Category overlap and neutralization: The importance of speakers' classifications in phonology*

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Abstract

This article briefly reviews categorization models in both cognitive psychology and cognitive phonology in order to set the background for a psycholinguistically plausible account of the classification of the allophones involved in category overlaps (i.e., the overlapping areas between phoneme categories) and in the so-called positions of neutralization. In addition, the traditional proposals of both Bloomfieldian phonemics (i.e., phonetic similarity) and the Prague School (i.e., archiphonemes) are discussed and an alternative proposal is offered. The latter claims that phonological theory should be informed by psycholinguistic evidence obtained by experimental methods. This line of research will progressively make cognitive phonology a functional phonological theory consistent with the way speakers classify the sounds of their language and will contribute to theoretical progress in phonological theory.

Keywords: *cognitive phonology; categorization; category overlap; neutralization; archiphonemes.*

1. Introduction. Phonemes, classification, and models of categorization: Providing a background

The phonological units called "phonemes" have traditionally been regarded in three different ways: first, as families of phonetically similar sounds (e.g., Gleason 1955; Jones 1918); second, as phonological constructs defined in terms of oppositions (e.g., Trubetzkoy 1939); and third, as psychological or conceptual entities (e.g., Baudouin de Courtenay 1895; Sapir 1933). The definition of phonemes as conceptual entities, with which this article is concerned, has persisted as a thread throughout the history of phonology. More recently, cognitive phonology, a

Cognitive Linguistics 15–4 (2004), 429–469 0936–5907/04/0015–0429

functional phonological theory born within cognitive grammar (e.g., Lakoff 1987; Langacker 1987) and advocated by Nathan (1986, 1994, 1996, 1999a, 1999b) and Taylor (1989, 1990, 1998), has also discussed this view of the phoneme. Under this paradigm, phonemes may be considered as conceptual categories instantiated by phonetically different sounds that speakers classify as members of the same category. As a consequence, the term "phoneme category" is sometimes used to refer to such categories.

The present work assumes the conceptual view of the phoneme as a conceptual category to which speakers assign different sounds and, within the framework of cognitive phonology, deals with the phenomena of "category overlap" and "neutralization". The notion of category overlap refers to the fact that two or more phoneme categories may be instantiated by the same type of allophone (e.g., [ɾ] may be an instance of both /t/ and /d/), whereas neutralization, a well-known Praguean structuralist notion, refers to the lack of phonetic contrast between two phoneme categories in a specific phonetic context (e.g., the contrast between /t/ and /d/ after tautosyllabic /s/). Both category overlap and neutralization, reconsidered in light of the view of phonemes as conceptual categories to which people assign phonetically different sounds, are phenomena for which speakers' classifications may be worth examining in detail. In this respect, this article intends to offer a psycholinguistically plausible account of the classification of the sounds involved in category overlaps and in the so-called positions of neutralization which is supported by some evidence from psycholinguistic studies. In addition, the account provided in this article departs from traditional solutions to the classification of the sounds involved in the so-called positions of neutralization such as proposals based on the American structuralist criterion of "phonetic similarity" or the Praguean theory of the "archiphoneme".

The phenomena of category overlap and neutralization can essentially be considered as classification problems and classification is, in turn, a central part of the fundamental human cognitive ability of categorization. As a consequence, a preliminary discussion of some essential aspects in relation to categorization is necessary here to better understand the suggestions provided in this article to account for the classification of sounds in category overlaps and positions of neutralization. Some of these aspects include the nature of both the classification process and human conceptual representation as proposed by different models of categorization.

Although categorization involves more than just classification, researchers have often discussed the former with reference to classification.[1] Definitions of categorization like "the process by which people assign objects to categories" (Smith 1990: 33) or "a cognitive process in which people decide whether an instance is a member of a category by comparing the instance with their conceptual representations" (Lin and Murphy 1997: 1153) illustrate the point. However, although classification (or the assignment of items to conceptual categories) is generally considered as an essential aspect of categorization, accounts of the workings of this process vary depending on what is assumed to be stored for those categories. For many years, researchers have tried to ascertain how concepts or categories are stored in memory. In order to account for mental storage and classification, several models of categorization have been devised and tested. These can be divided into four main types (see Barsalou 1992; Medin and Smith 1984; Mervis and Rosch 1981; Smith and Medin 1981 for reviews).

The first type of model is based on the "classical view" of categorization. This view holds that a concept stored in memory is an abstract summary description made up of "defining" features. These features have been previously shown to be possessed by absolutely all the items classified as instances of the category or concept. The assignment of a new entity to a category is made only if the entity possesses all the features of the category's summary description, which are necessary and sufficient to determine category membership.

The classical view of categorization provides an intuitively appealing account of classification and the nature of conceptual structure. In fact, it was taken for granted as an unquestionable truth for centuries in many disciplines. Despite this, the view began to run into numerous problems uncovered by an enormous body of experimental evidence obtained mainly during the 1960s, 1970s, and 1980s. This body of evidence gave rise to alternative models of categorization that could account for the problems that plagued the classical view.

Probabilistic models of categorization became a serious alternative to classical models in the psychological literature of the 1970s and the 1980s. Probabilistic models maintain that a concept is an abstract summary description containing a set of "probabilistic" features. These features are those which have been shown to have a substantial probability of occurring in instances previously classified as members of the category. Probabilistic models of categorization account for the classification of items in the following way: the assignment of a new item to a given category is determined by whether or not the instance is sufficiently similar to the summary generalization of that category.

A different set of proposals generally called "exemplar" models also emerged as an alternative to both classical and probabilistic models of categorization during the 1970s and 1980. Exemplar models argue that a category is normally represented by separate descriptions of some of its specific instances or "exemplars". The assignment of a new instance to a category is determined by whether the instance is sufficiently similar to one or more of the category's known exemplars.

A third alternative to the classical theory of categorization came from mixed probabilistic-exemplar models of categorization. These models represent an integration of the proposals of both probabilistic and exemplar models. Mixed models argue that the representation of a category contains both generalizations and a collection of specific exemplar memories. They also claim that the assignment of an item to a particular category is determined by whether the instance is sufficiently similar to either the abstracted summary representation of the category or to one or more of its known exemplars.

In retrospect, mixed models of categorization were highly successful because they addressed most problems that strict probabilistic or exemplar models posed (e.g., failure to store information about specific exemplars and failure to account for numerous generalizations that people know about categories respectively). A mixed model explains, for example, why specific exemplar memories may be more accessible on some occasion, and hence the major determinant of classification, while at other times it is the generalization abstracted from category members. However, although mixed models of categorization provided a better theoretical understanding of categorization and conceptual structure, they typically shared the same problems that were common in both probabilistic and exemplar models. Amongst these were their failure to account for context effects, to represent more knowledge in concepts, and to provide constraints on possible attributes and categories.

The attempt to solve these problems motivated in part the second of two major shifts in categorization research (Medin 1989; Murphy 1993). The first one is the shift from the assumption that conceptual representations have defining properties (the classical view) to the idea that they contain properties that are only characteristic of category members (the probabilistic, exemplar, and mixed views). The second shift consists in considering conceptual representations as being organized around "theories" instead of being exclusively structured by similarity. It should be mentioned that, as far as the first shift is concerned, practically all of the otherwise different models proposed as alternatives to classical models of categorization share the following three assumptions. First, summary representations or exemplar memories are described as independent collections of features. Second, conceptual coherence is based on similarity: members of a category seem "coherent" and belong to the category because they are similar to one another and dissimilar to members of other categories. Finally, classification is driven by similarity (Medin 1989; Medin and Wattenmaker 1987; Murphy and Medin 1985). Classification is believed to involve a feature matching process and computation of feature similarity carried out by the cognitive system between a to-be-classified entity and the conceptual representation (summary abstraction, exemplar memories or both) with which the entity is compared. Entities are classified as instances of a category by virtue of the attributes they share with the stored representation of the category. The likelihood of assigning some entity to a category depends on the entity's reaching some "threshold of similarity" to the category representation.

