

The phenomenon that refers to the concept of “silent letter” has appeared in a number of operational technical terms and is defined very differently in several writing systems around the world. For example, in Abugidas writing systems based on Akshara’s or also called Alphasyllabaries (cf. Bright, 1996; Daniels, 1996), terms such as the following appear: the term “*halanta*” (Hindi) with basic shape |◌| refers to a subscript diacritic that does not have a mapping with a specific linguistic unit, indicating “the absence of an inherent vowel” (Pandey, 2014); the term “*tsec*” or also called “hanging dot” with basic shape |...| (Tibetan) refers to a diacritic subscript that does not have a mapping with a specific linguistic unit. It functions to remove the inherent vowel attached to a consonant or C without a vowel (Fedorova, 2013); the term “*pangkon*” with basic shape |... ʳ| (Javanese) refers to a diacritic subscript that does not have a mapping with a specific linguistic unit. It functions to present a dead consonant or a closing in a syllable or *panyigeging wanda* (Darusuprta et al., 2002); the term “*pat é*” or “*pama é*” with basic shape |... ʒ| (Sundanese) refers to a diacritic subscript that does not have a mapping with a specific linguistic unit. It functions to remove the inherent vowel /a/ attached to the main consonant or *ngalangena* so that it becomes dead (Baidilah, 2008).

The Balinese script writing system, which is a derivative of the Abugida writing system, also has a term that refers to the concept of silent letters. This term is known as ‘*adeg adeg*’ with basic shape |◌| (Unicode character: U+1B44). *Adeg adeg* (◌) is a diacritical sign or character *pangangge* (cf. the term “garment” by Fedorova, 2013) that is grouped into *pangangge tengenan* (Medera et al., 2003; Simpen AB, 1979; Tinggen, 1994). According to three Balinese script experts, the *adeg adeg* function serves to “kill” (eliminate) the vowels in Akshara’s, resulting in consonants without inherent vowels, known as *nengen*. However, this explanation is metaphorical, ambiguous, and does not use adequate terms to describe the systematic mappings between graphic unit sequence and linguistic unit sequence. Based on these reasons, it is very important to conduct research that can explain and describe the characteristics of silent letters *adeg adeg* |◌| in the Balinese script writing system, especially studies that are based on adequate terms to describe systematic mappings between graphic unit sequence and linguistic unit sequence that are universal across writing systems.

The analysis of graphetic and graphematic features (as a main module of the Modular Theory of Writing Systems) is a methodological framework that can identify the systematic characteristics and mappings of basic shapes as graphemes, which are the basic units of writing systems related to the presentation of visual units and their connection with linguistic units (Meletis, 2018; Neef, 2012, 2015). Clarity of systematic characteristics and mapping significantly contributes to a more comprehensive and transparent cognitive-linguistic mechanism depiction, especially in deciphering writing systems based on Akshara’s that have highly complex characteristics, such as non-linear symbol arrangements (Sproat, 2000; Vaid & Gupta, 2002; Winskel & Perea, 2014), unmarked and inherent symbol features (Bhide et al., 2014; Nag, 2007), and visually complex symbol sets (Joyce & Meletis, 2021; Nag, 2014).

II. STRUCTURE OF WRITING SYSTEMS

A. Modular Theory of Writing Systems

In the field of grapholinguistics, it is imperative to establish a model that comprehensively outlines the structure and functioning of writing systems. A profound understanding of the organizational principles of writing systems is essential for effectively formulating and exploring grapholinguistic inquiries. However, this perspective has not always been universally embraced, and a significant portion of writing systems research often neglects to elucidate the underlying model or theory on which it is predicated. This oversight could be attributed to the absence of a foundational model or theory in much of the research (Neef, 2012, 2015). Modular Theory of Writing Systems serves as the foundational framework for this model, aiming to delineate the subsystems, or modules, that constitute writing systems. Figure 1 illustrates a modified version of this model from Meletis (2018, p. 61), featuring language systems, graphetics, and graphematics as obligatory modules, with orthography as an optional module within writing systems.

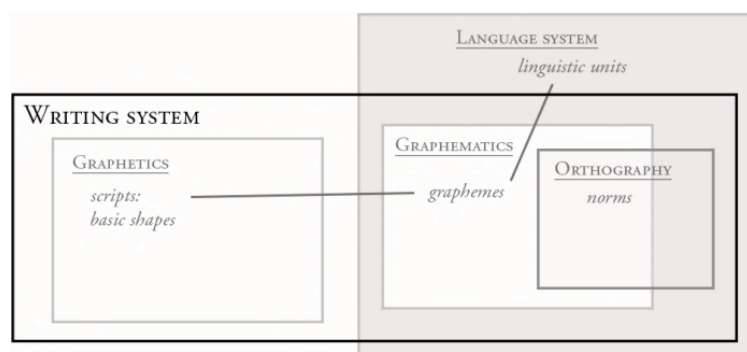


Figure 1. Multimodular Model of Writing Systems Adaptation

(a). Language System

The initial component of a writing system is the language system, which serves as the basis for its operation as a sign system based on language (Neef, 2012, 2015). Modular Theory divides each language system into two parts: grammar and lexicon. Grammar encompasses the regular aspects of a language, including phonology, morphology, semantics, and syntax. In contrast, the lexicon encompasses all the irregular properties of the same language and defines morphemes as the arbitrary associations of forms and meanings.

(b). *Graphetic*

Before delving into more abstract script ideas, it is essential to ascertain the status of concrete molds on paper that can be visually observed. In the study of grapholinguistics, graphetics refers to the forms or materialization of primary forms (and their names) in a writing system related to specific linguistic units (Neef, 2012). The central unit in this module in abstract form is called basic shape, and its concrete realization is called a graph. Basic shapes are material but sometimes abstract, representing the set of visual features needed to visually distinguish shapes from other figures in the visual form repertoire in a writing system (Meletis, 2019a). Basic shapes are defined as abstract units, groups with distinguishing geometric features from written signs, so that literate individuals will recognize them as embodiments of writing. Bredel in Meletis (2018, p. 114) proposed four features to distinguish the different graphetic segment materials used in the German writing system. These features are (1) context-free identification, (2) recodability, (3) combinability, (4) paired variants, and (5) additive (see Table 1). Feature 1 is graphetic, with determination based on visual properties. Feature 2 is graphematic, which includes linguistic units related to basic shapes. Feature 3 and 4 are graphotactic, depending on the graphematic perspective.

