Visual crowding and the tone orthography of African languages

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Abstract: The effect of Crowding has long been recognised by cognitive psychologists engaged in examining the reading process. Yet it is not generally taken into account by most field linguists involved in the development of tone orthographies for emerging African languages. True, there is a general recognition that diacritic overload is unhelpful, but this has never been articulated with the help of the more precise terminology already on offer from the field of cognitive psychology. Using an experimental tone orthography developed for Kabiye (Gur, Togo) as an example, I postulate that an near-exhaustive representation of tone by means of accents will trigger Crowding. This is a hypothesis that has yet to be tested under clinical conditions. But the aim of this article is to call the phenomenon by its name for the first time and thereby stimulate further research. I also hope to demonstrate by means of this single example the gulf that exists between the cognitive psychology and linguistics. Once we recognise that the gulf exists, we can begin to build bridges.

Keywords: tone orthography, diacritics, Visual Crowding, African Languages

1 Introduction

Over the past forty years, the Psychology of Reading has become a truly interdisciplinary crossroads of scientific inquiry in which psychologists, neurologists, educationalists and IT specialists all contribute from their own perspectives (For a summary of research up to the turn of the century see Labelle, 2001). This collaboration has spawned a vigorous and fruitful growth in our knowledge about the cognitive processes involved when reading. However, linguists have been rather slow to involve themselves in this collaboration, as Jaffré notes (2003: 37-38):[1]

> *"If we look at the last three decades, we cannot fail to notice the absence of any genuine dialogue between linguists, who seek to understand how a linguistic object functions, and psycholinguists, who describe the process by which that object is accessed [...] There is a real and enduring institutional divide in the world of linguistics [...] If any genuine dialogue is to establish itself, linguists should undoubtedly take into account the processes described in psycholinguistics more than they currently do."*

Jaffré's comments are certainly apt when it comes to the debate about tone orthography in emerging African languages. Numerous researchers have underlined the importance of psycholinguistic factors in orthography design (Bauernschmidt, 1980; Bird, 2001; Gordon, 1986; Gudschinsky, 1970; IIALC, 1930; Miller, 1970; Powlison,

[1] My translation of the original French*: « Si l'on s'en tient aux trois dernières décennies, on ne peut que constater en effet l'absence d'un véritable dialogue entre une linguistique qui cherche à comprendre comment fonctionne un objet linguistique et une psycho-linguistique qui décrit les procédures utilisées pour accéder à cet objet [...] Il existe dans le champ de la linguistique une véritable coupure institutionnelle, toujours vivace [...] Pourqu'un véritable dialogue s'instaure, les linguistes devraient sans doute tenir compte plus qu'ils ne le font des processus décrits par la psycholinguistique. »*

1968; Simons, 1994; Snider, 1998; Venezky, 1970; Weaver, 1980; Wiesemann, 1981, 1995), yet somehow the notion of exactly what constitutes psycholinguistics remains rather vague in the minds of most field linguists. For most of the 20th century, top priority has almost always been given to phonemic analysis as the Royal Way to an optimal orthography (Gudschinsky, 1959: 68; Pike, 1947: 208-209; Swadesh, 1934: 125; Wiesemann, Sadembouo & Tadadjeu, 1988).

Quite apart from the divide between linguistics and psycholinguistics, there are divisions within the world of linguistics itself. Linguists tend to align themselves in one of two camps: theory and description. On the one had, theoreticians are far removed from the concerns of practical orthographies. On the other, descriptivists are only interested in the written language in their quest for adequate scientific notation. So the development of practical orthographies tends to be left to long-term field workers who often have years of hard-won experience in linguistics and literacy but little or no training in psycholinguistics. And because their fieldwork is open-ended, they are also less likely to write-up their conclusions. Small wonder that the literature on tone orthography is so scarce.

The aim of this article is to help break some new ground by describing one single psycholinguistic phenomenon and examining its implications for the tone orthography of African languages: the phenomenon of Crowding.

