Research Article

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Types of allography

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Abstract: Variation in writing is highly frequent at both the visual and the functional levels. However, as of yet, the associated notion of allography has not been systematically described. In this article, two major types of allography are proposed: graphetic allography, conceptually comparable to allophony, depends on visual similarity and captures how concrete units are associated with visual abstractions, i.e., how three graphs in <cabana> are instances of the basic shape |a|. Graphematic allography, conceptually closer to allomorphy, does not depend on visual similarity but groups together units that share the same function, i.e., represent the same linguistic unit (phoneme, syllable, morpheme, etc.) and are complementarily distributed, meaning there exist no contexts in which they contrast. An example is the positionally conditioned alternation between |σ| vs |ς| for the Greek grapheme <σ>. By means of a number of criteria, subtypes of graphetic and graphematic allography are proposed and examples are given from different writing systems. A special case that is discussed is the complex phenomenon of capitalization. Additionally, examples of variation phenomena that are not included in the concept of allography are given, and orthographic variation is addressed as a marginal case of variation dependent on the norm rather than the system.

Keywords: allography, graphetic variation, graphematic variation, basic shape, graph, grapheme

1 Introduction

In language, variation is ubiquitous. Virtually every time a person speaks, variation plays a role at some level, be it in the choice of words or the pronunciation of an utterance. Against this background, it is not surprising that variation has emerged as one of the core phenomena studied in linguistics. And not only speech but also writing is affected by it. Examples are the difference in the outer form of a written utterance when jotting something down hastily on a shopping list vs penning something meticulously on a greeting card, but also the alternation between uppercase and lowercase letters in different positions of a written sentence.

Although writing is, like speech, a modality of language, and research on writing, a field that can be termed *grapholinguistics* (from German *Schriftlinguistik*, cf. Neef et al. 2012 ff.), is becoming increasingly accepted in linguistics, variation in writing remains a largely understudied topic. More than two decades ago, Coulmas (1996: 174) observed that there was "no general theoretical model for categorizing graphs as allographs of a grapheme in a given writing system". This situation has scarcely changed. Moreover, what Coulmas mentions is a simplification of the many facets that constitute the complex phenomenon of variation in writing. While concepts such as *allophony* and *allomorphy* have entered mainstream linguistic discourses long ago and have developed into well-described and clear-defined concepts, the notion of *allography*, much like the closely related notion of *grapheme*, remains more or less a mystery. While there exist descriptions of writing systems, the majority of them introduce and work with individual descriptive categories tailored to the specific writing system in question. This is an understandable reaction to the seemingly insurmountable diversity of the world's writing systems and the associated lack of established and universal descriptive categories such as *phoneme* and *morpheme* in phonology and morphology.

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However, settling for highly individual descriptive categories and altogether avoiding the search for a more universal way of describing writing is what has created this situation of a conceptual and terminological grapholinguistic vacuum in the first place, and adhering to this practice only perpetuates it. This, in turn, complicates both the construction of a general theory of writing and, in consequence, any reasonable structural comparison of diverse writing systems.

The lack of attention that the concept of allography has received concerns primarily descriptive works in which the matter is most often oversimplified. Daniels (2017: 88), for example, who rejects a concept of *grapheme*, discarding it as a "scientific-sounding word for 'letter' or 'character'", adds – in parentheses, nonetheless – that "'[a]llograph, however, remains useful for conditioned variants of lettershapes". A definition of letter shapes or an explanation of the mentioned conditions, however, is sorely lacking. Qiu (2000: 297), in his description of the Chinese writing system, writes that "[a]llographs are characters which have the same pronunciation and meaning but have different outward forms. Strictly speaking, only characters which are used in completely the same way, that is, alternate forms of a single graph, can be called allographs". While this is already a more detailed definition, questions do remain: What are *graphs* supposed to be in this context? Are they not commonly understood to be concrete realizations of a grapheme? In his textbook on writing systems, Rogers (2005: 10–11) vaguely defines "graphemes as classes of allographs" and adds that "[a] grapheme often has a good deal of allographic variation related to style of handwriting or printing". He obviously speaks of the visual level and thus a different phenomenon than Qiu. Roger's brief treatment of allography is all the more surprising since he mentions that the "nature of allographic variation and its conditioning factors is more complicated for graphemes than for phonemes". A concept of allography that captures precisely this complexity remains a desideratum.

Aside from descriptive works in grapholinguistics and general linguistics, the lack of a concept of allography also affects psycholinguistic research and specifically questions concerning processes of reading and writing. Here, the lack of a definition of different types of allography is detrimental, resulting in a confusing situation in which altogether different phenomena are blanketly labeled as *allography*, which complicates considerably a straightforward comparison of psycholinguistic research on writing and an integration of otherwise valuable findings into more general models of reading and writing. For example, the question of whether readers and writers store visually dissimilar but co-occurring allographs such as |σ| vs |ς| in Greek separately or as variants of a grapheme (cf. also, for example, Yakup et al. (2014) and Friedmann and Haddad-Hanna (2012) for diverging opinions concerning the psychological status of positional allographs in Arabic) does not invoke the same type of allography as does the question of why users have difficulty producing from memory closed-loop |g| (as opposed to open-loop |ɡ|) although it is ubiquitous in their visual input (cf. Wong et al. 2018), and the type of allography addressed by this question, in turn, differs from the allography relevant in evaluating whether serif or sans serif typefaces are more legible (cf. Arditi and Cho 2005). Obviously, a clear-cut structural definition of allography would allow for a better operationalization in the design of different psycholinguistic experiments and, in the crucial next step, a better interpretation of results and a more theoretically sound assumption of models.

By finally addressing the question "What is *allography*?" in detail, this article proposes a typology of phenomena that pertain to structural variation in writing at both the visual and the functional levels. It not only constitutes foundational research for the young subdiscipline of grapholinguistics but, as mentioned above, also provides welcome input to other disciplines interested in writing. It is structured as follows: Section 2 provides a concise overview of the structure of writing systems. The central notions of *graph*, *basic shape*, and *grapheme* will be introduced. Section 3 then presents the first major type of allography, *graphetic allography*, with its syntagmatic and paradigmatic subtypes. It is constituted by variants that exhibit visual similarity and can, thus, be identified solely on visual grounds. In Section 4, *graphematic allography* will be characterized. For this type of allography, visual similarity is not required, which is why function is crucial and the assignment of allographs to the same grapheme becomes the deciding criterion. Section 5 briefly addresses *orthographic variation*, a type of variation determined by the standardization of the writing system. Finally, a summary is given, remaining questions are collected, and an outlook is given in the conclusion in Section 6.

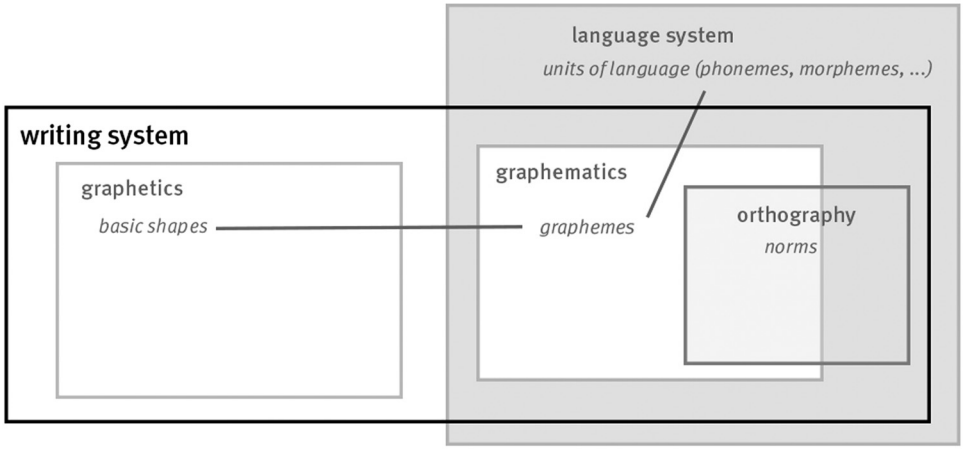

Figure 1: Multimodular model of writing systems.