TABLE 1
CLASSES OF BASIC SHAPES FEATURES

	diacritics	letters	digits	special characters	punctuation marks	empty spaces
identifiable without context	+	+	+	+	+	–
recodable	–	+	+	+	–	–
combinable	–	+	+	–	–	–
paired	–	+	–	–	–	–
additive	+	–	–	–	–	–

(c). *Graphematic*

A written representation of each word in a language, called a graphematic module, is facilitated by the language system (Neef, 2012, 2015). This module delineates all conventional associations between characters or character combinations and phonological segments that are permitted in the system. The minimal unit that represents the unity of shape or fundamental entity in the graphematic module is called a grapheme. Meletis (2019b, p. 17) suggests three criteria for defining graphemes that are applicable across all writing systems: lexical distinctiveness (condition 1), linguistic value (condition 2), and minimality (condition 3), as shown in Table 2.

TABLE 2
CONDITIONS FOR THE GRAPHEME DEFINITION; GRAPHEMES ARE HIGHLIGHTED IN GREY

	Condition (1)	Condition (2)	Condition (3)
German <ng>	+	+	–
		phoneme /ŋ/	both <n> and <g> are already graphemes
German <ch>	+	+	+
		Phoneme /ç/	
German <sch>	+	+	–
			both <s> and <ch> are already graphemes
German <cl>	+		+
German <ll> (hasta) in <p> vs 	+	–	+
Chinese <河> ‘river’	+	+	+
		Morpheme {river}	
Chinese [𣶒]	+	–	+
		Semantic component ‘water’, which itself represents no linguistic unit	
Thai <๓>	+	+	+
		Phoneme /d/	
Thai <๓>	+	+	+
		Phoneme /i/	

(d). Orthography

In reality, different spellings are used by convention to distinguish between homophones. Modular Theory explains this phenomenon through the orthography module called *systematic orthography*, which prescribes how to spell individual words correctly within the confines of the graphematic solution space. These constraints are systematic in the sense that they apply to a particular layer of the vocabulary. Systematic orthography does not always provide a single fixed spelling of a given word. For instance, the constraint on the well-formed spelling of [a] in German still leaves <a> <Wal> ‘whale’ and <ah> <Wahl> ‘choice’ as two possible representations of the segment. Instead of using these forms interchangeably, the German writing system has standardized conventions stipulating which form should be used on a word-to-word basis (e.g., <a> for [val] ‘whale’ but not for [val] ‘choice’). Modular Theory distinguishes such conventions from systematic orthography and refers to them as *conventional orthography* (Neef, 2012, 2015).

B. Balinese Script Orthography

Table 3 shows the primary consonant phonemes with inherent vowel /Ca/ (called *Aksara lagna*), which are represented by *Aksara wianjana* (*wresastra* and *sualalita*) (Medera et al., 2003). The Aksharas for independent vowels are represented by the basic shape || *akara* for /a/, || *ikara* for /i/, || *ukara* for /u/, || *ekara* for /e/, and || *okara* for /o/. There is no independent basic shape for the vowel /ə/ (Table 4 left). Table 4 right shows that the Balinese script for dependent vowels is represented by the basic shape || /ha/ or called *wisarga* with diacritic or *pangangge suara*. Dependent vowels in Balinese script appear in a combination of visual units || for /a/ from *wisarga* || /ha/ without diacritic (where the glottal stop phoneme /h/ is not pronounced or not verbalized); || /i/ from *wisarga* || + || (dependent vowel sign *ulu* /-i/); || /u/ from *wisarga* || + || (dependent vowel sign *suku* /-u/); || /e/ from || *wisarga* /ha/ + || dependent vowel sign *taling* /-e/; || /ə/ from *wisarga* /ha/ || + || dependent vowel sign *pepet* /-ə/; and || /o/ from *wisarga* /ha/ || + || (dependent vowel sign *taling tedung* /-o/) (Paramarta et al., 2023).

TABLE 3
AKSARA WIANJANA (WRESASTRA AND SUALALITA)

Aksara Wianjana (consonant with inherent vowel /Ca/)																	
Poem	First Line				Second Line				Third Line				Fourth Line				
Aksara Wresastra	𑀓𑀸	𑀓𑀺	𑀓𑀻	𑀓𑀼	𑀓𑀽	𑀓𑀾	𑀓𑀿	𑀓𑀻	𑀓𑀼	𑀓𑀽	𑀓𑀾	𑀓𑀿	𑀓𑀻	𑀓𑀼	𑀓𑀽	𑀓𑀾	𑀓𑀿
Aksara Sualalita		𑀓𑀻	𑀓𑀼		𑀓𑀽	𑀓𑀾	𑀓𑀿	𑀓𑀻				𑀓𑀽	𑀓𑀾		𑀓𑀻	𑀓𑀼	
IPA	[ha]	[na]	[tʃa]	[ra]	[ka]	[da]	[ta]	[sa]	[wa]	[la]	[ma]	[ga]	[ba]	[ŋa]	[pa]	[dʒa]	[ya]
Phonemic	/ha/	/na/	/ca/	/ra/	/ka/	/da/	/ta/	/sa/	/wa/	/la/	/ma/	/ga/	/ba/	/ŋa/	/pa/	/ja/	/na/
Latin Transcription	ha	na	ca	ra	ka	da	ta	sa	wa	la	Ma	ga	ba	nga	pa	ja	ya

TABLE 4
INDEPENDENT AND DEPENDENT VOWELS

Independent vowel	Dependent vowel ( + Pangangge suara)	Phoneme	Latin Transcription
	 → 	/a/	a
	 +  → 	/i/	i
	 +  → 	/u/	u
	 +  → 	/e/	e
	 +  → 	/ə/	e
	 +  → 	/Ø/	o

Inherent vowel /-a/, which is attached to the *aksara lagna*, will disappear if it has received a diacritic or conjunct & ligature (*Pangangge aksara*) (cf. Fedorova, 2013). *Pangangge aksara* in the Balinese script writing system includes: *Pangangge suara* (Table 4), *Pangangge tengenan* (Table 5), and *Gantungan* and *Gempelan* (Table 6).