2 Crowding

2.1 Definitions

The effect of *Crowding* is sometimes referred to as *Lateral Masking*, particularly in the earlier literature (cf. Fine, 2001). Some researchers distinguish between these terms (Huckauf & Heller, 2004). Elsewhere it is known as *spatial interference* (e.g. Tsandilas & Balakrishnan, 2005) or, by those who do not want to beat about the bush, *clutter* (Rosenholtz, Li & Nakano, 2007).

According to the effect of Crowding, the visual perception of an object decreases if another object is located in a critical area around the target. This is a fundamental property of vision in general, not just the recognition of characters during the reading process. Any secondary object decreases visual acuity in relation to the target, but the degree of interference depends on at least three factors:

Similarity: If the secondary object is similar to the target in size and shape, it is more difficult to identify the target. And if the secondary object is identical to the target, the effect is even more acute.

Proximity: Visual acuity is reduced by the edge of a secondary object in the visual field. The closer the edge of the secondary object is to the target, the more the interference.

Number: The more secondary objects there are clustered around the target, the more difficult it is to identify the target.

We meet the effect of Crowding many times each day. It is enough to try to count the vertical stripes on someone's shirt or the horizontal slats on a window shutter to

realise how pervasive it is in our daily lives. The eye has difficulty focusing on an object when many similar objects are nearby.

Crowding is currently the focus of much research; the Journal of Vision recently devoted an entire special issue to the subject (Pelli, Cavanagh, Desimone, Tjan & Treisman, 2007). The research is as varied as it is intensive. Contemporary contributions focus on, to cite but a few, the Crowding effect with relation to movement (Bex & Dakin, 2004), colour (Poder, 2007), contrast, luminance (Chen, 2007), shape, size (Bex, Dakin & Simmers, 2003) and salience (Gheri, Morgan & Solomon, 2007).

No writing system escapes the effect of Crowding. It is extremely marked in the identification of characters (Fine, 2001; Huckauf, Heller & Nazir, 1999; Pernet, 2004), especially if the target is presented in the peripheral visual field (Leat, Li & Epp, 1999). Crowding makes identification more difficult when the target is embedded than if it is isolated. The embedding of the target may extend the time taken to identify it by 40%. On this point, Taylor and Taylor (1983: 206) add the insightful comment: *"Text is apparently laid out badly if the object of reading were simply to identify letters."*

The effect of Crowding can occur over a distance of 5 to 8 characters (Bouma, 1970). It is for this reason that, in arithmetic, it is much easier to read the numerical representation of the figure "one trillion" (short scale) if the thousands are separated by commas:

1,000,000,000,000

- than if the same figure is written without commas:

1000000000000

Crowding is also the reason why, in reading as it is practiced today, orthographic words are separated by blank spaces.

Thissentenceismoreddiffiiculttoreadthantheothersinthisarticlebecausetherearenowhitespacesbetweenthewords.

The reader has difficulty focussing on a character when many similar characters are nearby.

A wry illustration from popular history refers to Crowding without naming it as such (Lacey & Danziger, 1999: 191, 187):

> *"The use of Roman numerals had a paralysing effect on calculation [...] The scholar Alcuin said that 9,000 should be regarded as the upper limit beyond which figuring was not possible, and when that was written out as MMMMMMMMM one could understand what he meant [...] Only the literate were in a position to concern themselves greatly with what would happen when the year DCCCCLXXXXVIIII became a simple M [...]"*

2.2 Crowding in African tone languages

So examples of Crowding abound, but what do they have to do with the tone orthography of African languages? I will answer this question with the help of an example from Kabiye (Gur, Togo). First, I will present an experimental tone orthography that I developed for testing purposes, in which the strategy for representing tones is near-exhaustive (Roberts, 2008a).