However, categorization researchers soon began to note problems with these assumptions. First, conceptual representations do not seem to be satisfactorily described in terms of collections of features. As Barsalou and Hale (1993: 142) express it, collections of features are "like a few pieces of a dinosaur's skeleton discovered by a paleontologist in that they provide hints of the dinosaur's overall structure but are far from constituting it completely". Second, the notion of similarity seems too unconstrained to give a satisfactory account of conceptual coherence. It is not at all clear whether some members belong to the same category because they are similar or whether they are similar because they are in the same category. Similarity could be a by-product of conceptual coherence rather than its determinant. Third, even if classification is driven by similarity, the problem of how it is decided what should count as a feature discredits the feature-matching process and comparison of feature similarity assumed by probabilistic, exemplar, or mixed models of categorization. These models do not explain why certain features of a concept are relevant to conceptual representation and are used in the feature matching process while others are not. Unless constraints specify some properties as relevant and others as irrelevant, similarity becomes a meaningless construct.

The dissatisfaction with similarity-based models of categorization led to the emergence of the "theory-based" view of conceptual structure and categorization, the second major shift in categorization research. As mentioned above, the shift consists in viewing concepts as being organized around "theories" instead of being exclusively based on similarity. Theories are the set of beliefs that people have about the interrelations and causal connections between the features of a concept and between concepts themselves. According to Rips (1995), the beliefs in question may be sketchy, naive, stereotyped, or incorrect. Therefore, theories are "any of a host of mental explanations rather than a complete, organized, scientific account" (Murphy and Medin 1985: 312). As the term "theory" is polysemous and somehow ambiguous in the sense being discussed, other terms like "background knowledge" (Lin and Murphy 1997), "complex knowledge structures" (Murphy 1993), "naive theories" (Rips

1989), "intuitive theories" (Barsalou 1992), or even "mini-theories" (Rips 1995) have sometimes been used to avoid possible confusions with other senses of the word "theory" in the now extensive literature on "theories".[2] In addition, other, similar kinds of knowledge structures have been proposed by cognitive scientists, such as "frames" (e.g., Fillmore 1985), "scripts" (e.g., Schank and Abelson 1977), "mental models" (e.g., Barsalou 1992), "idealized cognitive models" (Lakoff 1987), etc.

The "theory" view of conceptual structure and categorization improves on probabilistic, exemplar, and mixed models of categorization in the following ways. First, it rejects the view of concepts as lists of independent features. The theory-based view explains why and how features are tied together to form a coherent concept, that is, the interproperty relationships in which features participate. Furthermore, it also rejects the view of concepts as independent units of knowledge. Concepts are interconnected with one another in rich knowledge structures in much the same way as the features of the concept itself. The theory view of conceptual structure holds, then, that a theory does not exist independently of its concepts and that a concept is partly defined by the theories into which it enters (Murphy 1993). This is in direct opposition to traditional theories of conceptual structure, which represent concepts in ways that fail to bring out the relationship between conceptual and theoretical knowledge.

To illustrate this, consider the concept of "car". According to the view of conceptual structure held by similarity-based categorization models, the concept (a summary representation, exemplar memories, or both) can be defined by a set of independent features. These include, amongst others, the following: "has wheels", "has doors", "has windows", "has a metal body", "has an engine", "transports people or goods", etc. On the contrary, the theory view assumes that the features are interconnected by the background knowledge that people have about cars, which refers to the "causal, underlying beliefs about how various components of a car fit or work together to give rise to its function as a vehicle" (Lin and Murphy 1997: 1153). Thus, a belief such as "the engine turns the wheels, enabling the car to move about, and being able to move about in turn is a critical function of a car" in which the features are related to one another in different ways which would be considered as part of the knowledge associated with the concept and thus, as part of its conceptual representation. This knowledge is, in addition, part of a wider background knowledge structure or "theory" in which the concept of "car" is embedded: the "journey" theory. This "journey" theory, as Lakoff claims (1987: 78), involves a structured scenario that specifies the steps to be followed in a journey (e.g., you have access to the vehicle, you get into it and start it up, you drive, row, fly, etc. to your destination, you park and get out, you are at your destination, etc.). In addition, the "journey" theory provides appropriate interrelationships amongst concepts and so, the concept of "car", for instance, is interconnected with other concepts like "driver", "goods", "traffic", etc.

Second, the theory-based model also improves on similarity-based models of categorization as it notes the insufficiency of similarity as a general explanation of conceptual coherence. In fact, some classifications blatantly contradict perceptual similarity (like classifying a "dolphin" and a "bat" as "mammals" and not as "fish" or "bird" respectively). Coherence can be achieved, according to the theory view, in the absence of any obvious source of similarity. However, the theory view does not claim that similarity is a useless determinant of conceptual coherence and that underlying beliefs about the nature of categories are the sole factor contributing to conceptual coherence. Recent reassessments of similarity testify to its importance in conceptual coherence (e.g., Goldstone 1994; Hahn and Chater 1997). What the theory view maintains is that both knowledge-based and similarity-based determinants of conceptual structure are not mutually exclusive but equally necessary for a complete account of category structure and conceptual coherence (Murphy 1993).

Finally, theories specify the relevant features of conceptual representations. Theories easily justify why certain features are chosen and represented in concepts while others are not. In general, theories constrain similarity by selecting (as well as by interpreting and integrating) the properties of category members (Murphy and Medin 1985). In addition, the theory view acknowledges that, once the features of a domain are known and the relevant aspects of similarity defined, feature matching processes may provide an adequate account of classification (Murphy 1993). According to Rips (1995), deciding whether a particular instance belongs to one category or another comes down to determining which theory corresponding to the different categories best explains the properties manifested by the instance.

2. Categorization models and phoneme categories

After this preliminary yet necessary review of the two major shifts in categorization research, the current state of the art of categorization models in cognitive phonology may be better understood. In addition, a new tentative approach to category structure for phoneme categories will be advanced that might prove useful in accounting for the notions of "category overlap" and "neutralization".

As in the case of other areas of linguistics, classical models of categorization in phonology, which have dominated the field for a long time

(Prague School phonology, Bloomfieldian phonemics, classical generative phonology), have been strongly criticized for the same reasons as those discussed in the psychological literature (see, e.g., Taylor 1989: 24–29, 222–238). In an attempt to propose alternative models of category structure and conceptual coherence for phoneme categories, two models born within the framework of cognitive grammar, the "radial category" model and the "network" model, have already contributed to a departure from such classical models in important ways.

The first of these models, the "radial category" model, was proposed by Nathan (1986, 1996) and has also been more or less endorsed by Taylor (1989) as well as by Cuenca and Hilferty (1999). Following Lakoff (1987), Nathan claims that the internal organization of phonemes categories can be conceived of as a radial category. The adjective *radial* is used in order to evoke the type of relationship amongst the members of the category, a relationship which is similar to an image of the spokes of a wheel.

In a radial category, there is at least one central member or "prototype". In Figure 1, a tentative representation of the phoneme category /t/ in English, the voiceless unaspirated alveolar plosive [t] appears as the category prototype at the center of the category. In addition, other members of the category can be found in different directions.[3] These are exten-