2 A brief overview of structural grapholinguistics

Similar to how language consists of various subsystems, including phonology, morphology, syntax, etc., writing systems are semiotic systems and, as such, consist of subsystems, or *modules*, which is the basis of Neef's (2015) multimodular theory of writing systems. Figure 1 shows a modified version of it. If, as is the consensus in modern linguistics, the narrow definition of writing is adhered to, in which writing is interpreted solely as the visual (or tactile)[1] representation of language, i.e., specific linguistic referents as opposed to ideas, concepts, etc., then the underlying module of writing systems is a specific language system. For the English writing system, it is English; for the Chinese writing system, it is (a variety of) Chinese. These language systems consist of units and structures at various levels: the phonological, morphological, etc. The visual/tactile, i.e., the *material* part of a writing system including scripts as inventories of graphic shapes, is contributed by the *graphetic module*. The core of a writing system, however, is the *graphematic module*: it relates material units to linguistic units and thereby constitutes graphematic units such as graphemes but also larger ones such as written words or sentences. While the modules mentioned so far are obligatory, the *orthographic*[2] *module* is optional. As a standardization, it acts like a corset around the other modules and restricts the use of graphematic and, though to a lesser degree, graphetic resources provided by the writing system. For example, *<foks> might, in a given context, be easily deciphered as "fox", but, as the asterisk[3] highlights, even though it is a graphematically licensed spelling, it is orthographically incorrect, i.e., it does not conform to the orthographic norm of English. System and norm, thus, are two different phenomena (cf. also Berg 2016). Here, we are only interested in the system (but cf. Section 5 for normative aspects).

1 Although sometimes, in restrictive conceptions of writing (cf. Glück 2016: 593), braille, which is tactile, is not regarded as a form of writing (or simply not mentioned as such), it is a graphic representation of language, and I argue it should be counted as writing. "Graphic", which derives etymologically from Greek *γράφω* gráphō "scratch, carve" emphasizes this broader reading. This article, however, will focus on the visual form of writing.

2 This means I do not regard *orthography* and *writing system* as synonyms. Instead, orthography – as is aptly illustrated by its etymology, see Greek *ορθός orthós* "right, true (*also*: straight, erect)" – is to be understood as the standardization of a writing system (cf. Kohrt 1990: 116). It deals with the question of how to write (or spell) correctly with respect to external, explicit norms. Therefore, it is not to be conflated with the internal and implicit regularities that a writing system and its resources display – these are studied by graphematics (cf. Dürscheid 2016: 128) or, if they concern the visual resources of writing, graphetics.

3 In linguistics, the asterisk usually marks ungrammatical structures or utterances (or, in historical linguistics, reconstructed structures). However, in grapholinguistics, the asterisk can signify orthographically – i.e., prescriptively – incorrect spellings (cf., for example, Neef 2005). This use clearly differs from the marking of ungrammaticality, as *<foks>, for example, is not an "ungrammatical" spelling – precisely because it is found in the graphematic solution space of the English word *fox*.

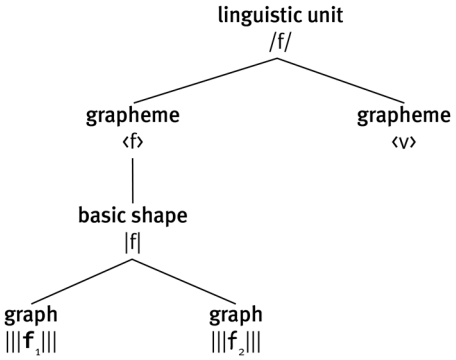

Figure 2: Hierarchy of units of writing systems illustrated by the graphematic representation of /f/ in German

When it comes to the concepts relevant to the description of writing systems, three are central for the ensuing characterization of allography: *graph*, *basic shape*, and *grapheme* (cf. Figure 2).[4] Graphs, which are sometimes also referred to as *glyphs* (cf. Neef 2015: 711), are concrete realizations; each graph is a unique physical event. When writing <matter>, six graphs are produced. Two of these graphs can be subsumed under the same category, |t|.[5] |t| is a so-called basic shape (from German *Grundform*, cf. Rezec 2013). It is "an abstract […] unit" constituted by "a group of geometrical distinctive features which a written mark must have so that a literate person will recognize it as an embodiment of a certain" category (Herrick 1974: 11). Thus, the basic shape is visually defined, but the fact that it is at the same time an abstraction makes it hybrid in being a graphetic unit despite being abstract.[6] What is constitutive for its identity as a unit are its distinctive visual features, and these are the number and nature (including the relative size) of segments of a basic shape as well as the spatial and topological relation between these segments. |X| and |T|, for example, both consist of two straight lines, but these lines are arranged differently in space and are characterized by different junctions.[7] As will be shown below, |a| and |ɑ| are distinct basic shapes precisely because they differ in the mentioned visual features. While they are obviously related, this relation manifests itself only at a higher level, the level of graphemes, the grapheme being the third central unit in the description of writing systems. The definition and even usefulness of the grapheme have often been debated, up to the point where some scholars claim it is a concept that should be abandoned (cf. Share and Daniels 2016: 23). A detailed characterization is obviously beyond the scope of this paper. It suffices to say that even though |a| and |ɑ| are visually distinct, they are – in most writing systems[8] – assigned to the same grapheme, in English <a>.[9] In brief, in

4 This trichotomy is not new. It was described, for example, by Rezec (2013), but renditions of it – using different terminology – were mentioned as early as in Veith (1973).

5 Graphetic units are enclosed in vertical strokes | | and graphematic units in angle brackets < > (cf. Berg & Evertz 2018: 190). Since I want to make a further distinction between different graphetic units, basic shapes – as the central graphetic units – are enclosed in single vertical strokes | |, while graph classes are enclosed in double vertical strokes || || and concrete graphs in triple vertical strokes ||| |||. This precise differentiation might seem cumbersome, but a notational differentiation is necessary.

6 For an analogy in phonetics/phonology, consider the sounds listed in the IPA. They are categories of sounds that differ phonetically. They are not concrete sounds (i.e., phones), but without the context of a given language's phonology, they are also not phonemes. These sounds in the IPA are to phonetics and phonology what basic shapes are to graphetics and graphematics.

7 The switch from the concrete graph level to the abstract basic shape level also highlights the difference between *signal* and *symbol graphetics* (cf. Günther 1990). As these designations imply, signal graphetics deals with signals, i.e., physical events, and studies them with methods from the natural sciences. Symbol graphetics, on the other hand, is interested in the categories to which these physical events can be assigned, and, crucially, in the possible value these categories have for linguistics.