I describe as "near-exhaustive" any strategy which marks one accent less than the number of tones in the language, for example a two tone language which marks one accent, or a three tone language which marks two tones. Some of the early researchers promoted the leaving of one tone unmarked as a "minimal" representation (Pike, 1947: 222; 1948: 38; Williamson, 1984: 342). But the principle has become so assimilated in practice, at least in most parts of Africa, that few orthographers question it anymore. These days, what used to be regarded as minimal is widely perceived as being close to maximal, second only to truly exhaustive representations like Gbaya (Nilo-Saharan, Sudan)[2] which has five tones and marks all of them (Russell Norton, personal communication).

I will focus on Kabiye, but in fact I could have chosen any number of African orthographies, because near-exhaustive tone marking is quite common. Without travelling more than a day's distance from the Kabiye homeland in the north of Togo, one encounters no less than eight languages which mark tone in this way: Ditammari (Gur, Benin; Betica, 2008a, 2008b), Ede Idaca (Defoid, Benin SLI, 2001), Ifè (Defoid, Togo and Benin; Kohler, 1983), Igo (Ahlon; Ghana-Togo mountain, Togo; Gblem-Poidi, 2006), Mbelimé (Merz, Merz, Sambieni & Sambieni, 2005), Naténi (Gur, Benin; Winrikou, 1998), Tem (Gur, Togo; Craene & Tchagbra, 1996, 1998) and Yoruba (Defoid, Nigeria and Benin; Abraham, 1958; Fagborun, 1989; NME, 1969). To give a balanced picture, there are also parts of Africa where tone marking is non-existent. The official Malian government guidelines do not allow for the representation of tone at all (Thomas

[2] Not to be confused with Gbaya (Adamawa-Ubangi, Central African Republic).

Blecke, personal communication). Nevertheless, the Togolese and Beninese experience is by no means exceptional.

The background to my own research is that the Kabiye standard orthography does not currently mark tone, and there is some concern among key stakeholders that this strategy generates too much homographic ambiguity, leading to inaccurate, laboured oral reading and incomprehension. Working in collaboration with *Comité de Langue Nationale Kabiyè* to help resolve this problem, I developed two experimental Kabiye orthographies, in order to test a meaning-based approach which uses existing segmental graphemes to highlight the grammar against a sound-based approach which marks tone exhaustively with accents (Roberts, 2008a). It is only the second of these which concerns us in this article.

Very briefly, Kabiye is a two tone language with lexical and post-lexical morphotonological processes (Roberts, 2002, 2003a, 2003b, 2004, 2005a, 2005b). The experimental tone orthography marks all H tones with an acute accent | á | and non-automatic downstep before two grammatical particles with an apostrophe | ' |. As for the parameter of orthographic depth, the experimental tone orthography, to use Kiparsky's framework (1982; Mohanan, 1986; Pulleyblank, 1986), is transparent, representing the output of the lexical phonology (Roberts, 2008a: 411-440).

Apart from this briefest of sketches, the mapping of phonographic relationships is not what is in focus here; I have described them in detail elsewhere (Roberts, 2008a: 487-545). Our discussion will concentrate rather on the visual and cognitive strategies which the reader employs when accessing natural texts, of which the following is a sample (Alou, 1990):

1

Man-kabıyɛ kʋnʋŋ, ŋɖewá pıfέyí náv. Yee póyóódʋʋ-ŋ́ nɛ εyú welesî yó, pıwɛ-í ézí wóńdu pétéɣ. Ɛlé, yéé εyú éwɛ́ nɛ ɛ́ɛmaɣzıɣ ñɔ́-yóó camíyɛ yó, ɛɛnáɣ ñé-ɖéu. Nɔ́yʋ éwélésîɣ píŋ́ŋ́ né éníı póyóódʋʋ-ŋ́ yó, pılákı-í ezí étázı nɛ éná ñé-wétʋ yó, pısaŋı-í se éyele. Ŋwɛ yúŋ weyî nɛ εyú ɛɛtɛŋ ñɔ́-tóm yó, pıtına nɛ εyó éɖɔ́kı-ŋ́ pıfέyí yebu. Ńé-wétʋ línı le nɛ paasıŋ ñɔ́-tɔ́m? Tɔ́m kɔ́pɔ́záɣ ŋ́gá ɖicósuu-ké tobî. Ńé-wétʋ nɛ tı-tı sóló, mbú pʋyɔ́ yó ɖooo ŋŋwɛ́, natúyʋ taásóki ñá-táá se tıpısı-ŋ́ nɔ́yʋjaú. Kabıyɛ kʋnʋŋ, ñá-píɣ́á cánıɣná-ŋ́ nɛ kewîlîɣ-ŋ́, nɛ kásáŋ-ŋ́ ñó-yúŋ, ñé-ɖéu nɛ ñé-leléŋ yɔ́.