TABLE 5
PANGANGGE TENGENAN

Balinese script	Phoneme	IPA	Latin Transcription	Name
	/h/	[h]	h	bisah
	/r/	[r]	r	surang
	/ŋ/	[ŋ]	ng	cecek
	/Ø/	[Ø]		adeg adeg

TABLE 6
GANTUNGAN AND GEMPELAN

Gantungan and Gempelan Aksara Wianjana										
Poem	First Line						Second Line			
Aksara	ᮊ	ᮃ	ᮄ	ᮅ	ᮆ	ᮇ	ᮈ	ᮉ	ᮊ	ᮃ
Wresastra	ᮊ	ᮃ	ᮄ	ᮅ	ᮆ	ᮇ	ᮈ	ᮉ	ᮊ	ᮃ
Aksara Sualalita	ᮊ	ᮃ	ᮄ	ᮅ	ᮆ	ᮇ	ᮈ	ᮉ	ᮊ	ᮃ
IPA	[ha]	[na]	[tʰa]	[ra]	[ka]	[da]	[ta]	[sa]	[wa]	[la]
Phonemic	/ha/	/na/	/ca/	/ra/	/ka/	/da/	/ta/	/sa/	/wa/	/la/
Latin	ha	Na	ca	ra	ka	Da	ta	sa	wa	La
Transcription										

Gantungan and Gempelan Aksara Wianjana									
Poem	Third Line					Fourth Line			
Aksara	ᮊ	ᮃ	ᮄ	ᮅ	ᮆ	ᮇ	ᮈ	ᮉ	ᮊ
Wresastra	ᮊ	ᮃ	ᮄ	ᮅ	ᮆ	ᮇ	ᮈ	ᮉ	ᮊ
Aksara Sualalita	ᮊ	ᮃ	ᮄ	ᮅ	ᮆ	ᮇ	ᮈ	ᮉ	ᮊ
IPA	[ma]	[ga]	[ba]	[ŋa]	[pa]	[dʒa]	[ya]	[na]	
Phonemic	/ma/	/ga/	/ba/	/ŋa/	/pa/	/ja/	/ya/	/na/	
Latin	ma	ga	ba	nga	pa	ja	ya	Nya	
Transcription									

The basic shape sign | ʌ | *adeg adeg* is a diacritic sign or *pangangge aksara* that belongs to the *pangangge tengenan* group (Table 5). Tinggen (1994) reports that *adeg adeg* is only used in the last syllable of a sentence and to avoid stacking letters in threes. Currently, the use of *adeg adeg* is undergoing developments and improvements in the Balinese script writing system, becoming: 1) at the end of the word, 2) at the end of the sentence section or the end of the sentence, 3) the middle position of the word to avoid the arrangement of three-stack Akshara, and 4) mid-sentence position for affirmation of linguistic units, to maintain writing rules, and avoid misreading (Medera et al., 2003; Suasta, 2006).

Table 7, No. 1 shows the use of *adeg adeg* in the final position of the word *adan* 'name' which is presented after grapheme <ᮊ> /na/. Table 7, No. 2 demonstrates the use of *adeg adeg* in the middle of the word *Tamblingan* 'place name' after <ᮊ> /ma/ to avoid using triple-stack akshara's. Table 7 no.3 demonstrates the use of *adeg adeg* at the end of the word *lamaran* 'application' in the middle of the sentence and at the end of the sentence *pelengan* 'side of forehead' presented after <ᮊ> /na/. Table 7, Nos. 4-5 displays the use of *adeg adeg* in the middle of the sentence at the position of the end of the word to emphasize the language units that occur after <ᮊ> /na/ and <ᮊ> /ka/.

TABLE 7
EXAMPLE OF THE USE OF ADEG-ADEG

EXAMPLE OF THE USE OF ADEG-ADEG					
No	Balinese script Latin transcription	Context of use			Translate
		The final position of the word/ sentence	Mid-word/ sentence		
			triple-stack avoidance function	affirmation function of language units	
1	ᮊᮃᮄᮅ adan	√			‘name’
2	ᮊᮃᮄᮅᮆᮇᮈᮉ Tamblingan	√	√		‘place name Tamblingan’
3	ᮊᮃᮄᮅᮆᮇᮈᮉᮊᮃᮄᮅᮆᮇᮈᮉ Dugase nulis lamaran, I Nyoman mecik pelengan.	√			‘When writing a proposal, I Nyoman held the side of his forehead’
4	ᮊᮃᮄᮅᮆᮇᮈᮉᮊᮃᮄᮅᮆᮇᮈᮉ I Nyoman Widya.			√	‘proper name I Nyoman Widya’
5	ᮊᮃᮄᮅᮆᮇᮈᮉᮊᮃᮄᮅᮆᮇᮈᮉ Watek ksatriane ngamuk.			√	‘knights rampage’

III. RESEARCH METHOD

This research method employs a qualitative and descriptive approach to describe the characteristics of graphetic and graphematic features of silent letters, denoted as ꦱꦺꦴꦁ *adeg adeg*, in the Balinese script. The primary data is silent letters ꦱꦺꦴꦁ *adeg adeg*, which comes from the 16.162 lemma in the Balinese dictionary - Indonesian with Latin and Balinese script (Nala Antara et al., 2016). Secondary data related to various contexts of silent letter ꦱꦺꦴꦁ *adeg adeg* usage in Balinese script orthography is sourced from Guidelines for Writing Balinese Script (Medera et al., 2003). The silent letter in the Balinese script ꦱꦺꦴꦁ *adeg adeg* that has been registered is then analyzed graphetically and graphematically to find its characteristics. The mapping of Balinese script sequences on lemmas to phonetic and phonemic sequences is conducted by adopting the principles of the Akshara writing system from Nag (2014). The data analysis stages in this research are illustrated in Figure 2 by adapting the Multimodular Model of Writing System from Meletis (2018, p. 61).