8 Note that in IPA, which is, however, not a writing system (but cf. Neef 2015), |a| and |ɑ| have distinct values.

9 The symbol that is used for the notation of a grapheme – an abstract emic unit – is, in theory, arbitrary. What is commonly chosen is the basic shape that materializes the grapheme. In cases in which there is more than one basic shape for a grapheme – as in |a| and |ɑ| – different criteria can be prioritized to make a choice. These criteria do not have to be

the present framework, a grapheme semiotically relates a basic shape (or multiple basic shapes) to a linguistic unit[10] (or multiple linguistic units). A grapheme must (1) differentiate meaning as in <far> vs <for>, must have (2) linguistic value, i.e., refer to a linguistic unit, such as the <a> in <far> which corresponds with the phoneme /ɑ/,[11] and must (3) be minimal, i.e., must not consist of units that are themselves graphemes: <ng> in <sing> is not a grapheme since there are minimal pairs for both constituents such as <sing> vs <sink>, meaning <n> and <g> are graphemes individually (cf. Meletis 2019). Since, in English, there are no minimal pairs for |a| and |ɑ|, they are not separate graphemes but variants of one grapheme, i.e., allographs (cf. Section 4.1).

3 Graphetic variation and allography

Wherever there is writing, there is graphetic variation.[12] Every person who writes by hand has individual handwriting, and typographically, thousands of typefaces exist for most of the world's scripts, including Roman, Cyrillic, Arabic, and Chinese.

When writing by hand, each person's handwriting has a specific visual appearance and so does every typeface. Different people's handwriting and different typefaces (or even just styles of typefaces such as the roman, bold, italic styles of a given typeface, e.g., Times) can be conceptualized as so-called *inventories*. Prior to the writing process, an inventory is fixed either by the fact that the person who is writing by hand has specific handwriting or, in the case of typing, by the choice of a given (style of) typeface. Crucially, inventories are visually distinct: though there may be remarkable similarities between them, the appearance of handwriting inventories usually differs from writer to writer, and typefaces, i.e., typographic inventories, too, vary in visual respects, even if sometimes only slightly.[13] Note that even the visual appearance of a *single* person's handwriting inventory commonly varies depending on the communicative writing situation (including formality and the relationship between writer and addressee – in cases in which there is an addressee) but also due to physiological and motor factors

sophisticated: in this article, |a| is chosen for the grapheme <a> because it is the default in the typeface in which the paper is set. In theory, the very same grapheme could also be written as <ɑ>, |ɑ| being the default in handwriting, for example.

10 I am thankful to an anonymous reviewer for pointing out that it is odd to state that graphemes are related to linguistic units, since graphemes are themselves linguistic units. This is certainly true. However, I do want to note that the status of phonemes, morphemes, etc., vs graphemes as linguistic units is indeed different, rendering the picture a bit more complex: phonemes and morphemes are units of language that not only exist in every language system but are constitutive of language systems. Graphemes only exist in languages that are equipped with writing systems (and there do exist many languages without them) and are, thus, logically dependent on preexisting "linguistic units" such as phonemes and morphemes. Without wanting to adhere to the dependency hypothesis (cf. Dürscheid 2016: 36 f.), it can be stated that due to the phylogenetic and ontogenetic differences between phonemes, morphemes etc., on one hand, and graphemes on the other hand, the former are linguistic units of a first order and the latter linguistic units of a second order. When I speak of "linguistic units" in this article, I refer to the former.

11 Criterion (1) is typical of the analogical definition of the grapheme, where graphemes are discovered analogously to phonemes by means of (structuralist) minimal pairs, whereas criterion (2) is typical of the referential definition of the grapheme, where graphemes are defined as depictions of phonemes (for a review of these competing views, cf. Meletis 2019: Section 2.4). And, notably, in recent alphabet-based approaches of German grapholinguistics, the grapheme is defined as the lowest suprasegmental unit in a hierarchy of suprasegmental graphematic units (cf. Berg et al. 2016).

12 Variation is not only to be understood in a syntagmatic sense in which the different tokens of one type are compared with each other but also in a paradigmatic sense in which types are related to other types. Even if someone was to produce only a single graph, this graph would be a variant – in a paradigmatic sense – of all the graphs that could have possibly instantiated a given basic shape. As Spitzmüller (2013: 212) observes, variation is not choosing between different possibilities of graphically communicating "something", as this "something" is rather constituted by the choice in the first place.

13 As Hamp (1959: 2) remarks, "[m]any of these [typefaces, D.M.] are characterized in such subtle ways that the average person is not aware of their individuality as such".

such as fatigue (cf. Parush et al. 1998) or external aspects of the writing process such as pen pressure, pen grip, speed, etc. (cf. Van Drempt et al. 2011).

Since handwriting (or chirography) and print (or typography) pose different challenges to allography, they are often separated (cf. Fuhrhop and Peters 2013: 207). Once their differences have been dealt with, however, there is no reason not to consider both in the same conceptualization of allography. They differ mainly in the visual similarity between graphs: When writing <cabana> by hand or when typing it, six graphs are produced. Obviously, in this word, whether handwritten or printed, three of the six graphs are visually similar or, in print, almost identical. Due to the manner in which it is produced, handwriting is not constant, but dynamic in its appearance. Thus, graphs that are assigned to basic shapes will never look exactly the same. For <cabana>, there is, of course, a theoretical possibility that two or even all three of the graphs instantiating |a| look exactly the same, at least to the human eye, even if the likelihood is much greater that they differ visually at least in some details. This variability of graphs applies to handwriting more so than to print, i.e., typographically produced or digitally presented writing, since typefaces are usually constant.[14] In print or digital typography, therefore, the possibility of making a conscious style choice at the level of graphs is limited to the choice of typeface itself, and this choice either precedes or follows the writing (or typing) process. Thus, the potential of sociosemiotic self-referencing is not granted directly by the appearance of the typeface, which the producer of a text typically has no influence on, but rather by the choice of a preexisting typeface.[15] Then, once a typeface has been chosen, the graphs that are materialized and assigned to basic shapes are visually constant.

The first type of allography to be addressed is *graphetic allography*. It is constituted by the relationship between graphs which are assigned to the same graph classes and graph classes which are assigned to the same basic shapes (cf. Figure 3). Visual similarity is a deciding criterion the same way phonetic similarity is a deciding criterion in allophony: units must always be visually similar both to each other and to the visual configuration of the abstract unit at a higher level in order to be regarded as graphetic allographs. Visual similarity is defined by a similar or identical (1) number of segments that two (dis)similar units are composed of, the (2) relative size of these segments, their (3) arrangement in the writing space, and their (4) topological configuration, i.e., (dis)connections, junctures, etc. There are two types of *graphetic allography*, and the difference between them is constituted by the notion of *inventory* introduced above.

3.1 Intrainventory graphetic allography

The first subtype is *intrainventory graphetic allography*. As mentioned above, what precedes the writing process is the choice of an inventory: when a person decides to write by hand, the inventory is their handwriting, and when a person decides to write typographically, the inventory is the (style of) typeface they choose. Against this background, reconsider the production of the written word <cabana>. Whether in handwriting or in print, when this word is materialized, three graphs are produced that are visually (very) similar.[16] Since it is uncommon (although not impossible) to switch to another inventory within the context of a single written word (as in <cabana>), these three instantiations are members of the same

14 This claim must be relativized. Even when set in the same typeface, different graphs of a basic shape can differ within the same printed product of writing. Just to give an example: when the ink of a printer is slowly running dry, the color and quality and even shape of the individual graphs on a page might differ noticeably (Andi Gredig p.c.).

15 Note that people simply might not change the default typeface preset in an application, for example, Calibri (or in the past Times New Roman) in Microsoft Word. In this case, they have not actively chosen a typeface and might not even have given the use of typeface a thought. Notably, this non-choice can also have sociosemiotic potential, i.e., convey information about the producer of a given document.