My Kabiye language, you are so beautiful! When anyone pronounces you and another listens, you are like a song. But anyone who does not ponder you deeply will not perceive your beauty. Anyone who listens attentively when you are being spoken must, as it were, dig deeply to discover your character. It is because of this inexhaustible weightiness that we cannot let go of you. From where does this impenetrable character come? We can reply straight away to this question. Your character is unique, because ever since you came into being, you have never suffered any outside influences which could turn you into something else. Kabiye language, your child is glad for you, cherishes and praises you, because of your strength, your beauty and your sweetness.

My hypothesis is that the experimental Kabiye tone orthography, with its exhaustive accentual representation of tone, will suffer the effect of Crowding for the three reasons already mentioned:

Similarity: Most diacritics are similar to each other, especially those which are single strokes of the pen. The acute accent differs from its absence only by a single stroke, and from the apostrophe only by its orientation (cf. Kutsch Lojenga, 1993: 13). Every acute accent is identical to its neighbour, not to mention the similarity between the acute accent and the apostrophe with relation to the tilde on the palatal nasal | ñ |.

Proximity: I analysed of a text sample of 1,000 words taken from a corpus of published vernacular literature and re-written in experimental Kabiye tone orthography (including the text in example 1, page 9). This analysis reveals that 83.4% of accented words are juxtaposed with another accented word. Sequences of non-accented words are rare. In 82.0% of cases, there is only one non-accented word between two accented words. Such sequences are also short, never exceeding three words.

Number: Diacritic density may be precisely measured by calculating the number of diacritics as a percentage of the number of tone bearing units (Bird, 1999: 89)[3]. The diacritic density of the experimental Kabiye tone orthography is 48.12%, which means that almost half the segmental units capable of bearing an accent do so. To look at it another way, 83.2% of words contain accents. Almost two-thirds of words (60.3%) have one accent, but many of these are monosyllabic words, which in any case can never carry more than one. Moreover, there are many examples of words with two accents (27.4% of words) and some with three accents (9.2% of words). A text written in the experimental Kabiye tone orthography contains eight times as many diacritics as a text written in the orthography of French, the official language of Togo.

To these three inhibiting factors we can add a fourth, size, which although it is not an inherent property of Crowding undoubtedly contributes to it. It goes without saying that small objects are difficult to perceive. The acute accent and the apostrophe are the smallest characters in the Kabiye experimental tone orthography.

I should also add that the experimental Kabiye tone orthography is not nearly as graphically dense as the standard orthographies of some of its neighbours. Defoid languages provide a particularly striking example. For example, Ifè (Togo and Benin) uses the tilde to mark nasality and two accents for tone, sometimes resulting in stacking. The diacritic density of a sample text of 163 words is 79.43%. Example 2 is an extract from that text (Agbemadon & Boethius, 1989)[4]:

[3] Bird's term, "tone density", could be misleading because tones refer to spoken rather than written language.
[4] I am grateful to Mary Gardner for providing the English translation of this passage.

2 Gbágbó-Àtsú tse oko-ɔ̀kpɛ̀ lákű̃-kã̀ si. Ǹbɛ̀ɛ́, Àtsú náa káà kɔ ɛnyɛ ŋa wá. Tsî ó dị̀ nódzó nyɛ̀ŋɛ̀, tsí Àtsú lɔ kó káà kɔ ɛnyɛ̀ gé, tsî kò rî ɛnyɛ̀ ŋa ró. Ɔnyà-kã̀ ti wáa lɔ káà tsolɛ̀ ŋá kɔ.
Atsu's grandfather had a big palm orchard. Atsu used to go and pick palm nuts and take them home. One day, Atsu went to pick palm nuts but couldn't find any. Someone had been there before him and stolen them.