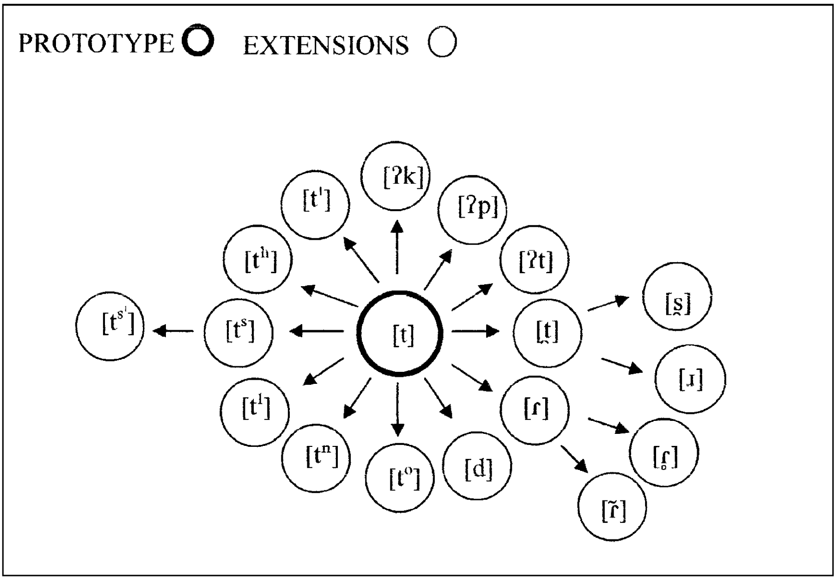

Figure 1. *The category /t/ according to the radial category model*

sions of the prototype (See Gimson 1980: 155–159, 162–163; Jones 1918: 141–144; Kreidler 1989: 108–112; Taylor 1989: 224–225 for details of the realizations of /t/ discussed below). Some of the extensions (e.g., [ʔt], [ɾ], [t^{s}]) are also believed to constitute the basis for further extensions via instance chaining. This means that members may form chains of association with one another, leading further and further away from the prototype to the peripheral instances of the category. Extensions are similar to the prototype but also differ from it in some respects. In the first place, the feature that specifies the place of production of the prototype, (i.e., alveolar) is shared by all members of the category except for [ʔ] (glottal), [t̪], and [s̪] (dental), [t̠], and [ɹ] (post-alveolar), [ʔp] (bilabial) and [ʔk] (velar). In the second place, the feature that specifies the manner of production of the prototype (i.e., stop) is shared by most members of the category except for [ɾ̥], [ɾ] and [ɾ̃] (flap) as well as [s̪] (fricative) and [ɹ] (approximant). In the third place, as far as the state of the glottis is concerned, the prototype is voiceless, a feature shared by most members of the category except for [ɾ], [ɾ̃], [ɹ], and [d], which are voiced. In the fourth place, variations regarding the closure stage of the prototype give rise to different extensions from it: the prototype is not reinforced by a closure (like most members of the category) but [ʔt], [ʔp], [ʔk] are. In the fifth place, variations regarding the values of the release of the prototype (i.e., oral, central, non-aspirated, non-ejective, non-affricated) also produce other extensions of the prototype: these can have a lateral release (i.e., [t^{l}]) or a nasal release (i.e., [t^{n}]). The release can also be aspirated (i.e., [t^{h}]), ejective (i.e., [t']), affricated (i.e., [t^{s}]) or ejective and affricated (i.e., [$t^{s'}$]). The stop can also be unreleased (i.e., [t^{o}]). Finally, the feature that specifies the nasality of prototype (i.e., oral) is shared by practically all members of the category except for [ɾ̃], which is nasal.

From what has been said so far, it can be argued that a phoneme category, defined as the set of its different types of phonetic realizations (or allophonic variants), cannot be defined by a fixed set of common necessary and sufficient features shared by all members of the category; instead, features are unevenly distributed across category members. There is simply no single feature that is shared by all members of the category phoneme /t/ although the realizations of the phoneme category are connected by a network of overlapping similarities. However, what a radial phoneme category specifically suggests is that we cannot understand the connection between a particular member and another without following a trail along the spokes of an imaginary wheel back to the center. It also suggests that adjacent spokes do not necessarily relate directly to one another, but they can, however, all be related to or traced back to the prototype of the category.

An alternative view of category structure for phoneme categories has been suggested by Langacker's (1988) "network" model, widely used by cognitive linguists in syntax, morphology, semantics, etc. Applied to phonology (see also Bybee 1994, 1999; Taylor and Nathan 2001), this model considers phonemes as complex categories in which one particular allophone is considered as the category prototype and other allophones as context-induced extensions from this prototype. These, the model assumes, are assimilated into the category on the basis of perceived similarity to the prototype. As in the case of the radial category model, the category prototype and its context-induced extensions are best regarded as fully specified abstractions over specific instances of sounds rather than as specific phonetic segments.

The "network" model also claims that speakers may extract "schemas". Schemas emerge through people's ability to recognize what is common to the different members of a category with which they are already familiar. The ability to account for highly abstract schemas seems to be the main advantage of the "network" model, as it seems to capture speakers' intuitions that all or many members of the category share certain features.[4] Schemas represent the commonality that speakers perceive in the various fully specified allophones. Admittedly, the notion of schema corresponds rather closely to the abstract, criterial feature approach of the classical view of categorization. In fact, the commonality that schemas embody resembles what has often been called "phoneme" by structuralist phonological theories based on the classical view of categorization like Praguean phonology. However, schemas are not to be identified with the traditional bundles of criterial features (see Taylor 1990: 524–525 for a summary of the differences).

Figure 2 shows the representation of the phoneme category /ɪ/ in English, as in *sit* /sɪt/. The figure includes both the prototype (i.e., [ɪ]), specified as an oral short half-close front vowel of unchanging quality, and some of its context-induced extensions. For instance, /ɪ/ is somewhat nasalized (i.e., [ɪ̃]) when a nasal consonant follows, and it is longer or shorter (e.g., [ɪ.], [ɪː]) depending mainly on the voicing and manner of articulation of the following consonant and the accented/unaccented status of syllables in tone units. In addition, the tongue height and tongue advancement of the prototype vary significantly, being more open ([ë̜] and [ɪ̞]), more retracted ([ɪ̠]), more central and open [ə], and more front and close ([i]), depending on factors such as the position of the vowel in the word and the degree of stress in the syllable containing /ɪ/. Finally, /ɪ/ is often diphthongized (i.e., [ɪə]) when followed by /l/.

Figure 2 also includes the schema embodying the features common to all members of the category (i.e., [ɪ]). The extracted schema is neutral as

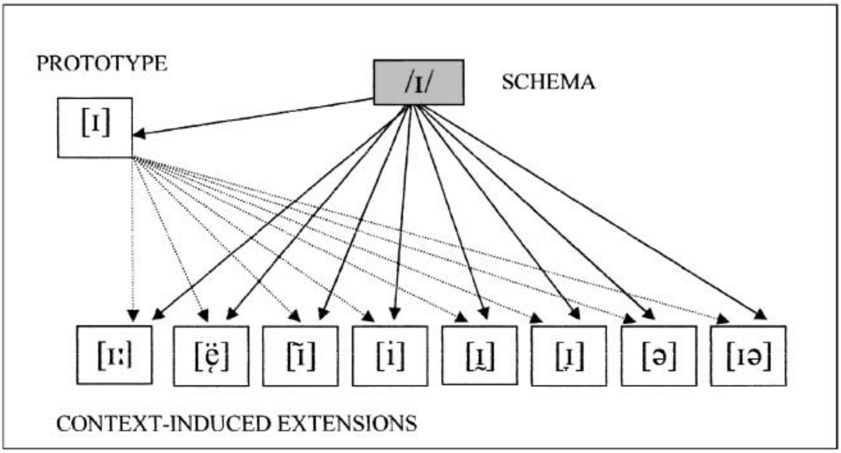

Figure 2. *The phoneme category /ɪ/ according to the "network model"*

to whether and how the basic vocalism of [ɪ] is modified by the phonetic context in which the different realizations appear (e.g., the nature of preceding or following consonants, the stressed/unstressed character of the syllable, speaking rate, etc.).