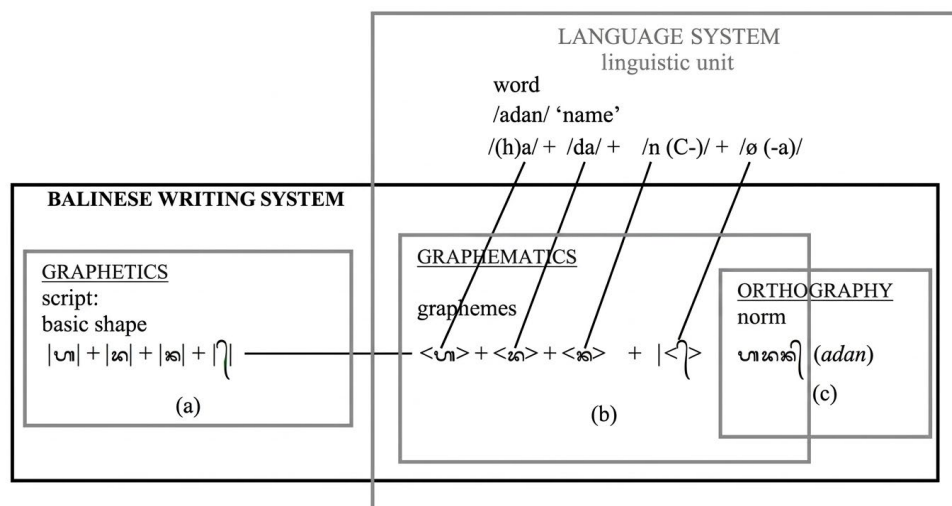


Figure 2. Multimodular Model of Writing Systems Adaptation

Silent letters, denoted as ꦱꦺꦴꦁ *adeg adeg*, in the Balinese script, are graphically analyzed as a graphetic unit (referred to as the basic shape) using a combination of graphetic features, graphematic features, and graphotactic features. This analysis is an adaptation of the model proposed by Bredel in Meletis (2018). These features include: (1) context-free identification, (2) recodability, (3) combinability, (4) paired variants, and (5) additive. The visual unit of silent letters ꦱꦺꦴꦁ *adeg adeg* as a grapheme is analyzed using the grapheme definition based on three criteria proposed by Meletis (2019b), which are: (1) lexical distinctiveness, (2) linguistic value, and (3) minimality. Although orthography is optional in the study of grapholinguistics (modular theory), it is still presented in this study to show the context of the rules for using *adeg adeg* in the Balinese script writing system.

IV. RESULTS AND DISCUSSIONS

The research results show that out of 16,162 lemmas in the Balinese script dictionary, as many as 7,905 lemmas use silent letters, denoted as ꦱꦺꦴꦁ *adeg adeg*. The graphetic and graphematic analysis of the various contexts of the use of *adeg adeg* in the lemma is demonstrated in Table 8. Graphically, ꦱꦺꦴꦁ *adeg adeg* is defined as a basic shape with several graphic features, namely: +context-free identification, -recodability, +combinability, -paired variants, and +additive. Meanwhile, graphematically the visual unit of *adeg adeg* is defined as a grapheme with the following criteria: + lexical distinctiveness, +linguistic value, and +minimality.

TABLE 8
GRAPHETIC AND GRAPHEMATIC ANALYSIS OF THE VISUAL UNIT *ADEG-ADEG*

Unit Visual	Unicode / Name	Graphetics Features					Graphematics Criteria		
		context-free identification	recodability	combinability	paired variants	additive	lexical distinctiveness	linguistic value	minimality
ꦱꦺꦴꦁ	1B44 adeg adeg	+	-	+	-	+	+	+/ø/	+

A. Graphetics Representation of Silent Letters ꦱꦺꦴꦁ *Adeg Adeg*

It is not possible to group basic shapes separately. However, specific characteristics can identify a basic shape within the writing system. The basic shape *adeg adeg* graphetically possesses a unique feature, -recodability, which is not recorded verbally. This means it is “not verbalized” or “not read” (see Figure 3).

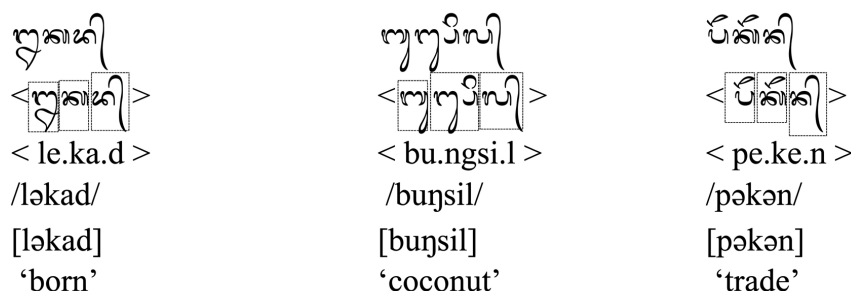


Figure 3. Illustration of Mappings of Balinese Script to Phonetic Sequence (Pronunciation)

Figure 3 shows an illustration of verbal representation from several basic shapes in Balinese script, adopting from Nag (2014, p. 112) to write the word: *lekad* ('born'), *bungsil* ('coconut'), and *peken* ('market'). The word *lekad* [ləkad], meaning 'born', is divided into three symbol blocks. The first symbol block is a basic shape (la lenga), which is pronounced [lə]. The second symbol block consists of a basic shape (ka), pronounced [ka]. The third symbol block consists of a basic shape (da), which, when added with shape (adeg adeg), can be pronounced [d] without the inherent vowel /-a/.

The word *bungsil* [buŋsil], meaning 'coconut', is divided into three symbol blocks. The first symbol block consists of a basic shape (ba), which is pronounced [b] because it is combined with a diacritic for the dependent vowel (suku), to be pronounced [u]. The second symbol block consists of a basic shape (nga), which is pronounced [ŋ] due to the addition of a conjunct & ligature (gempelan sa), which is pronounced [s] because of the addition of a diacritic for the dependent vowel (ulu), pronounced [i]. The third symbol block consists of basic shape (la), which, when combined with (adeg adeg), read [l] without the inherent vowel /-a/.

Likewise, the word *peken* [pəkən], meaning 'market', is divided into three symbol blocks. The first symbol block is composed of a basic shape (pa), pronounced [p] because it is combined with a basic shape for the dependent vowel (pepet), to be pronounced [ə]. The second symbol block consists of a basic shape (ka), which is pronounced [k] because it get is combined with a basic shape for dependent vowel (pepet), to be read as [ə]. The third symbol block consists (na), which, when combined with (adeg adeg), is pronounced [n] without the inherent vowel /-a/.

The basic shape *adeg adeg*, although easy to identify visually, is not verbalized or readable because, in Balinese script grammar, *adeg adeg* is presented as a device that cancels the inherent vowel. For instance, in the akshara block dimension (Figure 3), it is read as [d], which is a representation of the basic shape [da] followed basic shape (adeg adeg), so the inherent vowel [-a] is not verbalized ([Ø]). In this context, it is clear that the basic shape of *adeg adeg* cannot be verbalized, read, or pronounced.

When compared to the Latin alphabet writing system, punctuation also has the same graphetic features as *adeg adeg*. Punctuation marks (commas, periods, and exclamation points) do not have a specific linguistic unit representation, so they are not verbalized or readable (Cf. Meletis, 2019b). This graphetic feature differs from other basic shapes with verbalized or readable representations of linguistic units. For instance, the basic shape [ka], basic shape [p] when combined with the basic shape for diacritic or conjunct & ligature, is read as [p], like diacritic for independent vowel [ə] /ə/, which is read as read [ə].

Other special features of (adeg adeg) include the (+additive) characteristic. In the Balinese script writing system, *adeg adeg* can be added to several basic shapes for main consonants grapheme (*aksara lagna*) (refer to Table 9). Adding *adeg adeg* to most of the main consonant grapheme cancels the inherent vowel /-a/. Reports from Medera et al. (2003) also corroborate this (+additive) feature, explaining that one way to cancel the inherent vowel /-a/ in *aksara lagna* is to add basic shape (adeg adeg).