16 Note that all graphs in a (style of a) typeface – not just the ones instantiating the same basic shape – are in a way visually uniform, e.g., with regard to stroke weight, stroke contrast, and stress angles. This so-called font regularity (cf. Gauthier et al.

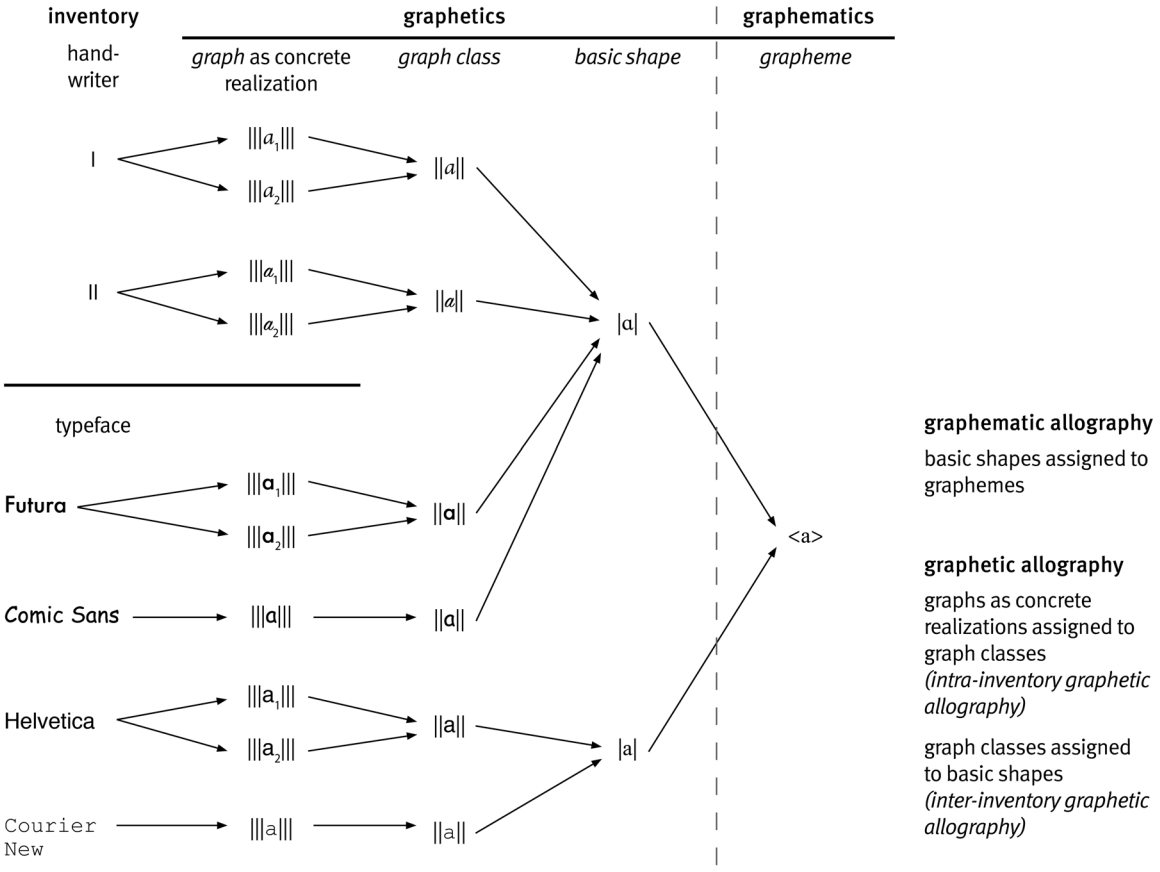

Figure 3: Overview of type-token-relationships in allography.

inventory. In this context, a first abstraction can be performed and concrete graphs can be assigned to the so-called *graph classes*. Graph classes capture the fact that three graphs produced in the same inventory will be more visually similar than |||a||| is to |||a|||, two graphs from Courier New and Arial, respectively. Visually similar graphs within a given inventory are referred to as *intrainventory graphetic allographs*.

They are in a syntagmatic relation as they occur simultaneously on a linear axis in slots in which allographs of the basic shape |a| need to be produced. Note that they are also in a paradigmatic relation: they are members of the same graph class and, in turn, the same basic shape |a|, but they are not identical due to being concrete unique physical objects. In theory, intrainventory graphetic allographs are not bound to a given position, meaning they are substitutable for each other within a given syntagma (e.g., the word <cabana> or a larger context such as a document set in one typeface or written in a given person's handwriting). This means they are (relatively) free allographs. However, since they are located at the lowest etic level, where, especially in cursive handwriting, coarticulation is of relevance, there are limitations to the notion of free.[17]

2006: 555) has a beneficial effect on reading processes as the processing system "[tunes] itself to exploit regularities of a font" (Sanocki and Dyson 2012: 133).

17 At the concrete level of production, in handwriting, coarticulation plays a certain role: at least in cursive handwriting, graphs that are produced are connected to each other and may adapt their shape to the graphs that precede and follow. Therefore, even intrainventory graphetic allographs might not be completely substitutable. In typography, too, there are types of coarticulation such as ligatures: for some combinations of basic shapes, in many typefaces, special connections are programmed, as for the combination of |f| and |i|. Thus, a concrete |||i||| that is produced after an |||f||| might not always be substitutable for a different |||i|||, even if that different |||i||| occurs in the same word, cf. <finish>.

3.2 Interinventory graphetic allography

Interinventory graphetic allography concerns allographs from different inventories: in the three instantiations <cabana>, <cabana>, and <cabana>, distinguished by the use of different typefaces, three different graph classes are associated with the basic shape |a|: ||a||, ||a||, and ||a||. Thus, *interinventory graphetic allography* is paradigmatic in nature, as ||a||, ||a||, and ||a|| constitute a paradigm, the paradigm "possible instantiations of the basic shape |a|". Note that they are not concrete graphs but graph classes. In larger contexts, e.g., whole layouts in documents, books, etc., interinventory graphetic allographs can co-occur if different typefaces are used next to each other, which is common (e.g., sans serif typefaces for headings, serif typefaces for running text).

Interinventory graphetic allography subsumes the above-mentioned intrainventory allography (cf. Figure 4): in <cabana>, for example, only one interinventory graphetic allograph (the graph class ||a||), but three intrainventory graphetic allographs of |a| are produced (which are underlined). This is the case regardless of which inventory is used to write the word. The crucial difference between the two types is that, as the name implies, interinventory graphetic allographs do not occur in the same context and are determined by the inventory that is used. A Courier New graph |||a||| only occurs in the inventory "Courier New", an Arial-|||a||| only in the inventory "Arial". To sum up, intrainventory graphetic allography is largely a syntagmatic phenomenon (and marginally a paradigmatic one), while interinventory graphetic allography is an exclusively paradigmatic phenomenon. As they are subtypes of graphetic allography, for both, visual similarity is crucial.

