categories for future research directions.

In this example, the causer is *kama* 'father' and the causee is the nominative first person singular clitic *aken*, both qualifying as mental entities. The causer holds the capability to directly influence the causee, with the agency to exert this influence of their own volition. Similarly, as depicted in (15), the category of "volitional" causation emerges when the construction involves a mental causer and a non-mental causee.

(15)
tja=kuda-in nu pa-pe-liaw
1PL.INCL.GEN=do.what-PV CONJ CAUS-PE-much
a paysu
NOM money
'How can we earn more money?'
(lit.) 'If we want to cause money to become more, what should we do?'
(Hsieh et al. 230)

Here, the causer is *tja* 'we', and the causee is *paysu* 'money'. This causative construction features a mental causer exerting influence on a non-mental causee. If the construction entails a non-mental causer and a mental causee, it falls into the category of "affective," as demonstrated in (16).

(16)
pa-pe-saqetju=aravac a valan ni pali
CAUS-PE-hurt=very NOM words GEN Pali
tjanuitjen
1PL.INCL.OBL
'Pali's words hurt us very much.'
(lit.) 'Pali's words cause us to hurt very much.'

In this instance, the non-mental causer *valan ni pali* 'Pali's words' influences the mental causee *tjanuitjen* 'us'. The non-mental causer does not engage with the causee through voluntary action; however, the causee itself becomes influenced. Lastly, "physical" causation is identified when both the causer and the causee are non-mental entities, exemplified in (17), reproduced from (11).

(17)
pa-v<in>(e)celaq-en a qipu na qadaw
CAUS-crack<PFV>-PV NOM soil GEN su
'The sun causes the soil to crack.'

In (17), both the causer and causee are non-mental entities. This scenario portrays an indirect action, where an inanimate causer triggers a reaction in another inanimate causee.

After capturing these attributes, we ascertain the valency-based transitivity of verbs following the causative affixes. As mentioned previously, we adopt a semantic view of transitivity because it enables us to capture the richness of Paiwan causative constructions, particularly how causative markers interact with verb valency and argument structure. This functional approach aligns with broader typological studies, allowing for a more nuanced understanding of how transitivity and causativity are expressed in Paiwan.

We classify the verb, which acts as the "effected predicate" (Verhagen & Kemmer 68), as intransitive (INTR) if it semantically functions as a monovalent verb, or as transitive (TR) if it exhibits a bivalent or higher valency.

A snapshot of our annotation scheme is given in Figure 2.

Paiwan	Chinese	Affix	causer	causee	Trans	Type
pavincelaqen a qipu na qadav.	太陽使土地乾裂。	pa	0	0	INTR	physical
pakalingdjeljen aken ni kama.	父親要我罰站。	paka	1	1	INTR	inducive
papeqacain anga u itung ni ina.	媽媽該把我的衣服改的更寬一點了！	pape	1	0	INTR	volitional
tja kudain nu papeliaw a paysu?	如何累積更多錢財？（如果要使錢變多，我們要做什麼？	pape	1	0	INTR	volitional
papesaqetju aravac a valan ni pali tjanuitjen.	Pali 這句話使我們很受傷	pape	0	1	INTR	affective

Figure 2. A Snapshot of the Annotation Scheme

The dataset resulting from this process was then stored in a JSON file, and an illustrative example is provided in Figure 3.


```
{
    "Paiwan": "tja kudain nu papeliaw a paysu?",
    "Chinese": "如何累積更多錢財？（如果要使錢變多，我們要做什麼？",
    "Affix": "pape",
    "Trans": "INTR",
    "Type": "volitional"
}
```


Figure 3. An Example of the Annotated Sentences

The annotated dataset is then employed to train a logistic regression model, following the methodologies outlined by Levshina (chap. 12-13). The selection of this model is grounded in its suitability for modeling binary dependent variables. The statistical outcomes produced by the logistic regression model will be thoroughly analyzed to facilitate the exploration of affix selection among *pa-Ø-*, *pa-ka-*, and *pa-pe-*.