TABLE 9
ADDING (ADEG ADEG) TO MOST OF THE MAIN CONSONANTS GRAPHEMES

Aksara lagna (phoneme representation)	Aksara lagna added adeg adeg (phoneme representation)	Word (Balinese script)	Phoneme transliteration meaning
na /na/	n /n/	jan	/jan/ 'ladder'
ka /ka/	k /k/	barak	/barak/ 'red'
da /da/	d /d/	ilid	/ilid/ 'hidden'
ta /ta/	t /t/	abut	/abut/ 'unplug'
sa /sa/	s /s/	alas	/alas/ 'forest'
la /la/	l /l/	sinjal	/sinjal/ 'cradle'
ma /ma/	m /m/	guləm	/guləm/ 'overcast'
ga /ga/	g /g/	sərag	/sərag/ 'key'
ba /ba/	b /b/	unjab	/unjab/ 'open'
pa /pa/	p /p/	alap	/alap/ 'pick'

In grapholinguistic, the representation of the linguistic value of graphemes refers to the referential view. Referentialists view graphemes as being “present for” specific linguistic units. Graphemes represent linguistic units not only at the phonological level but also for syllables and morphemes, even words. This feature implies that the basic shape represents at least one linguistic unit (see Table 11). In essence, graphemes have linguistic value in all the contexts in which they occur. This feature assumes that every linguistic unit in a language, either at the phonological or morphological level, is represented by a basic shape, and does not apply vice versa. Meletis (2019b) provides an analytical direction that is suitable for these criteria, as illustrated by the relationship “basic shape → linguistic unit”.

TABLE 11
LINGUISTIC UNIT REPRESENTATION FROM | ʌ | ADEG ADEG

Balinese script Phoneme Transliteration Translete	Basic shape arrangement	Linguistic unit representation
ᮊᮥᮒᮦ /buk/ ‘dust’	ᮊᮥᮒᮦ	/b/
	ᮊᮥᮒᮦ	/u/
	ᮊᮥᮒᮦ	/k/
	ᮊᮥᮒᮦ	/Ø/ (abstraction of the /-a/)
ᮊᮥᮒᮦᮒᮦ /abut/ ‘unplug’	ᮊᮥᮒᮦᮒᮦ	/a/
	ᮊᮥᮒᮦᮒᮦ	/b/
	ᮊᮥᮒᮦᮒᮦ	/u/
	ᮊᮥᮒᮦᮒᮦ	/t/
	ᮊᮥᮒᮦᮒᮦ	/Ø/ (abstraction of the /-a/)
ᮊᮥᮒᮦᮒᮦ /alap/ ‘pick’	ᮊᮥᮒᮦᮒᮦ	/a/
	ᮊᮥᮒᮦᮒᮦ	/la/
	ᮊᮥᮒᮦᮒᮦ	/p/
	ᮊᮥᮒᮦᮒᮦ	/Ø/ (abstraction of the /-a/)
ᮊᮥᮒᮦᮒᮦᮒᮦ /tamblīan/ ‘place name’	ᮊᮥᮒᮦᮒᮦᮒᮦ	/ta/
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/m/
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/Ø/ (abstraction of the /-a/)
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/b/
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/l/
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/i/
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/ŋa/
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/n/
	ᮊᮥᮒᮦᮒᮦᮒᮦ	/Ø/ (abstraction of the /-a/)

Table 11 shows the context of using basic shapes | ʌ | adeg adeg in the final position in ᮊᮥᮒᮦ /buk/ ‘dust’, ᮊᮥᮒᮦᮒᮦ /abut/ ‘unplug’, ᮊᮥᮒᮦᮒᮦ /alap/ ‘pick’, ᮊᮥᮒᮦᮒᮦᮒᮦ /tamblīan/ ‘place name’ and in the middle of the word ᮊᮥᮒᮦ /tam/ in the word ᮊᮥᮒᮦᮒᮦᮒᮦ /tamblīan/. The combination of basic shapes representing specific linguistic units has composes all the Balinese words above. Specifically, for | ʌ | adeg adeg, it does not appear to present a particular linguistic unit, but there is a linguistic unit that is not displayed (/Ø/ or zero or null phoneme), namely the inherent vowel phoneme /-a/.

To reveal orthographic transparency, the term zero or null phoneme is introduced in the context of strictly sequential grapheme-to-phoneme alignment (Protopapas & Vlahou, 2009; SIL, 2022). For students learning to read, write, and understand orthography, the presence of a “silent letter,” which represents a null phoneme, often poses a challenge. The term “silent letter” relates to graphic symbols that are not pronounced or do not have a mapping with a specific linguistic unit (Koda, 2007; Pike, 1956).

Is zero (/Ø/) a linguistic unit? The concept of zero or null in language studies refers to a segment of language (sound, writing, morpheme, word, clause, even sentence) that is not spoken or written. This concept is crucial in linguistic analysis to indicate symptoms of element deficiency, where the element is considered to exist. There are two meanings for this concept. First, zero is a constituent proposed in the analysis to represent elements considered to exist at the abstract level but not realized in the data. Zero is a unit proposed as a contrast to an element that may or is considered to exist (SIL, 2021). If associated with the concept of zero, silent letters, denoted as | ʌ | adeg adeg, can be interpreted as a visual form in Balinese script that is presented as a signifier for inherent vowels /-a/ which is not pronounced in the main consonant grapheme (C-). Adeg adeg is an abstraction of the inherent vowel /-a/ in the unspoken main consonant grapheme, contrasting with the main consonant grapheme with the inherent vowel (<C-> contrast <Ca>) (cf. grapheme notions from Fedorova, 2013).

Regarding the representation of linguistic units as one of the criteria for determining graphemes, it also presents a significant question. Are the linguistic values represented by singular graphemes in the form of concrete or abstract linguistic units, or do they even represent linguistic functions and information? Meletis (2019b) has not been able to

provide an answer to this question because the data from various world writing systems presented are not representative of that.

On the other hand, the characteristic of *adeg adeg* in the Balinese script writing system is very representative of this answer. Table 11 Nos. 1-4, shows that silent letters *adeg adeg* represents an abstract linguistic value, namely as an abstraction of the inherent vowel in the unspoken main consonant graphemes (/C-/) (Cf. Altmann, 1996).