3.3 Suprasegmental graphetic variation

While I would reserve the term *allography* for segmental alternations, graphetic variation occurs not only at the segmental level, i.e., the level of individual graphs. Take as an example the sentence <I do *not* believe this is true.>. Here the main function of the visual feature *italics* or more generally, the switch to a different inventory, is to indicate a contrast, to conceptually distinguish the word printed in italics from not only the other words in the sentence but also the other paradigmatic possibilities that could have been produced in its slot, mainly the nonitalicized <not>. Its function, thus, is contrastive, and it only works suprasegmentally, since if an italicized word occurred in isolation or all words in a sentence were italicized, no such contrast would be constituted (cf. Meletis 2015: 144–150). Even if this contrastive suprasegmental function can be interpreted as linguistic, as it most certainly involves linguistic levels – textual, pragmatic, discourse levels – it is not regarded as denotative, since the sequence of graphemes materialized by the graphs in <*not*> still corresponds with both the same phonological

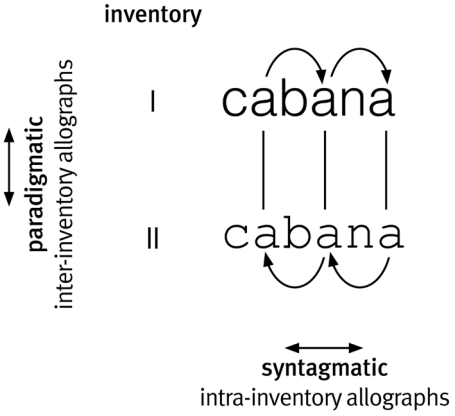

Figure 4: Intrainventory and interinventory graphetic allographies.

representation and the same semantics as the nonitalicized <not>.[18] This is one of the central reasons the etic level of writing is so often discarded in linguistic research.

4 Graphematic variation and allography

Whereas graphetic allography was concerned with graphs being assigned to graph classes and to basic shapes, graphematic allography is concerned with basic shapes being assigned to graphemes. Visual similarity was a necessary criterion for graphetic allography, but it is not for graphematic allography, i.e., graphematic allographs can exhibit visual similarity but do not have to. This way, graphematic allographs are conceptually similar to allomorphs, which can but do not have to be phonologically similar.

For the distinction between the subtypes of graphematic allography, three criteria are relevant:

(1) *intrainventory* vs *interinventory*: this category describes whether allographs occur within an inventory.
(2) *free* vs *positional*: positional allographs are complementarily distributed with respect to different positions; their use is conditioned by the system. The (initial) choice of free allographs is free; it is, to a large degree, a stylistic choice.
(3) *externally independent* vs *externally determined*: the default types of graphematic allography are based on graphematics alone, whereas the externally determined types are determined by other linguistic levels such as syntax or pragmatics. Since externally independent allography is the default, only externally determined types will be explicitly marked in the terminology.

A phenomenon that will not be considered as allographic in the narrow sense is *orthographic variation*, defined as variation that does not stem from the resources of the graphetic and graphematic modules but from the system-external codification of orthographic rules. For the distinction between graphematic and orthographic variation, the additional criterion (4) *systematic* vs *normative* can be proposed (cf. Section 5). Since systematic variation is the default, only normative variation will be explicitly marked in the terminology.

4.1 Interinventory free graphematic allography

The first type of graphematic allography is referred to as *interinventory free graphematic allography*. In writing systems using Roman script, it is exemplified by the pairs of basic shapes |a| vs |ɑ| and |g| vs |ɡ|,[19] respectively. At first glance, these pairs might appear like instances of interinventory graphetic allographs (cf. Section 3.2). However, crucially, they are not sufficiently visually similar. Basic shapes, including these four, are, as established above, defined by the number of segments, the relative size of these segments, their arrangement in space, and their topological configuration. In these regards, |a| vs |ɑ| differ, as do |g| vs |ɡ|, and also |b| as characteristic for print and |𝒷| as characteristic for cursive handwriting, to name just a few examples. By contrast, in order to count as graphetic allographs, two graphs may not differ with respect to these features.[20] Crucially, thus, basic shapes cannot be grouped together based on visual criteria. Nothing makes |ɑ| visually more similar to |a| than to |o|, so visual

18 Note, however, that the prosodic properties of the entire sentence – if read aloud/spoken – might be changed.

19 In a recent study, it was found that most participants were unaware of the fact that aside from |ɡ|, there is a second variant, |g|. They could not retrieve this second variant from memory and had trouble recognizing it when it was presented together with a series of ill-formed distractors (cf. Wong et al. 2018).

20 There must be some leeway for visual variation, however, otherwise readers would not be able to categorically perceive different graphs as members of the same basic shape. This variation is often of geometric nature, i.e., the relative size/length of segments differs from one graph to another, cf. |A| vs |𝖠|. In the latter, the horizontal stroke in the middle of the basic shape is

criteria could lead to wrong categorizations at the level of basic shapes. This renders this type of variation graphematic rather than graphetic: what is decisive to identify two basic shapes as allographs is that they are assigned to the same grapheme, i.e., that they are functionally equivalent. For example, in most writing systems using Roman script, |a| and |ɑ| are allographs because they are assigned to the same grapheme <a>. They are not graphemes themselves since they do not differentiate meaning in minimal pairs such as English <ask> and <ɑsk>. This also means they both typically relate to the same linguistic unit in a given writing system, e.g., the phoneme /ɑ/. They can substitute each other, but they typically only do so *across* inventories: they are paradigmatic, i.e., interinventory allographs. As such, they are – similar to interinventory graphetic allographs Courier New-||a|| and Arial-||a|| – complementarily distributed with respect to inventories.

Accordingly, when a typeface uses |a|, it will not simultaneously use |ɑ| – with the exception of different styles of typefaces, as in Times New Roman, for example, where the roman variant uses |a| and the italic variant uses |*a*| (cf. Rezec 2013: 245–247).[21] Accordingly, styles such as bold and italics within one typeface are also conceptualized as distinct inventories.

As the designation for this type of allography implies, the *choice* between |a| and |ɑ| is, in principle, free, but after a choice has been made, the use of either variant is constant. In this vein, Rezec (2013: 245) speaks of consistency rules, which can be illustrated with the example ?<egg> which at the very least looks strange to the eye. For handwriting, it seems plausible that people who use |a| stick to it, at least within one text. Their preferred choice of basic shapes can certainly also change as handwriting inventories evolve over time. Also, there exists no explicit (orthographic) rule claiming that even within one text, a person may not freely alternate between |a| and |ɑ|, although, as mentioned, this is uncommon.

Another well-known example of this type of allography comes from Cyrillic script. Here, the basic shapes associated with a grapheme are conditioned by the use of cursive handwriting vs print. The default basic shape for the grapheme <т> is |т|, but in cursive handwriting, the visually dissimilar |*m*| is used. Other notable examples include |г| and |*г*| for <г> as well as |д| and |*д*| for <д>, with the first listed allographs being used in print and the second in cursive handwriting. Note that this alternation occurs also in typographic writing, as italic styles of Cyrillic typefaces often use the cursive allographs.

In Chinese, there exist the so-called *yìtǐzì* (異體字) or *variant characters*, i.e., basic shapes that are in a graphematic relation with the same morpheme.[22] They are also *interinventory free graphematic allographs*. Galambos (2015) provides examples: |峰| and |峯| for *fēng* "mountain top", |群| and |羣| for *qún* "group, flock", and |册| and |冊| *cè* for "booklet" as well as |裏| and |裡| for *lǐ* "inside". In these examples, the same two subcomponents of basic shapes are either positioned next to each other, i.e., horizontally, or on top of/below each other, i.e., vertically.[23] Even though the different basic shapes, respectively, consist of the same components, they differ visually in a salient way due to the different spatial arrangement of these components, loosely[24] similar to the way |L| and |T| are distinct basic shapes although they consist of two straight lines. Moreover, due to positional constraints, components of Chinese basic shapes commonly change their form when occurring in different positions inside basic shapes (see below). Aside from these examples which are characterized by the use of the same components, there are other examples such as

shorter in length, which is why the two diagonal strokes are positioned more closely to one another. This is an example of geometrical variation, which is perceptually less salient than topological variation (cf. Changizi et al. 2006: E119).