A common assumption of both the radial category and the network models of conceptual structure is that phoneme categories have a central member or "prototype" (as well as a set of other category members). An important question, then, is to determine what exactly "prototypes" are and whether there is just one prototype per category or whether there are several. In this respect, both models assume that phoneme categories have a single prototype, which is the basic, fully specified allophone of the category. The prototype is therefore not conceived of as a summary representation including a set of necessary and sufficient features shared by all the allophones of the category (the classical view) or including a set of characteristic features shared by most category members (the probabilistic view). Instead, it is a category member that has some sort of privileged status. This view is more in accordance with an exemplar model of categorization, a point better understood if it is assumed that other fully specified allophones are also stored in long-term memory. However, this latter assumption is far from unanimously agreed upon in the existing literature. Nathan, for instance, considers that the only represented sound is the central allophone or "prototype", which he also calls the phoneme (Nathan 1999a: 325–326). According to Nathan, words are stored in memory in a concrete pronounceable form, as a string of real but mental sounds or mental images of audible speech (Nathan 1999a). Those mental but fully specified sounds are the prototypes. On the contrary, the network models permits one to guess that other allophones apart from the prototype are mentally stored. As schemas are generalizations extracted from representations previously stored in memory and retained after the generalization has been learned, the network model assumes that at least some allophones are somehow stored in long-term memory like the intervocalic voiced flaps in words like *latter* or *butter* (e.g., Bybee 1994: 298). In any case, even if the only represented allophone were the prototype, its very definition as a fully specified abstraction over a specific allophone and not as a summary representation would suggest an exemplar model of categorization (although it may only include a single member) rather than a probabilistic or classical model of categorization.

A further relevant question in relation to prototypes is that of what could make a particular allophone acquire prototype status. One of the hypotheses most extensively discussed may be generally called "physiological" (Geeraerts 1988). This hypothesis states that prototypes (at least those in categories with a distinct physiological base) are the consequence of inherent properties of human perception. In this respect, Nathan (1986) has claimed that just as there are colors and forms more perceptually salient than other stimuli in their categories (e.g., Rosch 1973a, 1973b, 1974), some sounds within a category are also more perceptually distinctive than others. Because of this, Nathan claims, they are selected as the prototypes of their respective categories.[5] In addition, Nathan has explained the perceptual salience of prototypes and their privileged status in phoneme categories using some of the proposals of natural phonology (e.g., Donegan and Stampe 1979; Hurch and Rhodes 1996). According to Nathan, in the natural phonology literature a type of process called "fortition" exists that readily explains why some sounds may become the prototypes of their respective phoneme categories. As fortitions are processes that make segments more perceivable by emphasizing specific phonetic features, they presumably select from all possible human sounds those which constitute the prototypes of the phoneme categories of a particular language (Nathan 1986, 1994, 1996). However, apart from fortitions, Natural phonology has proposed another set of principles, known as "lenitions". These processes determine possible relationships between the prototypes of phoneme categories and their contextual extensions (i.e., sounds that are similar to the former but are, because of their phonetic context, more appropriate to their surroundings). Therefore, Natural phonology also offers an explanation for why phoneme categories have "extensions" of the prototype: they are produced by the operation of lenitions.

In what way could the "radial category" model and the "network" model contribute to a departure from classical models of categorization in phonology? Both the radial category and the network models can be considered as improvements over classical phonological models of categorization in the following way: they do not require that all members of a given phoneme category should possess and share a set of necessary and sufficient phonetic features to be classified as such (i.e., as members of that phoneme category). Instead, these models maintain, conceptual coherence and category membership are based on similarity and different allophones may belong to a particular phoneme category even if there is not any single feature that is shared by all of them. As Taylor (1989: 529) expresses it, "it can (and frequently does) happen that the diverse members of a category fail to exhibit any substantive commonality amongst themselves". This is so because, although they do not share defining attributes, allophones are "similar" to the category prototype and/or to one another and precisely their reaching some (usually unspecified) threshold level of similarity makes them members of that category. Dealing with the phoneme category /t/, Taylor (1989: 227) argues that it is possible to establish chaining relationships between the different realizations of a phoneme "on the basis of phonetic similarity between individual members of /t/". Taylor also explicitly claims that allophonic variants are "associated with the prototype on the basis of similarity, in some respect, with the prototype" (1990: 529). He goes on to say that some allophones may become associated with the prototype on the basis of one dimension (e.g., [ʔ] on the basis of the stop articulation) while other allophones may be so on the basis of other dimensions (e.g., [ɾ] on the basis of its alveolar articulation). Similarly, Nathan claims that allophones are fully specified sounds "differing in one or more features from the principal allophone" (1999a: 326). In a similar vein, in their discussion of the phoneme category /n/ in Spanish, Cuenca and Hilferty (1999: 133–134) claim that all its allophones form a coherent category because they are connected by a network of overlapping similarities. Finally, Bybee claims that "phonetic categorization ... depends upon phonetic similarity: two sounds must be highly similar to be considered members of the same category" (1999: 218) and "assignment to a category depends upon phonetic similarity" (1999: 222). In short, by assuming that similarity is fundamental to both conceptual structure and classification, both the "radial category" model and the "network" model account for the difficulty of reconciling the different realizations of a given phoneme category together within the same category without the need for necessary and sufficient features that, according to classical models of categorization, every member of the category should have.

Phonetic similarity is certainly a powerful factor providing conceptual coherence to the members of a phoneme category (and a criterion to assign sounds to categories). However, it seems that an exclusively similarity-based view of conceptual structure and classification for phoneme categories poses the same problems that the theory view of conceptual structure exposed in relation to probabilistic, exemplar, and mixed models of categorization. For example, it is not at all clear whether some allophones belong to a category because they are similar to the prototype and/or to other category members or whether their perceived similarity results from the fact that they, for some reason, are considered as members of the same category. For example, the voiced alveolar flap (i.e., [ɾ]), the voiced frictionless continuant (i.e., [ɹ]) and the voiceless glottal stop (i.e., [ʔ]) are generally considered as instances of /t/ in the specialized literature, but they apparently have very little in common with the category prototype and/or most category members in the phoneme category /t/. What is more, some of the members of the phoneme category /t/ are apparently more phonetically similar to the category members of other phoneme categories than to those of /t/ as is the case of the voiced alveolar flap (i.e., [ɾ]). This flap shares two important phonetic features with the prototype of the phoneme category /d/ (Nathan 1986), namely being voiced and being alveolar. Therefore, if similarity is the primary criterion for assigning sounds to category, it seems surprising to find in many descriptions of the phonetics of English that the voiced alveolar flap is an allophone of /t/.

Regarding phonemes (or phoneme categories) in much the same way as the theory view considers conceptual representations might improve on this situation. The phoneme category /t/, for example, could be conceived of as a category of sounds embedded in a wider network of knowledge structures from which the relevant attributes characterizing the category are drawn. This background knowledge or these "theories" presumably might include the vast and multifaceted knowledge speakers have about language, its users and uses. This knowledge would justify the selection and inclusion of features of different sorts (e.g., phonetic, distributional, orthographic, stylistic, sociolinguistic, phonotactic, lexical, etc.) into the representation of /t/ and provide interconnections between them. In addition, this background knowledge might provide interconnection between different concepts or categories such as different phonemes.

The phoneme category /t/ may again serve as a valid example. Part of the knowledge that speakers have about it presumably involves purely phonetic as well as distributional information, such as the articulatory characteristics of the different types of allophones and the positions in which they occur (e.g., "articulated as a voiceless aspirated alveolar plosive at the onset of a stressed syllable", "articulated as a voiceless unaspirated alveolar plosive after /s/", etc.). Some of the distributional and phonetic knowledge speakers have about sounds may also be connected with stylistic features (e.g., "articulated as a voiceless aspirated alveolar plosive released ejectively at the coda of a stressed (or unstressed) word-final syllable in highly emphatic utterances", "articulated as a voiceless alveolar fricative in post-stress onset positions in rapid speech", etc.). Also, distributional, phonetic and sociolinguistic features may be interconnected (e.g., "articulated as a glottalized or glottal stop in the coda position of a stressed syllable, which is typical of popular London (Cockney), and Glasgow", "articulated as a voiced alveolar flap in post-stress intervocalic positions, which is typical of American English", "articulated as a frictionless continuant in post-stress intervocalic positions, which is typical of some northern varieties of British English"). In addition, orthographic knowledge may be linked to phonetic information (e.g., "any t-sound is spelled with the letter *t*, sometimes with *tt*, or even *th*"). Background knowledge about /t/ also justifies the relationships in which /t/ is involved with other phoneme categories: phonotactic information is a clear example of this (e.g., "the combination /tl-/ cannot appear at the beginning of a syllable") as well as lexical information referring to the items in which the sound appears as words (e.g., "the sound 't' appears in certain sound sequences spelled -*ity* at the end of words"), etc. All these different sources of information illustrate the heterogeneity and richness of the knowledge people have about a phoneme category, a good deal of which could be elicited under appropriate experimental conditions.