4. Results

4.1. Evaluation

The outcomes produced by the logistic regression model are summarized in Table 4, displaying the overall performance of the logistic regression model used to analyze the selection of causative affixes (*pa-Ø-*, *pa-ka-*, and *pa-pe-*) in Paiwan.

Table 4. The Overall Performance of the Regression Model

```
##                         Model Likelihood      Discrimination    Rank Discrim.
##                               Ratio Test             Indexes          Indexes
## Obs           566    LR chi2      61.17      R2       0.115    C        0.647
##  paka         202    d.f.             4      R2(4,566)0.096    Dxy      0.293
##  pape         166    Pr(> chi2) <0.0001    R2(4,501.8)0.108    gamma    0.364
##  pa           198                          Brier    0.218    tau-a    0.195
## max |deriv| 2e-11
```

The table summarizes key statistical metrics, including the number of observations, the significance of the model, and the predictive accuracy. The first column provides the total number of observations analyzed in the model. The second column presents the Likelihood Ratio Test (LRT) statistic, which assesses the overall significance of the model. A significant p-value (< 0.0001) indicates that the model includes at least one significant predictor for affix selection. The final column contains the concordance index (C), which measures the model's ability to correctly predict the use of the causative affixes based on the input variables. A concordance score of 0.647 means that the model accurately predicts affix selection 64.7% of the time.

As shown in Table 4, the model is statistically significant ($p < 0.0001$), indicating that the variables included in the regression, such as causation type and transitivity, have a predictive value for determining the causative

affix. However, with a concordance index of 0.647, the model demonstrates moderate predictive accuracy, which suggests room for refinement in the variables or the model structure. While the model performs acceptably according to Hosmer & Lemeshow's scale in Table 5 below, the C-statistic below 0.7 suggests that the model's ability to discriminate between affix choices is not optimal. This might be due to the complexity of causative constructions in Paiwan or an insufficient distinction between direct and indirect causation in some cases.

Table 5. A Scale for the Index C (Hosmer & Lemeshow 162)

$C = 0.5$	no discrimination
$0.7 \leqq C < 0.8$	acceptable discrimination
$0.8 \leqq C < 0.9$	excellent discrimination
$C \geqq 0.9$	outstanding discrimination

The coefficient values are presented in Table 6, representing the estimated log odds of the outcome when all variables align with their reference levels—corresponding to *pa-Ø-*, volitional causation, and intransitive effected predicates.

Table 6. The Coefficient Values

```
## Coefficients :
##                      Estimate Std. Error z-value  Pr(>|z|)
## (Intercept):paka     -0.14720    0.22758 -0.6468  0.517748
## (Intercept):pape      0.95644    0.21124  4.5277 5.963e-06 ***
## Typeaffective:paka   -1.07295    0.60083 -1.7858  0.074135 .
## Typeaffective:pape  -18.99558 2404.12367 -0.0079  0.993696
## Typephysical:paka    -0.73022    0.42812 -1.7056  0.088079 .
## Typephysical:pape    -1.03827    0.36847 -2.8177  0.004836 **
## Typeinducive:paka     1.09792    0.23711  4.6305 3.649e-06 ***
## Typeinducive:pape    -0.33814    0.26356 -1.2830  0.199495
## TransTR:paka         -0.55145    0.22834 -2.4150  0.015733 *
## TransTR:pape         -2.68911    0.31860 -8.4405 < 2.2e-16 ***
## ---
```

Larger coefficients indicate an increased likelihood of the specified variable and reduced likelihood of *pa-Ø-*, while smaller coefficients signify diminished odds of the specified variable and increased odds of *pa-Ø-*. In

terms of causation types predictor, "volitional" serves as the reference level. The number of stars appended on the right indicates the statistical significance level of the result. Notably, only "Typeinducive:paka" displays positive coefficients, indicating that inducive causation reduces the odds of *pa-Ø-* and elevates the likelihood of *pa-ka-* relative to volitional causation. Remarkably, physical causation exhibits statistically significant negative estimates, signifying a strong preference for *pa-Ø-*. This indicates a strong inclination towards selecting *pa-Ø-* over the other two affixes. Regarding the type of effected predicates, transitive effected predicates exhibit a noticeable aversion to *pa-pe-* compared to their intransitive counterparts.