If it is related to a wider alternative, it is clear that silent letters *adeg adeg* in the Balinese script writing system represent a linguistic function and linguistic information. This phenomenon shows that the function of linguistics and linguistic information in graphematic analysis is important to be discussed comprehensively in the study of grapholinguistics.

As one of the strategies for determining graphemes for cross-writing systems, the minimality criterion presents a fundamental question: What is minimal? For example, is it entirely based on linguistic units or semiotics? The basic assumption that needs to be addressed is the postulate that graphemes in some writing systems must be identified based on the writing side related to semiotics, not from the linguistic side (Fedorova, 2013; Meletis, 2015). As an implication, graphemes, in general, need to be determined graphetically, in other words, visually. The concept of minimalism strengthens the visually silent letters *adeg adeg* that meets the minimality criteria because it is the smallest visual unit in the Balinese script writing system. Graphetically, *adeg adeg* is different from other visual units in a Balinese script-based writing system. Data (a), (b), and (c) (in the sub-discussion of the lexical distinctiveness criteria) show that |ꦲꦒꦒ| /Ø/ *adeg adeg* is visually different from |ꦲꦒꦒꦱ| /i/ (*ulu*) and different from |ꦲꦒꦒꦱꦸ| /u/ (*suku*). *Adeg adeg* in the Balinese script writing system is a separate visual unit that is very easy to distinguish from other visual units.

V. CONCLUSION

Graphetic analysis reveals that silent letters |ꦲꦒꦒ| *adeg adeg* possesses several graphic features as a basic shape |ꦲꦒꦒ|. These include: +context-free identification, -recodability, +combinability, -paired variants, and +additive. Meanwhile, from a graphematic perspective, *adeg adeg* is defined as a grapheme <ꦲꦒꦒ> with the following criteria: +lexical distinctiveness, +linguistic value, and +minimality.

Three graphetic characteristics that stand out from silent letter |ꦲꦒꦒ| *adeg adeg* are -recodability, -paired variants, and +additive. First, visually, the basic shape of *adeg adeg* is easy to identify. However, it is not verbalized, unreadable, or un-pronunciation because it phonemically represents a null vowel (zero) or is presented as canceling the inherent vowel device. Secondly, *adeg adeg* does not have a paired variants feature because it does not have paired visual variations representing the same linguistic reference. Third, *adeg adeg* has a feature that can be added to several basic shapes for the main consonant grapheme (*aksara lagna*) except |ꦱꦏꦱ| /ca/, |ꦗꦏꦱ| /ja/, |ꦤꦏꦱ| /na/, |ꦮꦏꦱ| /wa/, |ꦪꦏꦱ| /ya/. *Adeg adeg* cannot be added to the basic shape at the end of the word because, in the Balinese phonological system, the phonemes /c/, /j/, /n/, /w/, and /y/ are never found distributed at the final position of the word.

The silent letters in the Balinese script |ꦲꦒꦒ| *adeg adeg*, are identified as a grapheme because they meet the three features of grapheme criteria that can be applied across writing systems, despite having some contradictory features. Firstly, based on the data presented and analyzed, it was revealed that *adeg adeg* presents and has the potential as a lexical distinguishing unit (this applies if the grapheme is structurally not aligned with the phoneme). In other words, the phoneme analogy is only used as a methodological model of how distinctive units can be found. The grapheme criterion, with the analogy of a minimal pair of phonemes that refers to a grapheme, is inadequately applied to *adeg adeg* because the paired phoneme does not exist (not presented). Secondly, silent letters |ꦲꦒꦒ| *adeg adeg* phonemically represent zero linguistic units for the null vowel /Ø/ because there is a linguistic unit that is not displayed, namely the inherent vowel phoneme /-a/. *Adeg adeg* is associated with several zero concepts in linguistic studies, referring to the visual form in Balinese script that is presented as a signifier for the inherent vowel /-a/ that is not pronounced in the main consonant grapheme (C-). *Adeg-adeg* is an abstraction of the inherent vowel /-a/ in the unspoken main consonant grapheme as a contrast for the main consonant grapheme with the inherent vowel (<C-> contrast <Ca>). Thirdly, several minimalism concepts emphasize that visually *adeg adeg* meets the minimum criteria because it is the smallest visual unit in the Balinese script writing system. Graphically, *adeg adeg* is a separate visual unit that is very easy to distinguish from other visual units.

The analysis of graphetic and graphematic features can identify the systematic characteristics and mappings of silent letters in the Balinese script, specifically |ꦲꦒꦒ| *adeg adeg*. *Adeg adeg* represents basic shapes and graphemes, which are the basic units of writing systems. These are related to the presentation of visual units and their connection with linguistic units. The clarity of systematic characteristics and mapping significantly contributes to a more comprehensive and transparent depiction of cognitive-linguistic mechanisms. This is especially important when deciphering writing systems based on Akshara, which have highly complex characteristics. These characteristics include non-linear symbol arrangements, unmarked and inherent symbol features, and visually complex symbol sets.

ACKNOWLEDGEMENTS

The authors would like to thank Ministry of Education, Culture, Research, and Technology, Universitas Pendidikan Ganesha, Bali, Indonesia (Grant No. 651/UN48.16/LT/2023).