It must be pointed out that most of the knowledge associated with /t/ is presumably procedural rather than declarative. Declarative knowledge implies the subjects' ability to reproduce information propositionally (Ryle 1949), something most language users may probably find difficult to do in relation to the different allophones of the phoneme categories of their language. On the contrary, procedural knowledge is represented by means of productions. Once learned, procedural knowledge operates in a rapid, automatic, and unconscious way. Speakers who fully control the phonetics of their language know when, where, and how to pronounce all of the different realizations of a phoneme category although they may not be able to reproduce this information propositionally. As Reber puts it, "although much of what is acquired may eventually be made available to conscious expression, what is held or stored exceeds what can be expressed" (Reber 1989: 231).

After having argued that different sources of knowledge (apart from articulatory or acoustic information) should be taken into account to provide a better account of the conceptual coherence of the members of a phoneme category, it can further be argued that this body of knowledge may be also involved in the classification of sounds as members of phoneme categories. The discussion below focuses on a specific phenomenon in which the assumption that this multifaceted knowledge is useful and used in classification provides a psycholinguistically plausible solution to classification problems in phonology, such as that of the sounds involved in category overlaps and the so-called positions of neutralization.

3. Category overlap and the classification of flaps

Taking for granted that, as Nathan (1994, 1996, 1999a) claims, the prototypes of phoneme categories are produced by fortitions while lenitions are generally responsible for the contextual extensions of the prototype, an interesting phenomenon can be noticed in relation to those extensions: lenitions are the processes that cause phoneme categories to overlap in their instantiations (Nathan 1996). This phenomenon can be referred to as "category overlap", that is, the fact that two (or more) phoneme categories may be phonetically instantiated by the same type of fully specified allophonic variant. This can be illustrated with a typical example of lenition, the process of flapping of /t/ and /d/. Flaps have become a sort of classic example of category overlap (e.g., Nathan 1986, 1996; Taylor 1989) or, as Nathan puts it, a case of "overlapping and interlocking categories" (1986: 219).[6] Similarly Taylor (1989: 227) argues that some allophones of /t/ encroach on the phonetic space of other phoneme categories and that the flap is a possible instantiation of both /t/ and /d/.

Natural phonology explains this phenomenon by assuming that similar lenitive processes operate in both /t/ and /d/ (e.g., Stampe 1987: 294). In the case of /t/, a lenition converts the voiceless alveolar stop (the prototype of /t/) into a voiceless alveolar flap (i.e., [ɾ̥]) as in *hothouse* by the change of an alveolar stop gesture into an alveolar flap gesture. In addition, the prototype may be converted into a voiced alveolar flap (i.e., [ɾ]) as in *city*, by adding a voiced gesture and changing an alveolar stop gesture into an alveolar flap one. Similarly, a lenition turns the prototype of /d/ (i.e., the voiced alveolar stop [d]) into a voiced alveolar flap as in *ready*. The voiced alveolar stop gesture may also be converted into a voiceless alveolar flap, as in *red-hot*, by a process of devoicing, in addition to the change of an alveolar stop gesture into an alveolar flap one.

Be that as it may, it seems that both the voiced and the voiceless alveolar flaps may be regarded as members of two different categories. Figure 3 represents the phoneme categories /t/ and /d/ with their category pro-

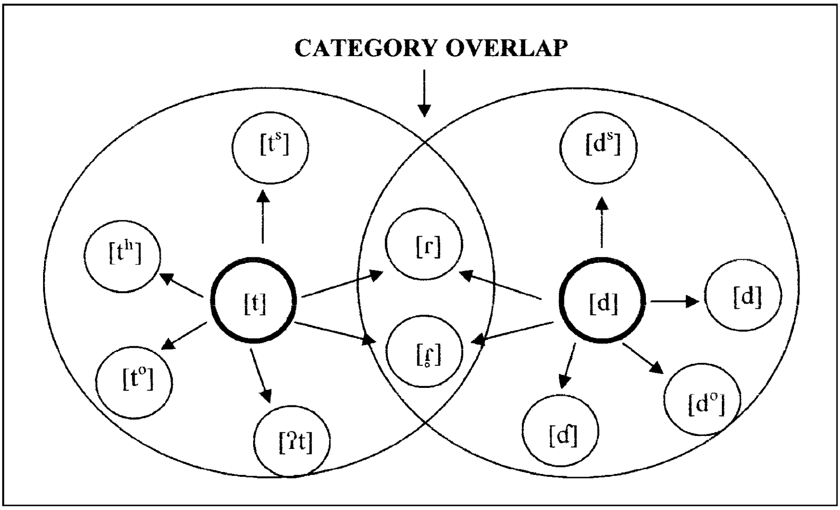

Figure 3. *Category overlap in the phoneme categories* /t/ *and* /d/

totypes at the center, some of their allophonic members and the overlap area occupied by both voiced and voiceless alveolar flaps.[7]

It follows from the notion of category overlap that flaps should be classified as instances of /d/ on some occasions and as instances of /t/ on others. The only problem should then be to determine the specific circumstances under which one or the other classification occurs. However, this assumption is at odds with a classical theory of categorization in phonology. Classical models of categorization assume that a particular allophonic variant (or an actual instantiation of it) should be a member of just one phoneme category in all cases but never of two (or even more) contrasting categories depending on the circumstances. The argument runs as follows: the classical view assumes that judgments about category membership are based on defining properties. Categorizers simply have to compare the defining features of the to-be-classified entity against the category's summary description. If the entity meets all of the necessary and sufficient features defining a certain category, it will be classified as a category member, otherwise, it will not. Partial fulfillment of the features (i.e., partial similarity) will not do. As a consequence, this type of category membership judgments predicts that "unclear" cases, that is, allophonic variants whose actual phonetic instantiations are not classified one hundred percent of the time as members of a given category, should not occur. Category boundaries should be clear-cut. If necessary and sufficient features define membership, it is not possible that a given allophonic variant (or one of its actual instantiations) could be classified as a member of a given phoneme category in one case and as a member of a contrasting phoneme category in another case. This argument has a long history in the phonological literature, where, in the sixties, it went under the heading of the "biuniqueness" controversy (e.g., Chomsky 1964; Chomsky and Halle 1965; Householder 1965). The "biuniqueness condition" expressed the idea that a given sound would always belong to a given phoneme and a given phoneme would always be associated with a given sound. Consequently, the biuniqueness condition implied that physical identity would necessarily lead to linguistic identity. Applied to the voiced alveolar flap, the biuniqueness condition would imply that [ɾ] should always be classified as an instance of either /t/ or /d/, but not sometimes as an instance of /t/ and at some other times as an instance of /d/.

However, the prediction of the classical view that a given entity (in this case a sound) should always be assigned to one and the same category amongst competing categories frequently fails. People often disagree with one another on the same occasion, and even with themselves on different occasions, as to whether some items should be considered as members of a given semantic category or not (e.g., Bellezza 1984; Brownell and Caramazza 1978; Hampton 1979; Labov 1973; McCloskey and Glucksberg 1978; Smith et al. 1974; etc.). This state of affairs is by no means restricted to semantic categories. An enormous amount of research on the identification and discrimination of sounds in the field of speech perception has shown that the assignment of one and the same physical stimulus to either of two phonetic categories varies significantly as a consequence of different factors (see Repp and Liberman 1987 for a review). Probabilistic, exemplar, and mixed models of categorization have never had problems in explaining such results. Probabilistic models claim that unclear cases appear when an instance is not sufficiently similar to the summary representation of a category, when it is similar to the summary representations of more than one category, or both. Exemplar models of categorization maintain that unclear cases arise when instances are similar to the exemplar memories of more than one category or when they are not sufficiently similar to the exemplars of any category. Mixed models of categorization embrace, of course, both explanations.