The Nigerian Yoruba orthography symbolises both -ATR vowels with subscript pointing and tone with two superscript accents, sometimes resulting in clustering. I specify "Nigerian" here, because the Beninese Yoruba community have rejected the pointing strategy in favour of special characters (Bada, 2008). However the representation of tone is exhaustive on both sides of the frontier. The diacritic density of a sample text of 350 words written in Nigerian Yoruba is 89.7%. Example 3 is an extract from that text (Fagborun, 1989: 88):[5]

3 Nîgbà yĩ̀ ni bàbá yĩ̀ bẹ̀rẹ̀ sî î wádĩ̀ ẹni tó rì i pé ó se àánú òun nîgbà tî àwọn kan jî ẹja panla rẹ̀ jẹ tî kò sì le rìn láìlo ọ̀pá.
At that time this man started finding out about the person who helped him out when some thieves stole his fish and he couldn't walk without a stick.

Given all that the cognitive psychology of reading reveals to us about Crowding, it is hardly surprising that all the researchers who have examined the parameter of diacritic density in formal experiments (Roberts, 2008b) are unanimous in their conclusion that exhaustive representation of tone by means of accents is not optimal (Badejo, 1989: 49; Bernard, Mbeh & Handwerker, 1995: 38; 2002: 345; Bird, 1999, 107; Essien, 1977: 159; Klem, 1982: 24; Mfonyam, 1989).

2.3 Crowding and functional load

There is often a correlation between the functional load of tone in a language and the level of diacritic density in the orthography. The higher the functional load of tone,

[5] I am grateful to Seun Gloria Adewara for providing the English translation of this passage. She commented that the sentence sounds unnatural. I have kept it because it is cited in a previous article on tone orthography.

the more difficult it is to avoid multiple diacritics, and the easier it is for a linguist to justify them.

Imagine two languages which both mark tone exhaustively. In language A, the functional load of tone is extremely high; in language B, it is extremely low. The degree of Crowding – fundamentally a visual effect – will be the same in both orthographies. But in language A, the reader's motivation to overcome the interference will be much higher than in language B, because (s)he knows that decoding the diacritics, even if arduous, is worthwhile: it leads to comprehension. In language B, on the other hand, motivation to overcome interference is low, because most of the diacritics are superfluous anyway.

This presents particular challenges for developing orthographies for languages in which the functional load of tone is high. It is self-defeating for the orthography to ensure a tight mapping of diacritic graphemes to tones, whilst ignoring the important psycho-cognitive principle of Crowding. Why develop an orthography that is satisfactory from the phonologist's point of view if the visual result actually impairs the reading process?

Evoking the notion of functional load is of limited value as long as no viable measure of functional load exists. Calculating diacritic density will certainly play a part in any such measure, but is of limited value in and of itself. If we agree that dialogue between linguists and cognitive psychologists is required, then both parties need to develop ways of measuring the concepts that are important to them. Then together they can develop reading and writing tests in which Crowding and functional load are varied in relation to each other in a systematic way.

2.4 Crowding and familiarity

Huckauf *et al.*, (1999) claim that once complex stroke combinations become familiar, the reader perceives them as single objects. So could it be that any crowding effect triggered by multiple diacritics would disappear with familiarity, once the diacritics are perceived as being integral to the letters that bear them?

This depends partly on how diacritics are taught in the first place. French pupils are often taught the letters | e, é, è | as being three entirely distinct graphemes. But this has not typically been the case in African tone languages. Literacy primers tend to introduce accents that symbolise tone as being supplementary to the basic inventory of letters.