These observations align with the direct/indirect differentiation proposed by Verhagen & Kemmer. As *pa-Ø-* is associated with "direct causation," it is typically employed when the causing event involves inanimate participants. In such cases, the force initiated by the cause directly leads to the resulting state of the causee. This explains why physical causation, involving both non-mental causer and non-mental causee, significantly favors the usage of *pa-Ø-* over the other affixes.

Conversely, *pa-ka-*, associated with "indirect causation," tends to be used when both animate participants are involved, and an additional force beyond the causer contributes primarily to the caused event. This clarifies why inducive causation, involving both mental causer and mental causee, exhibits a strong preference for selecting *pa-ka-* over the other affixes.

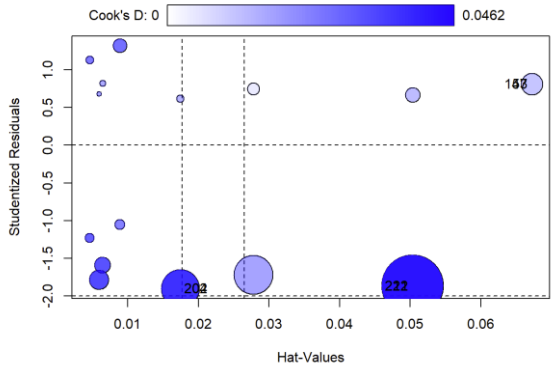

Figure 4. A Plot with Outliers and Discrepancy Values

Figure 4 visually represents outliers and discrepancy values within our dataset, indicating that a few observations exhibit significant discrepancies and notable Cook's distance values, scattered around the plot's periphery. Some outliers are highlighted in Table 7.

Table 7. Some Outliers in the Dataset

Affix	Type	Trans
pa-Ø-	affective	TR
pa-Ø-	affective	TR
pa-ka-	physical	INTR
pa-ka-	physical	INTR
pa-ka-	affective	INTR
pa-ka-	affective	INTR

Table 7 showcases instances that deviate from the typical usage of *pa-Ø-* and *pa-ka-*. As mentioned earlier, *pa-Ø-* is usually associated with physical causation rather than affective causation, while *pa-ka-* is typically related to inducive causation rather than physical or affective causation. This observation underscores the possibility that our assembled dataset might be overly generalized, potentially lacking the nuanced granularity needed to capture subtle conceptual distinctions, a common challenge in corpus-based semantic research.

Finally, during the validation of model performance, tests were conducted to assess the risk of overfitting, which occurs when a model performs well on the training data but fails to generalize to new, unseen data. The approach employed in this study involved bootstrapping (cf. Levshina, chap. 12), wherein the model was refitted 200 times. The results of this validation process are presented in Table 8.

Table 8. The Results of Testing for Overfitting

	index.orig	training	test	optimism	index.corrected	n
Dxy	0.2932	0.2944	0.2869	0.0075	0.2857	200
R2	0.1154	0.1229	0.1091	0.0138	0.1015	200
Intercept	0.0000	0.0000	0.0297	-0.0297	0.0297	200
Slope	1.0000	1.0000	0.9513	0.0487	0.9513	200
Emax	0.0000	0.0000	0.0161	0.0161	0.0161	200
D	0.1063	0.1141	0.1001	0.0140	0.0923	200
U	-0.0035	-0.0035	-0.8245	0.8210	-0.8245	200
Q	0.1098	0.1177	0.9246	-0.8069	0.9168	200
B	0.2183	0.2173	0.2198	-0.0024	0.2207	200
g	0.7096	0.7311	0.6808	0.0503	0.6593	200
gp	0.1489	0.1492	0.1415	0.0077	0.1413	200

To assess the extent of overfitting in the current model, Table 8 presents several metrics, including optimism scores, the Dxy statistic, and the R^2 value, all of which provide insights into the model's performance and reliability.