REFERENCES

- [1] Altmann, G. (1996). The nature of linguistic units. *Journal of Quantitative Linguistics*, 3(1), 1–7. <https://doi.org/10.1080/09296179608590059>
- [2] Apriani, H. (2016). Pengaruh Metode Iqra Dalam Pelajaran Membaca Aksara Sunda Terhadap Kemampuan Menulis Aksara Sunda [The Influence of the Iqra Method in Sundanese Script Reading Lessons on the Ability to Write Sundanese Script]. *Lokabasa*, 7(1), 44. <https://doi.org/10.17509/jlb.v7i1.3406>
- [3] Baidilah, I. (2008). *Direktori Aksara Sunda untuk Unicode* [Sundanese Script Directory for Unicode]. Disidik Provinsi Jawa Barat.
- [4] Berg, K. (2019). *Die Graphematik der Morpheme im Deutschen und Englischen* [The Graphematics of Morphemes in German and English]. De Gruyter.
- [5] Besner, D., & Smith, M. C. (1992). Basic processes in reading: Is the orthographic depth hypothesis sinking? In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology, and meaning* (pp. 45–66). Advances in Psychology, Elsevier Science Publishers.
- [6] Bhide, A., Gadgil, S., Zelinsky, C. M., & Perfetti, C. (2014). Does reading in an alphasyllabary affect phonemic awareness? Inherent schwa effects in Marathi-English bilinguals. *Writing Systems Research*, 6(1), 73–93. <https://doi.org/10.1080/17586801.2013.855619>
- [7] Bright, W. (1996). *The Devanagari Script* (Daniels &, pp. 384–391).
- [8] Daniels, P. T. (1996). *The Study of Writing Systems* (Daniels &, pp. 3–17).
- [9] Darusuprta, Hardjawijana, H., & Nursatwika. (2002). *Pedoman Penulisan Aksara Jawa* [Guidelines for Writing Javanese Script]. Yayasan Pustaka Nusantara.
- [10] Divay, M., & Vitale, A. J. (1997). Algorithms for Grapheme-Phoneme Translation for English and French: Applications for Database Searches and Speech Synthesis. *Computational Linguistics*, 23(4), 495–523.
- [11] Ehri, L. C. (2014). Orthographic Mapping in the Acquisition of Sight Word Reading, Spelling Memory, and Vocabulary Learning. *Scientific Studies of Reading*, 18(1), 5–21. <https://doi.org/10.1080/10888438.2013.819356>
- [12] Fedorova, L. L. (2013). The development of graphic representation in a Bugida writing: The Akshara's grammar. *Lingua Posnaniensis*, 55(2), 49–66. <https://doi.org/10.2478/linpo-2013-0013>
- [13] Frost, R., Katz, L., & Bentin, S. (1987). Strategies for visual word recognition and orthographical depth: A Multilingual comparison. *Journal of Experimental Psychology: Human Perception and Performance*, 13, 10–115.
- [14] Fry, E. (2004). Phonics : A Large Phoneme-Grapheme Frequency Count Revised. *Journal of Literacy Research*, 1, 85–98.
- [15] Fuhrhop, N., & Peters, J. (2013). *Einführung in die Phonologie und Graphematik* [Introduction to phonology and graphematics]. Metzler.
- [16] Hanna, P. R., Hodges, R. E., & Rudorf, E. H. (1966). *Phoneme-grapheme correspondences as cues to spelling improvement*. Department of Health, Education, and Welfare.
- [17] Joyce, T., & Meletis, D. (2021). Alternative criteria for writing system typology. *Zeitschrift Für Sprachwissenschaft*, 40(3), 257–277. <https://doi.org/10.1515/zfs-2021-2030>
- [18] Katz, L., & Feldman, L. B. (1983). Relation between pronunciation and recognition of printed words in deep and shallow orthographies. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 9(1), 157–166. <https://doi.org/10.1037/0278-7393.9.1.157>
- [19] Klima, E. S. (1972). How alphabets might reflect language. In F. Kavanagh & I. G. Mattingly (Eds.), *Language by ear and by eye*. The MIT Press.
- [20] Koda, K. (2007). Phonology and Literacy. In M. C. Pennington (Ed.), *Phonology in context*. Palgrave.
- [21] Liberman, I. Y., Liberman, A. M., & Mattingly, I. G. (1980). Orthography and the beginning reader. In J. F. Kavanagh & R. L. Vanesky (Eds.), *Orthography, reading, and dyslexia*. Pro-Ed.
- [22] Lukatela, G., Popadic, D., & Ognjenovic, P. (1980). Lexical decision in a phonologically. *Memory and Cognition*, 8(2), 124–132.
- [23] Maulina, L. (2013). *Peningkatan Keterampilan Membaca Aksara Jawa melalui Model Direct Instruction dengan Media Audio Visual pada Siswa SD N Wonosari 02 Semarang* [Improving Javanese Script Reading Skills through the Direct Instruction Model with Audio-Visual Media in Students of SD N Wonosari 02 Semarang]. Universitas Negeri Semarang.
- [24] Medera, I. N., Suasta, I. B. M., & Japa, I. W. (2003). *Pedoman Pasang Aksara Bali* [Guidelines for Writing Balinese Script"]. Dinas Kebudayaan Provinsi Bali.
- [25] Meletis, D. (2015). *Graphetik: Formund Materialität von Schrift* [Graphetics: formandmateriality of writing]. Werner Hülsbusch.
- [26] Meletis, D. (2018). What is natural in writing? *Written Language & Literacy*, 21(1), 52–88. <https://doi.org/10.1075/wll.00010.mel>
- [27] Meletis, D. (2019a). *Naturalness in scripts and writing systems Outlining a Natural Grapholinguistics*. Karl-Franzens-Universität Graz.
- [28] Meletis, D. (2019b). The grapheme as a universal basic unit of writing. *Writing Systems Research*, 0(0), 257–277. <https://doi.org/10.1080/17586801.2019.1697412>
- [29] Meletis, D. (2020). Types of allography. *Open Linguistics*, 6(1), 249–266. <https://doi.org/10.1515/opli-2020-0006>
- [30] Nag, S. (2007). Early reading in Kannada: The pace of acquisition of orthographic knowledge and phonemic awareness. *Journal of Research in Reading*, 30(1), 7–22. <https://doi.org/10.1111/j.1467-9817.2006.00329.x>
- [31] Nag, S. (2014). Akshara-phonology mappings : The common yet uncommon case of the consonant cluster Akshara-phonology mappings : The common yet uncommon. *Writing Systems Research*, 6:1(August 2014), 105–119. <https://doi.org/10.1080/17586801.2013.855621>
- [32] Nag, S., Treiman, R., & Snowling, M. J. (2010). Learning to spell in an alphasyllabary: The case of Kannada. *Writing Systems Research*, 2(1), 41–52. <https://doi.org/10.1093/wsr/wsq001>