Indeed, we followed this tradition in the pedagogical materials which introduce the Kabiye experimental tone orthography. Subjects were not taught that there are 26 basic vowel and nasal symbols, thirteen with accents | á é î ó ú ɛ́ ɪ́ ɔ́ ʊ́ ɣ́ ḿ ń ŋ́ | and thirteen without | a e i o u ɛ ɪ ɔ ʊ ɣ m n ŋ |. Rather, they learned that there are thirteen graphemes capable of carrying an accent | a e i o u ɛ ɪ ɔ ʊ ɣ m n ŋ | and one accent |´ |. Of course, this was partly because all the subjects came to the experiment with prior knowledge of the accentless standard orthography. But this apart, it is not unreasonable to teach accents as separate symbols given the autosegmental nature of tone in African languages (Goldsmith, 1976; Leben, 1971, 1973). The tonal tier operates with a degree of autonomy and mobility with relation to the segments which bear them. This is not merely a convenient theoretical framework. Tones are perceived by mother tongue speakers as being momentarily borne by a segment but capable of re-emerging elsewhere in the utterance under certain morphotonological conditions.

This was confirmed at numerous points in our pilot testing, when we had to modify our pedagogical strategies in the light of principles from autosegmental phonology (Roberts, 2008a: 421-440). For this reason, I think it would be unwise to teach diacritic and letter combinations as single, complex graphic units, and unlikely that readers would perceive them as such, even with familiarity.

But even if diacritic and letter combinations were taught in this way, it is not clear that any crowding effect would eventually disappear. The eye is the servant of the brain. It scans a text for anything that will help the reader towards the ultimate aim of comprehension. Field workers have often observed that over time, readers of average ability simply learn to ignore the separate visuo-graphic layer in an orthography with multiple diacritics (Hollenbach, 1978), and the best readers are astute enough to distinguish between meaningful diacritics and those that are superfluous.

2.5 Crowding and the upper part of the script

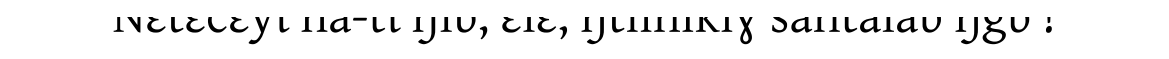
Now let us explore another dimension of the problem. As far back as the early 20th century, Huey demonstrated that the upper part of the Roman script bears more important information than the lower part (1908: 99). Since then, numerous researchers have confirmed the validity of this finding. It is not, by the way, a universal phenomenon; the opposite is true of the Hebrew script. But I predict without fear of contradiction that this effect will be applicable to the Kabiye orthography, because it is only a slight modification of the basic Roman script. And sure enough, during informal tests, this proved to be the case. I chose a sentence written in standard orthography:

4 Ɲɛtɛcɛyı ña-tı ŋlʊ, ɛlɛ, ŋtiihikiɣ santalaʊ ŋgʊ !

As for you, you didn't even try hard, but even so you passed that exam!

I presented this sentence in two forms to my two research assistants, who are fluent readers. Both of them had far more difficulty reading the sentence when it retained only the lower part -

Figure 1: Lower part of a sentence written in Kabiye standard orthography



- than the same sentence when only the upper part was displayed:

Figure 2: Upper part of a sentence written in Kabiye standard orthography

But doesn't this suggest that the location of acute accents on the upper part of the experimental Kabiye tone orthography is actually optimal? If the aim is to maximize the visual impact of accents, isn't it judicious to place them in the very position where the trained reader is already primed to find important graphic information? Isn't the reader likely to fixate on the upper part of the script, thus minimising the Crowding effect? I predict that the answers to these questions will certainly be affirmative in the case of an occasional, well-placed accent, but I suggest that they may not be in the case of multiple accents. What is the job of an accent? Clearly, it is to accentuate. The more accents there are, the less each accent has the room to fulfil its vocation. The experimental Kabiye tone orthography, because it represents tone exhaustively, generates a plethora of minimal graphic strokes on the upper part of the line of text. In such cases, I predict that Crowding may well interfere with the reading process, troubling the reader's eyes in the very place where they already anticipate being able to glean the most important visual information:

Figure 3: Upper part of a sentence written in the experimental Kabiye tone orthography

This is a prediction, and as yet, it remains untested. Whether multiple accents on the upper part of the script are well or badly placed can only be proved when linguists and cognitive psychologists begin to collaborate in formal experiments that furnish empirical evidence.