The optimism scores indicate the degree of overfitting by measuring how much the model's performance deteriorates when evaluated on new samples compared to its performance on the training data. Higher optimism scores suggest a greater risk of overfitting. In Table 8, the "Optimism" column shows that the optimism values for each parameter (e.g., Intercept, Slope) remain relatively low. For instance, the optimism score for the "Slope" is 0.0487, indicating only a slight reduction in model accuracy when applied to new data. This low optimism value suggests that the model is not heavily overfitted and can be considered reasonably robust.

The Dxy statistic is another indicator of model performance and is closely related to the concordance index (C). The Dxy statistic measures the rank correlation between predicted and observed responses, with values ranging from -1 (perfect discordance) to 1 (perfect concordance). A higher Dxy value indicates better predictive performance. In this study, the Dxy statistic presented in Table 8 falls within an acceptable range, suggesting that the model's predictions are aligned with the observed outcomes in a consistent manner. This supports the validity of the model's predictions regarding causative marker selection in Paiwan.

The R^2 value reflects the proportion of variance in the dependent variable that is explained by the independent variables in the model. In this context, a higher R^2 indicates that a greater proportion of variation in causative marker selection is captured by the predictors, such as causation type and verb transitivity. The relatively high R^2 values reported in Table 8 indicate that the model has a good fit, accounting for a significant portion of variability in the data.

Additionally, Table 8 includes bootstrap validation results, which provide a more nuanced assessment of model stability and generalizability. The bootstrap validation was performed by refitting the model 200 times with different random samples, and the reported "Optimism" values indicate the average decrease in model performance across these iterations. Since the optimism values remain relatively low, it suggests that the model's performance does not vary significantly with different sample subsets, enhancing the reliability of the regression estimates.

Overall, the results in Table 8 demonstrate that the model is not overly optimistic in its predictions, with minimal evidence of overfitting. This suggests that the estimates of the regression coefficients are reliable and can be considered trustworthy. The low optimism scores, acceptable Dxy statistic, and robust R^2 values collectively indicate that the logistic regression model performs well in predicting the choice of causative markers in Paiwan, supporting the study's claims regarding the relationship between causation type and affix selection.

4.2. A Cross-linguistic Comparison

This subsection conducts a comparative analysis that juxtaposes our findings with research conducted by Levshina (chap. 12-13) on the causative verbs *doen* and *laten* in modern Dutch, as well as the study by Shih et al. on the causative verbs *shi* and *rang* in Mandarin Chinese.

Mandarin and Dutch were selected for cross-linguistic comparison with Paiwan due to their typological diversity and the distinct ways these languages encode causation. Mandarin, a Sino-Tibetan language, predominantly uses lexical causative verbs such as *shi* 使 'cause' and *rang* 讓 'let', while Dutch, an Indo-European language, relies more on analytic causatives, employing the verbs *doen* 'make' and *laten* 'let'. These languages offer a contrast to Paiwan, which utilizes **morphological causatives**. By comparing languages from different families and typological

systems, this study aims to highlight both universal and language-specific patterns of causative construction.

Figure 5, 6, and 7 illustrate the relationship between the transitivity of verbs and the selection of causative verbs/affixes in Paiwan, Chinese, and Dutch, respectively. The figures present how frequently each verb/affix is selected in both transitive and intransitive contexts.