Like the similarity-based psychological models of categorization mentioned above, both the "radial category" model and the "network" model readily account for the fact that flaps (as idealized allophonic variants or as actual occurrences of such variants) may be classified as members of different categories. Since these models assume that conceptual coherence is determined by similarity, they implicitly assume that flaps may be classified as members of both /t/ and /d/ because they are sufficiently similar to the prototypes and/or category members of /t/ and /d/ to be considered as category members.

However, several questions remain insufficiently explained by those models. For example, it is unclear on what basis a voiced alveolar flap can be classified as an example of /t/ on a particular occasion and as an example of /d/ on another occasion. A "phonetic similarity"-based feature-matching process between an instance of a flap and the prototypes of phoneme categories may be insufficient to provide a satisfactory account because it does not explain what would motivate the variation in category assignment. On the contrary, if the information relative to the conceptual category retrieved at the time of classification were not exclusively limited to the phonetic features of the to-be-classified sound but also included information of different epistemological sorts (as mentioned at the end of section 1), the classification of flaps might be more satisfactorily explained. An example may illustrate this. An experimental classification task might instruct speakers to decide whether different flaps appearing in the post-stress intervocalic positions of different words are instances of either /t/, /d/, or any other category. After hearing words like *comedy* (i.e., [ˈkɒməɾi]) or others like *ready, lady*, etc., subjects would probably classify the flaps in these words as examples of /d/. It is likely that, if that were the case, the criterion of perceived phonetic similarity could be readily evoked to explain such classificatory behavior: people classify the flaps as a /d/, it might be argued, because the latter are phonetically similar to the prototype of the phoneme category /d/ or are perceived as such. Now imagine that speakers were made to hear flaps in words like *pretty* (i.e., [ˈprɪɾi]) or others like *city, reality*, etc. and they then classified the flap in these words as a /t/. Although it might be claimed that the flaps are also classified as a /t/ because they are phonetically similar to the prototype of /t/, other explanations are plausible or should also be considered. For instance, American speakers (at least) may retrieve the knowledge that words like *pretty* or *city* can optionally be pronounced with a voiceless alveolar stop (i.e., [t]) for the sake of emphasis or formal reasons (stylistic information) and also the spelling form conventionally associated with it. These two pieces of information (stylistic and orthographic) constitute part of the background knowledge people have about /t/[8] and which could be used to classify the flap in those words as an instance of the phoneme category /t/.

Another example of the insufficiency of a phonetic similarity–based explanation of the category membership and category assignment of a given sound to either of two or more competing phoneme categories is provided by countless examples of assimilatory phenomena in connected speech. As far as the phoneme category /t/ is concerned, it must be noted that syllable final /t/ assimilates readily to a following /p/ and /k/ so that the place of articulation of /t/ changes from alveolar to bilabial (e.g., *that pen* ['ðæʔp ˌpen]) or from alveolar to velar (e.g., that cup ['ðæʔk ˌkʌp]) as well as being reinforced by a glottal closure. As Gimson claims (1980: 294), although such changes are normal in colloquial speech, native speakers are usually unaware that they are made (see also Brown 1977: 58; Kreidler 1989: 99; O'Connor 1973: 250). However, if speakers were made to classify the modified stops in question most answers would probably be /t/ rather than /p/ or /k/. If this impression were confirmed, a phonetic similarity–based explanation would find it hard to explain, for instance, why subjects classified the [ʔp] in ['ðæʔp ˌpen] as an instance of the phoneme category /t/ and not of the phoneme category /p/. On the contrary, if other sorts of knowledge that speakers probably use to classify [ʔp] as an instance of /t/ were taken into account, a theoretical explanation for this classification would be more satisfactory. For example, people know that ['ðæʔp ˌpen] is spelled *t-h-a-t p-e-n*, that the sequence has two words, that the first word has three "sounds" and that the final sound of the first word (i.e., *that*) is "a t-sound" which is spelled with the letter *t*.

So far we have been assuming that speakers may use information other than merely fine phonetic cues to classify sounds as members of phoneme category but what evidence is there to support this assumption? As far as orthography is concerned, Jaeger (1980a: 156–158) claimed that many subjects in her experiments were consciously accessing the spelling of each word while classifying different instances of the phoneme category /k/ as members (or nonmembers) of that category. In fact, five out of nine subjects in her experiments reported that they visualized spelling as a strategy to assign sounds to /k/. The use of spelling as a criterion to classify sounds as members of phoneme category becomes even more obvious if we consider the classifications that American pre-school children make of flaps, which is well documented. In this respect, Read (1971: 16, 1986: 29) noticed that American children wrote words like *letter* or *pretty*, with a *d*, (i.e., *ladr* and *prede* respectively). Similarly Treiman (1993: 130–131) noticed that flapped /t/ in nonderived words was spelled with *d* or *dd*, rather than with *t* or *tt* in twenty-point-seven percent of first graders' attempts to spell the flap (e.g., *wodr* for "water"). These classifications (as reflected by spelling behavior) seemed to represent the perception of the voiced alveolar flaps in those words as more similar to a voiced alveolar stop than to a voiceless alveolar stop, the prototypes of /d/ and /t/ respectively. However, Treiman also noticed that flapped /d/ in nonderived words was also represented with *t* or *tt* twenty-two-point-nine percent of the time (e.g., *nobutty* for "nobody"). Discussing the same phenomenon, Read (1986: 19–30) suggested that pre-school children might have learned from adults that the flaps are sometimes spelled with *t* and therefore use the standard spelling, which they nonetheless sometimes applied inaccurately at the beginning. In a similar vein, Ehri and Wilce (1986) also found that children learning to read and spell who heard sentences containing nonderived words like *letter, butter*, etc. and were asked whether each word contained a "t-sound" or a "d-sound" also provided similar inconsistent answers for basically the same reasons.

However, at a later stage of development, noticing or learning that specific lexical items like *reality* are written with *t*, the typical spelling form of /t/, children may change their classifications of flaps. They may, in addition, reshape the phonological representation of the word as stored in long-term memory.[9] Children's eventual acquaintance with spelling conventions finally makes them classify the flap in words such as *reality* with a /t/. According to Treiman, Cassar and Zukowski (1994: 1336),

> phonology and orthography are closely related systems that interact during development. The phonemic status of some phones, such as flaps in noninflected or derived words, is established as a consequence of learning how the flaps are symbolized in print.

In addition, an important role has already been attributed to orthography in the phonemicization of the alveolar flaps in words like *latter* or *ladder* (e.g., Skousen 1982; Treiman et al. 1994). This is a stage that adult literate language users have already reached: following an orthographic criterion, adults typically classify flaps in words like *city* as /t/ rather than as /d/.

Another type of information that speakers use in assigning allophones to phoneme categories is the distribution of allophones in words. Using a concept-formation experimental technique, Ohala (1983, 1986) made subjects learn a category consisting of words containing [kʰ], which we could call "phoneme category /k/". Positive items in the learning session included words containing [kʰ] while negative instances contained items beginning with [g̊] in words like *gore* and items with [k] like *score* in which the [s] had been spliced off. When subjects performed a test session, in which they had to decide whether words exemplified the category they had learned in the learning session and they were presented with examples like *score* (in which the [s] had not been spliced off), they included such words in the category "words with [kʰ]". This result showed that despite physical identity, voiceless unaspirated velar plosives are considered as members of the category /k/ when they occur after [s] but they are considered as nonmembers when they appear in initial position. In Ohala's experiments, subjects clearly followed a distributional criterion to assign sounds to phoneme categories rather than a strictly phonetic one.

A further type of information that speakers use in assigning sounds to phoneme categories is the tacit (or more or less explicit) knowledge of morphological relationships between words (e.g., Carlisle 1988; Fowler and Liberman 1995; Nunes et al. 1997a, 1997b; Templeton 1989; Templeton and Scarborough 1985; Treiman and Bourassa 2000; Treiman and Cassar 1996; Treiman et al. 1994). For instance, Treiman, Cassar and Zukowski (1994) examined children's spellings of words like *dirty, biting, attic*, or *water* pronounced with voiced flaps. These researchers found that even kindergartners produced significantly more correct spellings of flaps when there was a stem that could help them, as with *dirt-y* or *bit-ing* than when there was no such a stem, as with *attic* or *water*. Thus even young children seem to have some ability to detect some morphological relationships and use them to override the tendency to commit a sound-based error (i.e., representing the voiced alveolar flap in *dirty* with the letter *d*, as they sometimes but less often do).