21 Herrick (1974: 11) even remarks that the latter basic shape, |ɑ|, is "considered typical of the suprasegmental grapheme 'italics'".

22 Many thanks to Zev Handel for his helpful answers to my questions about *yìtǐzì* which have shaped this part of the paper.

23 "[...] the vertically stacked one is viewed as more 'correct' but because it is difficult to squeeze in all the components, the horizontally-arranged one is preferred for readability" (Zev Handel p.c.).

24 Note that this comparison is reductive since the subcomponents of Chinese graphemes are most often complex, i.e., themselves made up of simpler components (such as lines), and often already have a graphematic function themselves, i.e., signaling meaning or phonological representation, whereas the lines that constitute |L| and |T| are not complex and do not have graphematic functions. Chinese graphemes, thus, are doubly articulated (cf. Ladd 2014: Chapter 5.4.2), whereas the letters of Roman script are not (but cf. Primus 2006 for a different view regarding Roman lowercase letters).

|詠| and |咏|, two basic shapes which share only one component but still both represent the same morpheme *yǒng* "to chant". Evidently, here, different basic shapes are associated with the same grapheme that refers to a specific morpheme.[25] The use of these different variants is not positionally restricted – it is free. However, as is the case for |a| vs |ɑ|, the use of a variant is conditioned by the inventory that is used, which means it would be strange if two variants of the same grapheme appeared in the same portion of a text. By contrast, it is acceptable in contexts in which more than one typeface is commonly used, e.g., entire layouts.

Something that must be mentioned at this point is that the choice of variants, even if it falls under the category of "free", might not be entirely free but conditioned by sociolinguistic factors. In this context, Bunčić (2016) describes the phenomenon of *biscriptality*. From a sociolinguistic perspective, written variation can be diaphasic (conditioned by registers and style), diastratic (conditioned by social strata), diamesic (conditioned by the conceptual dimension of written vs spoken, cf. Koch & Oesterreicher 1985), diatopic (i.e., geographical), medial (depending on the writing material), ethnic, confessional, etc. (cf. Bunčić 2016). Since this article is concerned with the structural dimension of variation, these sociolinguistically relevant conditions for variation are not elaborated further at this point.

4.2 Intrainventory positional graphematic allography

The second type of graphematic allography, *intrainventory positional graphematic allography*, is the type most often mentioned in the literature. The most popular example of this type is the alternation between the visually dissimilar basic shapes |σ| and |ς| in the writing system of Greek. Since both of these basic shapes occur in different positions within the same text instantiated in the same inventory, they are of the intrainventory type. Consider the pronoun <σας> /sas/ "you (2nd pers. pl. gen./acc.)"/"your" in which both shapes occur.

While both of these basic shapes differentiate meaning, there are no minimal pairs |σ| vs |ς| since they always occupy different positions: |σ| occurs word initially and word medially, |ς| only occurs word finally. Thus, they are complementarily distributed with respect to word position. However, occurring in different positions alone would not suffice to assume these basic shapes as graphematic allographs of one grapheme. For that, it is necessary to establish that both basic shapes are in a graphematic relation with the same linguistic unit: the phoneme /s/. Note, however, that representing the same linguistic unit alone also does not suffice to assume allography (cf. Section 4.4).

A different well-known example of intrainventory positional graphematic allography is Arabic. Graphemes in the Arabic writing system have up to four positional allographs: there is always a free (or isolated) basic shape of a grapheme, and since the shapes in Arabic script are always connected, there are connected (or ligated) shapes which are dependent on whether they are positioned initially, medially (in the middle of two other basic shapes), or at the end of a string of basic shapes. For example, the grapheme <ب> has |ب| as its isolated form, |بـ| as its initial form, |ـبـ| as its medial form, and |ـب| as its final form. A number of graphemes are exceptions: <وزرذدا> do not have allographs that connect to the left (the writing direction in sinistrograde Arabic script), so they only have two allographs, an isolated shape and a shape that connects to the right (cf. Majidi 1996: 5).

Thus far, examples have only concerned the alternation of basic shapes, i.e., graphetic units that occupy a whole segmental space on the writing surface (cf. Meletis in press). There are, however, also cases of intrainventory positional graphematic allography that are subsegmental. Take the components of complex graphemes in Chinese. These components – regardless of their function – can change their shape depending on where in the segmental space they are positioned. Radical number 61, the heart radical,

25 Qiu (2000: 299–300) lists eight categories of this type of allography in Chinese. Note, however, that for most of the examples he gives, the respective allographs cannot be exchanged since only one of them is the "present standard or current [form]".

appears as |心| as an independent character; notably, when positioned at the bottom of compositional characters, it is |忄|, while when it occurs on the left, it is 忄. Radicals are not graphemes themselves since they do not meet all of the relevant criteria (cf. Section 2); however, they are subsegmental graphetic units that do have certain graphematic functions (cf. Meletis 2019: 38–39).

4.3 The special case of case

An additional type of allography is controversially debated in the literature. It concerns only those writing systems whose scripts offer two corresponding sets of uppercase basic shapes (or *majuscules*) and lowercase basic shapes (or *minuscules*). This concerns the Roman, Cyrillic, Greek, and Armenian scripts and raises the question of whether upper- and lowercase basic shapes which are conventionally paired together are two separate graphemes or allographs of one grapheme. For English, Sampson (2015: 16, emphasis in original) claims unequivocally – yet *en passant* – that "<g> and <G> would not belong to a single grapheme; [...] the upper versus lower case distinction is significant". For the German writing system, in which capitalization is a more complicated matter, there exist two differing opinions. One of these is that case is lexically distinctive and thus upper- and lowercase basic shapes belong to two different graphemes. Indeed, minimal pairs can be found: <Arm> "arm (as in limb) *noun*" vs <arm> "poor *adjective*". Crucially, however, these contrasting words are not paradigmatic since, as instances of different parts of speech, they cannot occur in the same position in a sentence. The second opinion is that capitalization of words at the beginning of sentences as well as sentence internally can be explained with recourse to other linguistic levels (cf. Fuhrhop & Peters 2013: 207 f.). In any case, there is not one "capitalization" but there are instead various types of capitalization in German: the mentioned sentence-initial and sentence-internal capitalization, but also capitalization of address pronouns (*Sie*/*Ihre* "[formal] you, your"), capitalization of proper nouns, capitalization of conventionalized idioms (such as *Schwarzes Brett* "bulletin board"), and all caps.

Sentence-initial capitalization is what unifies all writing systems whose scripts exhibit a case distinction. In this position, majuscules function to signify the start of a graphematic sentence, as minuscules cannot be used sentence initially (cf. Schmidt 2016). Sentence-initial capitalization, thus, is indeed a form of complementary distribution conditioned by position and, thus, an instance of the above-mentioned *intrainventory positional graphematic allography*.