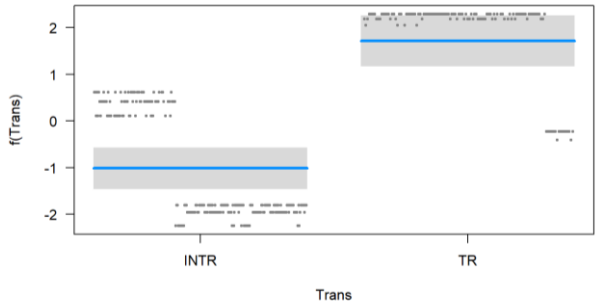

Figure 5. Relation between Transitivity and Selection of Affix in Paiwan

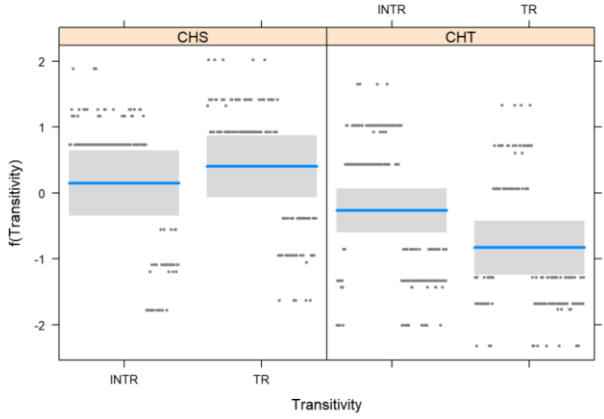

Figure 6. Relation between Transitivity and Selection of Verb in Chinese

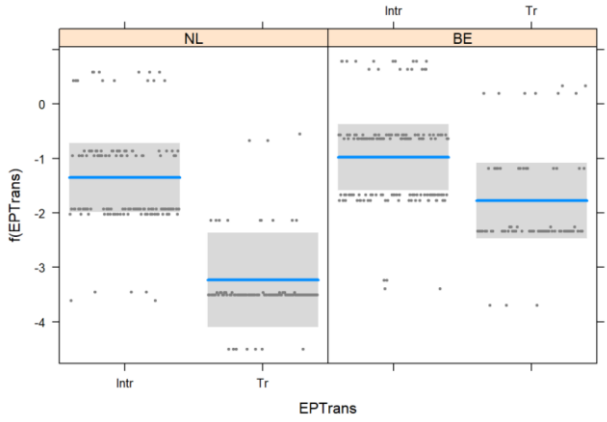

Figure 7. Relation between Transitivity and Selection of Verb in Dutch

In these figures, the x-axis represents the transitivity of the verb (transitive vs. intransitive), while the y-axis indicates the frequency of the two specified causative affix/verb in the dataset. In Figure 5, the specified affixes are *pa-Ø-* vs. *pa-pe-*. The higher the horizontal bar is, the more frequently the affix *pa-Ø-* will be used, and less likely the affix *pa-pe-* will be used. And vice versa, the lower the horizontal bar is, the more frequently the affix *pa-pe-* will be used, and less likely the affix *pa-Ø-* will be used. In Figure 6, the higher the bar is, the more frequently the verb *shi* will be used, and less likely the verb *rang* will be used, and vice versa. In Figure 7, the higher the bar is, the more frequently the verb *doen* will be used, and less likely the verb *laten* will be used, and vice versa.

At the outset, it becomes evident that the behavior of the three languages diverges significantly with regard to the transitivity of the matrix verb. In Paiwan, an absence of pronounced preference for either direct or indirect causation is observed. However, transitivity plays a pivotal role in determining the choice of affix. Specifically, Figure 5 shows that Paiwan speakers tend to favor *pa-pe-* when the effected predicate is intransitive, as indicated by the bar on the left, while opting for *pa-Ø-* when the effected predicate is transitive, as indicated by the bar on the right.

In Chinese, the Taiwan Mandarin variety, represented as CHT, exhibits a tendency to favor *rang*, indicative of indirect causation, while the Mainland Mandarin variety, indicated by CHS, inclines towards the use of

shi, representing direct causation. However, Shih et al. unearth an intriguing contrast in terms of transitivity (173). Taiwan Mandarin speakers are more likely to use *rang* when the matrix verb is transitive, whereas Mainland Mandarin speakers are more predisposed to selecting *shi* in such scenarios.

In Dutch, the indirect variant *laten* is more commonly employed than the direct variant *doen* in both dialects. This phenomenon has led many scholars to designate *laten* as the default form of causative constructions in Dutch (cf. Speelman & Geeraerts, Lenshina et al., Geeraerts). Furthermore, both dialects share a transitivity pattern, where the probability of opting for *laten* is notably higher when the main verb is transitive.

The second distinction among these three languages pertains to causation types. The interplay between the Causation Types variable and the selection of causative verbs/affixes in Paiwan, Chinese, and Dutch is visually represented in Figure 8, 9, and 10, respectively.