Finally, one of the strongest sources of evidence of the use of nonacoustic information influencing the classification of sounds whose category membership is uncertain probably comes from studies on the "lexical" effect in word recognition tasks (e.g., Connine and Clifton 1987; Connine et al. 1993; Fox 1984; Ganong 1980; Newman et al. 1997; see also Barsalou 1992: 244–247). The lexical effect refers to the finding that perception of an ambiguous phonetic segment is affected by the lexical status of the spoken word in which the segment occurs. For example, in a typical experiment, subjects presented with a series of stimuli ranging from *beef* to *peef* and from *beace* to *peace* are asked to classify the initial sound as being either a /p/ or a /b/. In doing so, they are likely to classify intermediate, ambiguous stimuli in the *beef–peef* series as starting with /b/. Also, they are bound to classify the same intermediate stimuli in the *beace–peace* series as beginning with /p/. Ambiguous phonetic segments are then classified as being members of whichever category makes them a real word (*beef* and *peace* respectively). Therefore, it appears that listeners often determine the identity of the phoneme only after having identified the word.

In short, the classification of alveolar flaps as members of either the phoneme category /t/ or the category /d/ is only satisfactorily accounted for if we take into account various sorts of knowledge (which speakers have actually shown to use) and do not exclusively rely on the phonetic features of the flaps themselves, although these are also important.

4. Neutralization and the archiphoneme revisited

The notion of category overlap and the possibility that flaps can be classified as members of more than just one category evokes what over half a century ago Bloch (1941: 66–67) called "complete phonemic overlapping", which the American linguist discussed in opposition to "partial phonemic overlapping". Complete phonemic overlapping implies that some instances of a particular allophone are classified as members of a certain phoneme category on some occasions and as members of another category in other cases even when all instances occur under the same phonetic conditions.[10] If the discussion in section three is accepted, complete phonemic overlapping can be exemplified by flapped /t/ and /d/ in words like *reality* and *comedy*. Under the same phonetic conditions (e.g., post-stress, intervocalic position), the voiced flap occurs as an instance of /t/ in *reality* and as an instance of /d/ in *comedy* and so it falls within the definition of "complete phonemic overlapping" or "category overlap".

Intuitively reasonable as it may seem, the idea behind complete phonemic overlapping has seldom been accepted by linguists, particularly structuralists. The usual practice in Bloomfieldian phonemics when an allophone could be classified as an instantiation of more than one category with apparently equal justification was to choose the most phonetically realistic solution.

As far as flaps are concerned the criterion of "phonetic similarity" would predict that flaps in words such as *comedy* and *reality* would always be classified as members of /d/ (see for example Gleason 1955: 294–295). This is supposedly so because the voiced flap is more phonetically similar to /d/ than to /t/. For most linguistics, however, this explanation might seem satisfactory for the flap in *comedy* but perhaps not for the one in *reality*. The classification of the flap in *reality* as a /d/ seems to run counter to the linguist's (and the linguistically naive speaker's) intuitions precisely because it fails to take into account average adult literate speakers' knowledge that the word *reality* can optionally be pronounced with a voiceless alveolar plosive (i.e., [t]) on more formal and/or emphatic occasions (stylistic information) and that the flap in *reality* is spelled with the letter *t*, the prototypical spelling form of the members of the phoneme category /t/ (orthographic information), a type of knowledge which is not strictly phonetic and which has probably given rise to the belief that the word *reality* instantiates the phoneme category /t/ and not /d/. Furthermore, the classification of flaps in words like *dirty* or *writing* is more satisfactorily accounted for if the theoretical explanations includes the fact that speakers know about derivational morphological relationships and/or the internal morphological structure of the word containing the flap. For instance, in *dirty*, people know about its morphological relationship with the stem word (i.e., *dirt*) and the fact that subjects assign the final sound to *dirt* to the phoneme category /t/ may influence subjects' classification of the flap as an instance of /t/. In this respect, knowledge about the morphological composition of words is also decisive when pairs of words like *writing–riding, biddy–bitty, conceited–conceded*, in which both members are pronounced with voiced flaps, come into play. Surprisingly enough, speakers frequently distinguish one member of the pair from the other even if the words are pronounced in isolation (Kreidler 1989: 110; Port 1996) and the main reason for this has been found to be the length of the preceding vowel (e.g., Fisher and Hirsh 1976; Fox and Terbeek 1977; Huff 1980). However, the interesting fact about pairs like *writer–rider, butting–budding, coated–coded*, etc. is that even if the perceptual distinction were not made and subjects were made to classify the voiced flaps in words like *writing* in an appropriately contextualized sequences (e.g., *I handed in the writing assignment*), almost every speaker would classify the flap as an instance of /t/. The most plausible reason for it is that once the lexical item *writing* is identified people relate it to *write*, which they know has a "t-sound" at the end and consequently, they take for granted that *writing* also has it and assign the flap in *writing* to /t/ and not to /d/.[11]

Apart from the case of voiced flaps in intervocalic position, another classic example of a "phonetic similarity"–based classification of controversial allophones in English is that of the oral stops occurring after syllable-initial /s/, which seem to be in complementary distribution with the two members of pairs of phonemes like /p/–/b/, /t/–/d/ or /k/–/g/. Applying the criterion of phonetic similarity, many linguists preferred the interpretation /sp st sk/ (e.g., Gleason 1955; Pike 1947; Swadesh 1934; Trager and Smith 1951; etc.). However, other linguists like Twaddell (1935) argued that the decision had to be made quite arbitrarily as phonetic similarity might justify the inclusion of the stops with the voiced stops. In fact, a researcher from outside American structuralism, Davidsen-Nielsen, would suggest /sb sd sg/ as a legitimate analysis on "phonetic similarity" grounds (Davidsen-Nielsen 1969). The solution adopted by Davidsen-Nielsen is not at all surprising as several perceptual studies have also discovered that, once the [s] portion is removed from words like *spy, store, score*, and people are asked to identify the words either as *pie, tore, core* or *bye, door, gore* respectively, people identify the words as beginning with /b d g/ (e.g., Lotz et al. 1960; Reeds and Wang 1961). Not surprisingly, children learning to spell usually write words like *speak, stay*, or *sky* with *b, d*, and *g* (e.g., *sbek, sda, sgy*) which reflects the fact that they perceive the oral stops after tautosyllabic /s/ as more similar to /b d g/ than to /p t k/ (see Read 1971, 1986; Treiman 1985, 1993).

Given the controversial solution provided by the supposedly objective criterion of "phonetic similarity" to the problem of the classification of oral stops after tautosyllabic /s/, some researchers have adopted a different perspective more in line with a psycholinguistic account of the classification of such oral stops. These researchers have resorted to language users' actual classifications to provide solutions to this particular problem. For instance, Jaeger (1980a, 1980b, 1986) and Ohala (1983, 1986) provided evidence obtained with a concept formation experimental paradigm that adult speakers of English overwhelmingly consider the voiceless oral velar stop after initial /s/ as a member of the /k/ phoneme category. Using the same experimental paradigm, Mompeán-González (2002) found support for the fact that adult native speakers of English classify oral bilabial stops after initial /s/ as members of the phoneme category /p/. In this study, twenty linguistically naive speakers were trained to group together words containing instances of /p/, which appeared in different phonetic contexts, and to disregard words not containing any instance of /p/. All subjects performed the task easily and accurately, showing that the phoneme /p/, operationalized as conceptual category instantiated by phonetically different sounds that speakers classify as "the same", was a psycholinguistically real category. Next, the twenty subject were made to classify the voiceless bilabials stop after /s/ in nine real words like *spa, spill, spend*, etc. Out of the 180 response elicited, 97 percent considered the bilabial stops after /s/ as instances of /p/. If the reverse had occurred (if speakers had not classified the oral bilabial stops after /s/ as instances of /p/), the results would have suggested that people treat oral bilabial stops after /s/ as instances of the phoneme category /b/ or any other (archi)phoneme category (see below). On the contrary, the fact that speakers consider oral stop after /s/ as instances of /p t k/ and not of /b d g/ or any other category despite the phonetic similarity of those stops to /b d g/ is a well-established fact observed in many studies. Using a different procedure (a spelling test) and type of population (viz., pre-school children), Fink (1974), Read (1971, 1986) and Treiman (1985, 1993) reached the same conclusions. These studies, together with those by Jaeger, Ohala, and Mompeán-González, suggest that despite the perceived phonetic similarity between oral stops after tautosyllabic /s/ and the lenis oral stops /b d g/ in word-initial position speakers treat oral stops after tautosyllabic /s/ as instances of /p t k/ and in doing so, they use different sorts of information—phonetic, distributional, and orthographic.