3 Conclusion

In conclusion, perhaps I should stress that I am not advocating indiscriminate zero tone marking for all African languages. The linguistic dangers of undermarking are certainly as great as the psycholinguistic dangers of overmarking. One leads to incomprehension; the other to visual interference. Both generate disfluencies in oral reading and erode readers' motivation.

Neither do I want to imply that stripping out all the accents is the only possible solution. Since we know that similarity is a key contributor to Crowding, the effect could be reduced by changing one diacritic so that it looks less like its neighbour rather than eliminating it entirely. Equally, if size inhibits recognition, diacritics could simply be increased in size. And we would do well to note the Vietnamese experience of widening line spacing when creating fonts for orthographies with multiple diacritics (Trager, 2006: 12). But these would all be supplementary strategies compared with the more pressing need to develop accurate ways of assessing the functional load of tone in a given language and only represent what needs to be represented in the first place.

I concede that, as yet, the effect of Crowding on multiple diacritics in the tone orthographies of African languages has the status of an untested hypothesis. Any experimentation using computerised tachistoscopic methodology, mother-tongue readers and natural texts in laboratory conditions would make a significant contribution to the literature. In summary, I propose some research questions which would help drive experimentation forward:

- Does the Crowding effect that has been widely demonstrated to occur between letters also occur between diacritics?
- What is the diacritic density threshold beyond which Crowding is triggered?
- What is the effect on Crowding when functional load and diacritic density are varied in relation to each other?
- Does Crowding triggered by multiple diacritics diminish with familiarity?
- Are diacritics perceived as being integral parts of the letters which bear them?
- Do letters bearing diacritics suffer more from Crowding than letters with no diacritics?
- Do multiple diacritics inhibit the reader more when placed on the upper part of the Roman script than on the lower part?
- What effects do similarity, size and line spacing have on Crowding triggered by multiple diacritics?

- Underlying all these questions is a more basic one: What is the fundamental unit of visual processing of written language: strokes, letters or words?

If the inhibiting effect of Crowding can be proved empirically in just one African tone orthography – such as Nigerian Yoruba with its extreme case of diacritic density – it would have considerable repercussions for all the others. Until then, we can at least enter the debate armed with precise scientific terminology. Numerous researchers and practitioners have rightly expressed their concern that exhaustive and near-exhaustive representation of tone leads to "graphic overload" (Bird, 2001; IIALC, 1930; Koffi, 1994; Mfonyam, 1990). But there is a more precise technical term from another domain waiting in the wings. What the field linguist calls graphic overload is, I predict, the source of what the cognitive psychologist calls Crowding. The difference between the two is that, although the linguist can calculate diacritic density in percentage terms, what exactly constitutes the acceptability threshold is ultimately a subjective opinion. Crowding, on the other hand, is a precisely measurable psychological effect. And having measured it, we can then objectively assess the relative impact of that effect on the reading process from one orthography to another. A researcher in cognitive psychology would probably be surprised by the banality of these remarks, because Crowding has been known in their field for more than a century. But I have found no reference to it in the Africanist literature on tone orthography. We would do well to introduce the term since the consequences are serious when decision makers ignore it.[6]

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Bernard Caron, Jean-Pierre Jaffré, Thomas McCormick, Jacques Nicole, Mary Pearce, Martin Taylor, Insup Taylor and two anonymous reviewers for reading and commenting on a draft of this article. I have revised several parts in the light of their helpful comments. The article also benefitted discussions following its presentation at the 25th West African Languages Congress, Ouidah, Benin, 30 July – 6 August 2006. It is based on an earlier French version (Roberts, 2008a: 442-486) which can be downloaded from **http://www.orthographyclearinghouse.org/phdma.html**.

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