- [33] Nala Antara, I. G., Suardiana, I. W., & Wisnu, I. W. G. (2016). *Kamus Bali-Indonesia beraksara Latin dan Bali Edisi II* [Balinese dictionary - Indonesian with Latin and Balinese script]. Badan Pembina Bahasa Aksara, dan Sastra Bali.
- [34] Neef, M. (2012). Graphematics as part of a modular theory of phonographic writing systems. *Writing Systems Research*, 4(2), 214–228. <https://doi.org/10.1080/17586801.2012.706658>
- [35] Neef, M. (2015). Writing systems as modular objects: Proposals for theory design in grapholinguistics. *Open Linguistics*, 1(1), 708–721. <https://doi.org/10.1515/opli-2015-0026>
- [36] Pae, H. K. (2020). Script effects as the hidden drive of the human mind, cognition, and culture. In *Sociolinguistic Studies* (Vol. 17, Issues 1–3). Springer. <https://doi.org/10.1558/sols.23457>
- [37] Pae, H. K., & Wang, M. (2022). The effects of writing systems and scripts on cognition and beyond: An introduction. *Reading and Writing*, 35(6), 1315–1321. <https://doi.org/10.1007/s11145-022-10289-z>
- [38] Pandey, P. (2014). Akshara-to-sound rules for Hindi. *Writing Systems Research*, 6(1), 54–72. <https://doi.org/10.1080/17586801.2013.855622>
- [39] Paramarta, I. K., Indrawan, Rai, I. B., & Martha, I. N. (2023). *Bound Vowels Grapheme Representation*. 1, 165–172. <https://doi.org/10.2991/978-2-494069-29-9>
- [40] Pastika, I. W. (2005). *Fonologi Bahasa Bali Sebuah Pendekatan Generatif Transformasi* [Balinese Language Phonology: A Generative Transformation Approach]. Pustaka Larasan.
- [41] Pike, K. L. (1956). *Phonemic: A Technique for Reducing Language to Writing*. : University of Michigan Press.
- [42] Protopapas, A., & Vlahou, E. L. (2009). A comparative quantitative analysis of Greek orthographic transparency. *Behavior Research Methods*, 41(4), 991–1008. <https://doi.org/10.3758/BRM.41.4.991>
- [43] Pusefariani, W., Mukhrizal, & Puspita, H. (2021). Students' Pronunciation Errors in English Silent Letters. *Journal of English Education and Teaching*, 5(3), 453–467. Retrieved February 15, 2023. from <http://www.nber.org/papers/w16019>
- [44] SIL. (2021). *Glossary of linguistic terms*. Retrieved May 21, 2022. from <https://glossary.sil.org/term/zero>
- [45] SIL. (2022). *Scriptsource Entry*. Retrieved August 18, 2023. from https://scriptsource.org/cms/scripts/page.php?item_id=entry_detail&uid=vjds8ckv3j
- [46] Simpen AB, I. W. (1979). *Pasang Aksara Bali* [Guidelines for Writing Balinese Script]. Dinas Pengajaran Provinsi Daerah Tingkat I Bali.
- [47] Sircar, S., & Nag, S. (2014). Akshara-syllable mappings in Bengali: A language-specific skill for reading. In H. Winkler & P. Padakannaya (Eds.), *South and Southeast Asian psycholinguistics* (pp. 202–211). Cambridge University Press.
- [48] Spencer, K. (2007). Predicting children's word-spelling difficulty for common English words from measures of orthographic transparency, phonemic and graphemic length and word frequency. *British Journal of Psychology*, 98, 305–338.
- [49] Sproat, R. (2000). *A computational theory of writing systems*. Cambridge University Press.
- [50] Suasta, I. B. M. (2006). Ejaan Aksara Bali Dalam Pelestarian Budaya Bali [Balinese Script Spelling in the Preservation of Balinese Culture]. In *Kumpulan Makalah Kongres Bahasa Bali VI*.
- [51] Sukreni Riawati, K., Paramarta, I. K., & Sukma Wirani, I. A. (2021). Kemampuan Memetakan Bentuk Aksara Bali Ke Huruf Latin Siswa Kelas 4 Dan 5 Sd Negri 2 Kalibukbuk [The Ability to Map Balinese Script Forms to Latin Letters of 4th and 5th Grade Students at SD Negri 2 Kalibukbuk]. *Jurnal Pendidikan Bahasa Bali Undiksha*, 8(1), 12–21. <https://doi.org/10.23887/jpbb.v8i1.40811>
- [52] Tarsaku, P., Somlertlamramch, V., & Thongprasirt, R. (2001). Thai grapheme-To-phoneme using probabilistic GLR parser. *Eurospeech 2001 - Scandinavia - 7th European Conference on Speech Communication and Technology, March*, 1057–1060. <https://doi.org/10.21437/eurospeech.2001-227>
- [53] Tinggen, I. N. (1994). *Celah-Celah Kunci Pasang Aksara Bali* [Key in Writing Balinese Script]. Rhika Dewata. Retrieved May 23, 2021. <https://www.babadbali.com/aksarabali/books/cck.htm>
- [54] Vadasy, P. F., & Sanders, E. A. (2021). Introducing Grapheme-Phoneme Correspondences (GPCs): Exploring Rate and Complexity in Phonics Instruction for Kindergarteners with Limited Literacy Skills. *Reading & Writing*, 34, 109–138. <https://doi.org/https://doi.org/10.1007/s11145-020-10064-y>
- [55] Vaid, J., & Gupta, A. (2002). Exploring word recognition in a semi-alphabetic script: The case of Devanagari. *Brain and Language*, 81(1–3), 679–690. <https://doi.org/10.1006/brln.2001.2556>
- [56] Winkler, H., & Perea, M. (2014). Can parafoveal-on-foveal effects be obtained when reading an unspaced alphasyllabic script (Thai)? *Writing Systems Research*, 6(1), 94–104. <https://doi.org/10.1080/17586801.2013.843440>
- [57] Ziegler, J. C., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Fašca, L., Saine, N., Lyytinen, H., Vaessen, A., & Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: A cross-language investigation. *Psychological Science*, 21(4), 551–559. <https://doi.org/10.1177/0956797610363406>



I K. Paramarta was born in Sulahan Village, Bangli Regency, Bali Province, Indonesia. He completed his Doctor of Linguistics at Udayana University (2015). His research interests are the study of the Balinese language from a comparative historical linguistic and sociolinguistic perspective, and the study of the Balinese script system from a grapholinguistic perspective.

He is a lecturer in the Balinese Language Education Study Program, Faculty of Languages and Arts at Universitas Pendidikan Ganesha, Bali Indonesia. He is currently serving as the Secretary of the Department of Indonesian and Regional Literature, Faculty of Languages and Arts. He is a member of Indonesian Linguistic Society (MLI).



G. Indrawan was born in Singaraja, Bali, Indonesia. He received his Ph.D. in Electrical Engineering and Informatics from Institut Teknologi Bandung, Indonesia in 2015. His research interests are biometrics, pattern recognition, and robotics, especially for Balinese script.

He is a lecturer in the Department of Computer Science, Engineering and Vocational Faculty at Universitas Pendidikan Ganesha, Bali Indonesia. He is currently also teaching in the Postgraduate Program for Computer Science Study Program.



I B. Rai was born in Sidemen Village, Karangasem, Bali Province, Indonesia. He completed his Master of Language Education at Universitas Pendidikan Ganesha (2012). His research interests are the study of the Balinese language from a sociolinguistic perspective.

He is a lecturer in the Balinese Language Education Study Program, Faculty of Languages and Arts at Universitas Pendidikan Ganesha, Bali Indonesia. He is currently the Coordinator of the Balinese Language Education Study Program. He is a member of Indonesian Linguistic Society (MLI).