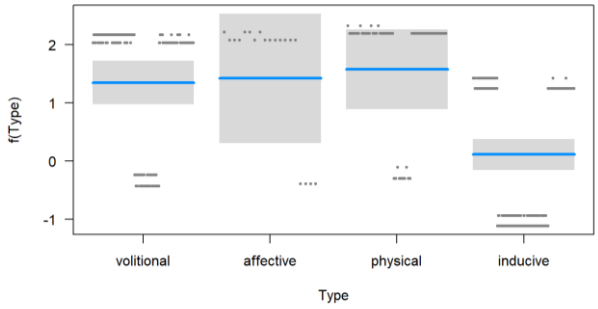

Figure 8. Relation between Causation Type and Selection of Affix in Paiwan

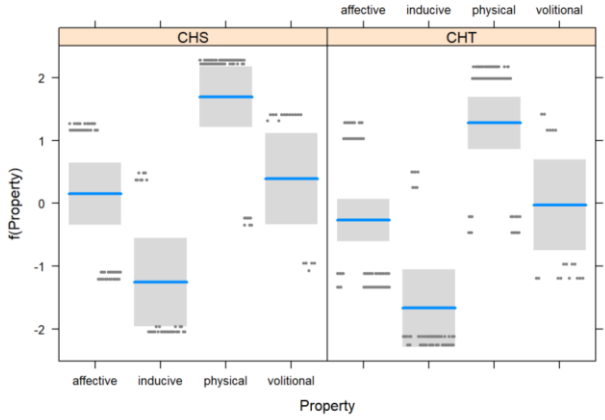

Figure 9. Relation between Causation Type and Selection of Verb in Chinese

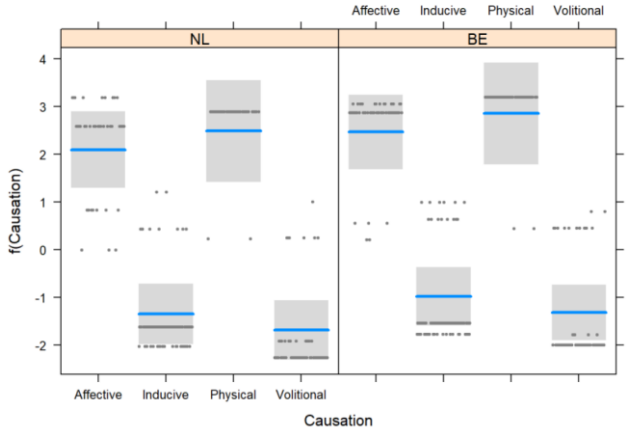

Figure 10. Relation between Causation Type and Selection of Verb in Dutch

In Figure 8, the specified affixes are *pa-Ø-* vs. *pa-ka-*. The higher the bar is, the more frequently the affix *pa-Ø-* will be used, and less likely the affix *pa-ka-* will be used, and vice versa. In Figure 9, the higher the bar is, the more frequently the verb *shi* will be used, and less likely the verb *rang* will be used, and vice versa. In Figure 10, the higher the bar is, the more

frequently the verb *doen* will be used, and less likely the verb *laten* will be used, and vice versa.

We can see from Figure 8 that Paiwan significantly diverges from the other two languages. In Paiwan, inducive causation is inclined towards the use of *pa-ka-*, indicating indirect causation, as indicated by the right-most bar in the figure, while the other three causation types exhibit a stronger tendency towards the remaining two causative affixes. However, the differences among these three causation types are subtle.

For Chinese, physical causation aligns with *shi*, while inducive causation leans towards *rang*. However, neither affective nor volitional causation displays a distinct preference. Furthermore, no significant divergence is observed between the two Chinese dialects in this context.

In Dutch, affective and physical causation demonstrate a propensity for *doen*, while inducive and volitional causation exhibit a preference for *laten*. No conspicuous dialectal distinction is discernible within this context.

5. Limitations and Future Directions

While this study offers valuable insights into the causative constructions in Paiwan, several limitations warrant acknowledgment. These limitations do not detract from the core findings but highlight areas for future refinement and exploration.