Sentence and even word internally, where lowercase basic shapes are the default (cf. Primus 2006: 9), capitalization can also occur, e.g., in the form of all caps. If a whole word in a graphematic sentence is capitalized, as in <I do NOT believe this!>, then this represents a form of *suprasegmental graphematic variation*. Similar to highlighting a string of text in bold print or italics (cf. Section 3.3), it changes the visual appearance of a word (or sequence of basic shapes). However, when setting a word in bold or italics, basic shapes are typically kept intact and are still characterized by visual similarity (with some exceptions, cf. |a| vs |*a*| in the different styles of a single typeface, cf. Section 4.1), which is what renders these forms of highlighting suprasegmental graphetic variation. By contrast, changing a string of graphemes to all caps equals substituting lowercase basic shapes for respective uppercase basic shapes associated with the same grapheme. Given that these shapes often do not exhibit visual similarity, this is a graphematic matter.[26]

The capitalization of address pronouns such as <Sie> "you pl." can be explained either pragmatically, arguing that capitalization is an expression of politeness toward the addressee, or simply orthographically, since capitalization of plural address pronouns is an orthographic rule in German. This leaves one critical case of German capitalization open for discussion: sentence-internal capitalization. Some attribute

26 Note that this may be different in writing systems using Cyrillic script, in which there is visual similarity between uppercase and lowercase basic shapes for most graphemes as lowercase basic shapes are in most cases just smaller variants of uppercase basic shapes, see e.g., |Ж| and |ж| (cf. Lockwood 2001: 309).

it to the noun as a part of speech, positing that all nouns require capitalization. However, nowadays, a more fine-grained syntactic explanation has largely superseded this view: syntactically, heads of noun phrases are capitalized (cf. Maas 1992; Primus 2010: 30).

Evidently, virtually all of the contexts in which capitalization occurs are determined by external factors, i.e., syntactic, pragmatic, orthographic, etc. The third of the criteria for graphematic allography listed above, externally determined vs externally independent, subsumes these different cases of capitalization in German. All of them are instances of *externally determined intrainventory positional allography*, with the external determinant unspecified since it must be identified distinctly for each type. The alternation between uppercase and lowercase basic shapes is deemed positional rather than free since the allographs are complementarily distributed: take a sentence-internal capitalized noun such as <Essen> "food" in <Das Essen schmeckt gut.> "The food tastes good". In this sentence, the lowercase version <essen> (which graphematically represents the verb "to eat") is not orthographically licensed since that spelling would lead to an ungrammatical syntactic representation of the sentence (literally translated as *"The to eat tastes good"). The random capitalization of individual basic shapes that are not word initial is also not orthographically licensed, so it would be incorrect to write *<Das EssEn schmeckt gut.>.[27] Obviously, uppercase basic shapes have certain contexts in which they are licensed, while lowercase basic shapes – as the default – occur in all other contexts.

To sum up, in the context of this proposal of types of allography, uppercase and lowercase basic shapes do not instantiate distinct graphemes but are allographs of the same graphemes.

4.4 Nonallographic types of graphematic variation

In the hierarchy of units of writing systems, allography as proposed here stops at the level of graphemes: while basic shapes assigned to the same grapheme (and, thus, representing the same linguistic unit) are allographs, graphemes which represent the same linguistic unit are *not* allographs. This is a trivial observation: since they are already separate *graphemes*, they cannot simultaneously be allographs. They are, however, graphematic variants of some sort. To distinguish between these two cases, Berg's (2016: 17) typology is useful: *graphematic variation in the narrow sense* includes variation between written units that does not correspond with a change in phonological representation, meaning, or categorical structure.[28] As such, it corresponds with allography as defined here. On the other hand, *graphematic variation in the broad sense* includes variation between written units that corresponds with changes in phonological representation and/or meaning and/or categorical structure. <far> and <fɑr> is a case of graphematic variation in the narrow sense and, thus, allography, while the pair <far> and <for> corresponds with a change in phonological representation, meaning, and categorical structure and is thus an instance of graphematic variation in the broad sense – *not* allography.

In the literature, there exist misconceptions about allography that are closely linked to the referential definition of the grapheme (cf. Lockwood 2001) and the associated dependency hypothesis (cf. Dürscheid 2016: 36 f.) which is based on analyses of alphabetic writing systems and regards graphemes "as those units that 'stand for' phonemes in written language, i.e. as phoneme signs" (Kohrt 1986: 84). This view is confronted with several problems. As Günther (1988: 76) points out, if graphemes are derived from phonemes, there is no need for the concept of grapheme to begin with, as they would simply be written labels for phonemes. In this view, allographs are those units that are used to write one phoneme, which leads to the theoretically and terminologically absurd situation of assigning allographs to a phoneme

27 The all caps version <Das ESSEN schmeckt gut.> would, however, be licensed. Here, the uppercase basic shapes cease to have any grammatical function and, as a suprasegmental form of highlighting, serve other functions instead.

28 Categorical structure is the sum of an expression's morphosyntactic constituent structure, i.e., {noun, singular,...} for a word like *song* (cf. Berg 2016: 14).

instead of to a grapheme. Take, for example, <f>, <v>, and <ph> in German. They are *not* allographs of a grapheme <f> simply because they can all correspond with the phoneme /f/. <ph> is disqualified since <p> and <h> are already graphemes individually, cf. the minimal pairs <Hass> "hatred" vs <Pass> "passport" and <Haar> "hair" vs <Paar> "pair". Also, when these graphemes occur together word internally and do not represent /f/, they are separated by a morpheme (and syllable) boundary, cf. English <hop.head>, German <Knapp.heit> "shortage", <Desktop.hintergrund> "desktop wallpaper", <Top.hits> "top hits". Also, there are minimal pairs <ph> vs <v>, resulting in a difference in meaning due to the fact that <v> can also represent the phoneme /v/: <Phase> "phase" vs <Vase> "vase". In cases in which they both represent the same phoneme /f/, graphematic[29] minimal pairs are still possible: <Phon> "phone" vs <von> "from". <f> and <v> are also not allographs solely on the basis that <f> always and <v> sometimes corresponds with /f/. There are (even if only few) minimal pairs in which they both represent /f/, e.g., <Vetter> "cousin" vs <fetter> "fatter (comparative of fat)", <viel> "much" vs <fiel> "(he) fell", <Feilchen> "little file" vs <Veilchen> "violet". Additionally, there are minimal pairs where <v> and <f> refer to /v/ and /f/, respectively, such as <Verse> "verses" vs <Ferse> "heel" or <Vokal> "vowel" vs <fokal> "focal". Evidently, <f> and <v> can occur in the same positions in the syllable and the word, although their distributions are not symmetrical.[30]

Another difference between <f> and <v> and |σ| and |ς| is that the latter two exclusively represent the same linguistic unit. They do not have the potential to represent phonemes other than /s/. In the case of <f> and <v>, <f> corresponds with /f/, a correspondence that is unambiguous and context free (cf. Neef 2005: 56). <v>, however, commonly also refers to /v/, a phoneme that is by default represented by <w>. With respect to <v>, Neef (2005: 69–71) speaks of an underdetermined correspondence rule, as it sometimes refers to /f/, sometimes to /v/. In order to be allographs of one grapheme, |f| and |v| would have to have stable correspondences with the same single linguistic unit, e.g., the phoneme /f/ – just as |a| and |ɑ|, |σ| and |ς|, and |N| and |n| do, respectively. A single minimal pair in a writing system suffices to disqualify them as allographs.

For an example from a nonalphabetic, abugidic (cf. Daniels 2017 for a definition) writing system, take Thai. In Thai, the existence of 42 basic shapes that are in graphematic relations with only 21 consonant phonemes results in a complex multi-grapheme-phoneme-correspondence, i.e., a situation in which multiple graphemes correspond with a single phoneme. They are graphemes, however, and not allographs, since there exist minimal pairs. The differently written words in these pairs have the same phonological representation but different meanings. Consider <พาย> /phaay/ 'paddle' and <ภาย> /phaay/ 'part (of space or time)' (cf. Brown 1988: 44). The contrast is constituted by <พ> vs <ภ>. Even though the shapes |พ| vs |ภ| are in a graphematic relation with the same phoneme, they are still part of two distinct graphemes precisely because of the existence of minimal pairs. These types of heterographic homophones in Thai are treated extensively in Brown (1988: Chapter 4). What must be noted at this point is that an analysis of graphematic variation in Thai is further complicated by the fact that lexical tones are marked in a graphematically suprasegmental manner, i.e., constituted by multiple factors including also features of consonant graphemes. Thus, whether two units in Thai are allographs can frequently not be decided simply and solely on a segmental basis (i.e., with minimal pairs).