A significant limitation of this study lies in the challenges associated with verb classes and transitivity types. Paiwan verbs exhibit complex valency patterns that influence how causative affixes are employed. For instance, the interaction between verb subcategorization and semantic roles of causer and causee complicates the direct/indirect causation framework proposed here. While adopting a functional (semantic) approach to transitivity provides a practical means of capturing general trends, this choice may oversimplify nuanced distinctions inherent to Paiwan's verbal morphology. These complexities may also affect how well the direct/indirect dichotomy applies across verb classes, especially given the gradient nature of transitivity in causative constructions. Future research could benefit from a more detailed examination of verb subcategorization, potentially incorporating a syntactic perspective to complement the semantic approach utilized here.

Another limitation stems from the inability to restrict the dataset to a single, well-defined Paiwan dialect. This study combines data from various sources representing multiple dialects, each exhibiting subtle morphological and syntactic differences. While this approach ensures a broad representation of causative constructions, it introduces variability that may obscure dialect-specific patterns in affix usage. For example, differences in voice marking and pronominal systems across dialects could influence the frequency or contextual applicability of causative affixes. Although the study assumes a degree of consistency in the semantic interpretation of causative markers, future research focusing on individual dialects could uncover more localized patterns and refine our understanding of how causative constructions operate within specific linguistic contexts.

Addressing these limitations presents several avenues for future work. Incorporating a more granular analysis of verb classes and subcategorization could provide deeper insights into how verb-specific properties influence affix selection. Additionally, building corpora for individual Paiwan dialects, while resource-intensive, would enable the identification of dialect-specific trends and enrich the typological analysis of causative constructions. By addressing these areas, future studies can build on the foundation laid by this research, advancing our knowledge of Paiwan causative constructions and their place in linguistic typology.

6. Conclusion

In summary, this study contributes to our understanding of Paiwan causative constructions by providing a quantitative analysis of direct and indirect causation, as well as the distribution of causative markers across different verb classes. While these contrasts have been previously described in the literature, this study offers new empirical evidence and a statistical perspective that enrich our comprehension of how these constructions operate in Paiwan.

Through a comprehensive analysis using logistic regression, focusing on the three Paiwan causative affixes *pa-Ø-*, *pa-ka-*, and *pa-pe-*, this research provides further insights into the usage patterns of these affixes, offering additional evidence to support the existing body of work on Paiwan causatives. The findings support the theory of direct/indirect

causation, providing a robust framework for comprehending the distinct features and lexical implications associated with these affixes.

To elaborate, we propose that the affix *pa-Ø-* is closely linked with the concept of "direct causation." It is predominantly used when the causative event involves inanimate participants, where the cause directly leads to the resulting state of the causee. In contrast, the affix *pa-ka-* is better categorized as representing "indirect causation," as it is frequently applied in contexts involving animate participants, often with an additional force contributing to the causal event. Notably, the affix *pa-pe-* occupies an intermediary position, showing a preference for intransitive effected predicates.

The significance of unraveling the intricate dynamics between causers and causees within causative constructions goes beyond linguistic analysis. It has implications for natural language processing tasks and corpus linguistics studies, where such understanding plays a pivotal role. By shedding light on the distinct usages of these causative affixes, this research, along with its accompanying annotated dataset, has the potential to enhance performance in a range of related tasks.

In conclusion, the study shows that the selection of causative affixes in Paiwan is influenced by contextual factors, such as verb transitivity and the type of causation (direct or indirect). While broader cognitive or pragmatic influences may also play a role, these aspects were not directly examined in the current analysis and would require further research to confirm. Additionally, the cross-linguistic comparison with Dutch and Mandarin highlights typological differences and provides a basis for further exploration of causative constructions in other languages. This study builds on existing research, offering a more comprehensive perspective on the usage patterns of causative affixes in Paiwan, while leaving room for future investigations.

Abbreviations

AV Agent Voice
BV Beneficiary Voice
CAUS Causative
CONJ Conjunction
COS Change of State
GEN Genitive
IMP Imperative
INCL Inclusive
IRR Irrealis
IV Instrumental Voice
LNK Linker
LV Locative Voice
NEG Negation
NOM Nominative
OBL Oblique
PFV Perfective
PL Plural
PV Patient Voice
RED Reduplication
RV Referential Voice
S Singular

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