29 Note that this is not technically a minimal pair as there are two basic shapes that together form a contrastive graphematic sequence instead of only one grapheme (such as <f>) that contrasts with <v>. Also, while graphematically, it is the consonant(s) in the onset that form a contrast, phonologically, it is the vowel: <Phon> has the phonological representation /foːn/ while <von> is decoded as /fɔn/.

30 In word-final position, <v> is very rare. It mostly occurs in the suffix <-iv> as in <attraktiv> "attractive". Note that here, it corresponds with /f/ because of final obstruent devoicing in German. In other forms of the paradigm, it corresponds with /v/ as in <attraktive> since the syllable boundary precedes it: <attrakti.ve>.

5 Orthographic variation

One type of variation that is marginal since it falls out of the realm of graphematics is *orthographic variation*. Here, the fourth criterion of allography comes into play, (4) systematic vs normative. All of the types of allography described above are systematic, which means that in each case, allographs are licensed units of the graphetic and graphematic modules and the variation between them is an inherent feature of the writing system. Orthographic variants do not fit neatly into this picture – they are normative in the sense of representing a standard that does not have to correspond to the inner regularities of the writing system.

There exist many words that have more than one orthographically codified spelling. In some cases, these words differ not only in one segment but are distinct in more than one respect. Examples in German are *<Majonäse> and <Mayonnaise> "mayonnaise", *<Bravur> and <Bravour> "bravery", and *<Wandalismus> and <Vandalismus> "vandalism", where the respective first variants, however, as highlighted by the asterisks, are old variants since they were deemed incorrect by the Council for German Orthography in 2016 (cf. Duden 2017: 18). Orthographic variants, crucially, are not part of the system if they are decided on by orthographic authorities and are not motivated by users' actual use of the writing system. Note that if two variants are licensed orthographically, users must choose between them and stick to their choice within a text for reasons of consistency. In this sense, orthographic variants are also of the interinventory type.

6 Conclusion

The bundle of phenomena that can be subsumed under the heading of structural variation in writing has not been treated systematically in the literature. This has various reasons, the most important of which is the lack of established comparative concepts and terms that would allow a comparison of different types of writing systems within a single framework. Against the background of a multimodular model of the structure of writing systems and the universal definition of the basic concepts of writing – graph, basic shape, and grapheme – a systematic analysis of allography becomes possible and reasonable.

Table 1 gives an overview of the two main types of allography proposed in this article. *Graphetic allography* captures variation at the lowest levels of writing. It hinges on the criterion of visual similarity and is, in this vein, conceptually similar to allophony. Concrete graphs are categorized into graph classes,

Table 1: Types of allography

	Externally independent		**Externally determined**
Graphetic allography	**Intrainventory** graphs → graph classes	**Interinventory** graph classes → basic shapes	
Visual similarity necessary	|||a_1|||, |||a_2||| → ||a||	||ɑ||, ||a||, ||ɑ|| → |ɑ|	
Graphematic allography	**Intrainventory** **Positional** basic shapes → graphemes	**Interinventory** **Free** basic shapes → graphemes	**Intrainventory** **Positional** lowercase and uppercase basic shapes → graphemes
Visual similarity not required	|σ| (default), |ς| (word-final) → <σ> |n| (default), |N| (sentence-initial) → <N>	|a|, |ɑ| → <a> |ᴛ| (print), |*m*| (cursive handwriting, italic print) → <ᴛ>	|n|, |N| → <n> (in all cases except sentence-initial capitalization)

which are abstractions of what graphs in an inventory – someone's handwriting or a given typeface – typically look like. These graph classes are in a paradigmatic relation and are allographs of a basic shape, the most abstract graphetic unit characterized by salient visual features required for categorical perception. *Graphematic allography* describes how basic shapes are associated with graphemes. In order to be allographs of a grapheme, basic shapes do not need to be visually similar. Accordingly, graphematic allography can be compared to allomorphy, where allomorphs can exhibit phonological similarity but do not have to. Two types of graphematic allography are distinguished based on the question of whether allographs occur in the same context, i.e., the same inventory used for writing. This leads to a characterization of the relevant criteria in the assumption of subtypes of allography.

Besides visual similarity, a decisive criterion is whether allographs can occur within the same (part of a) text instantiated in the same inventory. If they cannot, they are in a paradigmatic relation that depends on the inventory chosen to produce a text. A person who uses the basic shape |ɑ| to instantiate the grapheme <a> in their handwriting will likely not switch to |a| within the same text. If allographs do occur together in an inventory, they are complementarily distributed with respect to position: the positional allographs of an Arabic grapheme logically occur simultaneously within a text if the grapheme in question can occupy multiple or all positions within a word. While they are distinct criteria, *inter- vs intrainventory* and *free vs positional* are expected to only occur in the combinations *interinventory free* and *intrainventory positional*.[31] Note that "free" in this case means that the choice of a variant is free: when writing by hand, one can choose between |g| and |ɡ|, and when typing, one can choose a typeface that uses either |g| or |ɡ|. But once a choice has been made, the use is not "free" in that one can freely alternate between |g| and |ɡ|.

The difference between interinventory graphematic allography and intrainventory graphematic allography can also be captured as a difference between *stylistic* vs *systematic allography*. Using either |ɑ| or |a| is a personal – and free – choice that, essentially, boils down to style or other (e.g. sociolinguistic) factors (cf. Bunčić 2016). It means choosing one of a series of inventories including different possible allographs, sticking with the choice throughout the writing process, and thereby discarding all the other allographs. Intrainventory graphematic allography, on the other hand, is systematic in that all allographs are simultaneously integral parts of the system. If one wants to write in Arabic, all positional allographs need to be used in their specific positions. There is no choice.

More marginal cases of variation in writing include graphematic variation in the broad sense, i.e., when different graphemes or sequences of graphemes have the potential to refer to the same linguistic unit (e.g. phoneme, morpheme) but still produce minimal pairs that constitute a lexical contrast, cf. German <viel> "much" vs <fiel> "(he) fell" where both <v> and <f> refer to /f/ but are lexically contrastive, making them graphematic variants in the broad sense but not allographs. Moreover, there exist orthographic variants that are dependent on the externally codified standardization of the writing system. Spelling reforms, etc., produce variants that – at least for some time – are codified as coexisting correct variants and thus, similar to intrainventory allography, give users a choice (or, seen differently, require a choice from them).

This proposal of types of allography is only a descriptive starting point. It needs to be refined by means of more examples from a greater typological variety of writing systems, primarily with examples from the often highly complex abugidas that exhibit different allographic phenomena (cf., for some examples, Meletis 2019: 39–41). Finally, the next necessary step in attaining a better understanding of allography is to investigate how the proposed typology reflects the psychological reality of how written variation is processed by readers and writers. In this context, this proposal can serve to systematize the existing research and to guide the design of future research.

31 They are distinct criteria because there is at least the theoretical possibility of *intrainventory free* and *interinventory positional allography*. An analysis that incorporates data from even more of the world's diverse writing systems might reveal instances of these types of allography.

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