The psycholinguistic investigations mentioned above suggest that the classification of sounds as members of phoneme categories does not depend exclusively on a supposedly objective phonetic–similarity computation of phonetic feature similarity between the to-be-classified sound and the prototype and/or category members of a given phoneme category. Instead, those studies suggest that speakers use other sources of knowledge to assign sounds to categories. In doing so, they produce classifications which are more intuitively acceptable precisely because they reflect the average speaker's multifaceted knowledge about phoneme categories, which is not restricted to the phonetic details of the classified sounds—although these details are also important. However, psycholinguistic data supporting theoretical classifications in phonological theory have seldom been provided or adduced by phonologists not truly concerned with (or overtly against) the psycholinguistic aspect of phonological theories. To give another example, the Prague School considered that the necessary or essential criterion for considering a particular allophone as a member of a given category was its ability to establish a phonetic contrast with members of another phoneme category. This is best understood in the context of the Praguean notion of the phoneme, a theoretical construct acquiring its value in a system of phonological oppositions; the phoneme /m/ in English, for example, acquires its value by virtue of its capacity to stand opposed to /n/ in the prevocalic initial (e.g., /met/ vs. /net/), intervocalic medial (e.g., /ˈemɪ/ vs. /ˈenɪ/) and postvocalic final (e.g., /tɪm/ vs. /tɪn/) positions of words. According to Praguean phonologists, these positions, in which the contrast between both phonemes is realized phonetically, are called "positions of relevance". However the places in a word where no contrast is possible are called "positions of neutralization". For instance, the opposition between /m/ and /n/ is not realized phonetically in words such as *symphony* ([ˈsɪɱfəni]) and *infant* ([ˈɪɱfənt]). This is so because the nasal consonant in each case is a labio-dental sound preceded by a vowel and anticipating a voiceless labio-dental fricative (i.e., [f]). The nasal is said to occupy the so-called position of neutralization. Something similar applies to voiced flaps in intervocalic position and to oral stops after tautosyllabic /s/. On the one hand, in words like *kitty* and *kiddy* or *reality* and *comedy*, there is no opposition between /t/ and /d/ because, although these phonemes can be readily distinguished in other contexts (e.g., in initial prevocalic position), the phonetic contrast between /t/ and /d/ disappears if both phonemes are flapped in post-stress intervocalic positions (i.e., the position of neutralization). On the other hand, there is no opposition between /p t k/ and /b d g/ after tautosyllabic /s/ as there is, for example, in initial position of words preceded by silence (e.g., *ten* /ten/ vs. *den* /den/), so the former is also a position of neutralization.

As neutralization of contrast threatened the Praguean definition of the phoneme, a solution to the classification of the sounds involved in the positions of neutralization was achieved through the creation of a new phoneme category called "archiphoneme" (see Akamatsu 1988; Davidsen-Nielsen 1978 for a history of the concept). Archiphonemes were defined as units sharing all the properties common to the phonemes involved in the neutralization. Those units were considered to occur in the positions of neutralization (Akamatsu 1988: 432). The phonological representations of words such as *symphony* or *infant* would then be /ˈsɪMfəni/ and /ˈɪMfənt/ respectively, those of *reality* and *comedy* /riˈælɪDi/ and /ˈkɒmɪDi/, and those of words like *spill, still*, or *skill* /sBɪl/, /sDɪl/ and /sGɪl/. /M/, /B/, /D/, and /G/ symbolize the archiphonemic units said to occur in the positions of neutralization.[12]

The question that immediately arises after recalling the solution adopted by the Prague School in relation to the sounds involved in the positions of neutralization is whether or not archiphonemes are psycholinguistically plausible entities for speakers. The Prague School phonologists did not ask themselves these questions as the psychological reality of phonemes lay outside their interest. However, the question remains unanswered and has been taken up by cognitive phonology: are archiphonemes psycholinguistically plausible or mere theoretical constructs devoid of any mental correlate? In this respect, it is difficult to claim that the segment appearing in the so-called positions of neutralization is the phonetic realization of a category known as "archiphonemes", which is a "phoneme category" after all. The distrust of archiphonemes simply derives from speakers' actual classifications in categorization tasks. The existing evidence for adults (e.g., Fink 1974; Jaeger 1980a, 1980b; Mompeán-González 2002; Ohala 1983, 1986; Sawusch and Jusczyk 1981) suggests that language users classify sounds (allophonic variants) appearing in so-called positions of neutralization as members of one of the phoneme categories involved in the neutralization (e.g., /m/ or /n/, /t/ or /d/, /p/ or /b/, /k/ or /g/, etc.) but not as members of a third category created ad hoc and supposedly instantiated by the very problematic cases they were evoked to explain. The existing evidence suggests that the archiphonemic category is not one of language users' actual categories involved in classification.[13] For example, in the study by Mompeán-González (2002) mentioned above, if the oral bilabial stops after syllable-initial /s/ had really instantiated a category other than /p/ (e.g., /b/ or a third phoneme category, archiphoneme /B/), the results would have probably shown a higher percentage of responses that had not considered those oral bilabial stops as members of the category /p/, but this is not what the 97 percent of answers considering the stops as /p/ showed.

Given the lack of faith in archiphonemes as psycholinguistically plausible units, it seems that they should be dismissed from a functional phonology such as cognitive phonology. That is, unless some of the intuitions captured by the notion of the archiphoneme could be somehow retained. In this respect, it is important to revise traditional phonological concepts in an attempt not to "reinvent" cognitive phonology from scratch (Nathan 1999b). One attempt to retain archiphonemes in some sense is to think of them in another way. A possibility is that the term *archiphoneme* could be used to refer to abstract schematic representations (similar to those assumed by the network model) of the commonality abstracted from the phoneme categories involved in so-called positions of neutralization. However, if posited as phonological units, the main restriction for these abstractions would be that they be psychologically plausible for speakers; such schematic abstractions should not be mere abstract descriptions displaying the intellectual virtuosity of a linguist. They should reflect speakers' real knowledge of relationships between phonemes. As Bybee claims (1999: 225), "what constitutes a viable schema is an empirical matter that can be determined on the basis of speakers' reactions to novel forms". This possibility, however, remains to be determined through testing.

5. Conclusion

In conclusion, the new perspective offered in this article is that in order to account for the assignment of allophones to phoneme categories in phonological theory, it is particularly advisable to have recourse to the classifications that speakers make of those allophones and consider all the possible types of knowledge on which such classifications could be based (e.g., phonetic, orthographic, distributional, morphological, lexical, stylistic, etc.).

The relevance of considering speakers' categorizations in phonological theory becomes apparent if the theory is to be consistent with what is empirically known about cognition, language, and thought. This is the well-known "cognitive commitment", one of the defining characteristics of linguistic research done from a cognitive perspective (Gibbs 1996: 26–27). In this respect, research on speakers' sorting of sounds into phoneme categories appears to be part and parcel of what a functional, psycholinguistically plausible theory of phonology such as cognitive phonology should be devoted to. By resorting to "external" evidence provided by psycholinguistic experimentation on the classification of sounds, phonological theory may then reflect the manner in which speakers classify the sounds of their language. In this way, phonological theory can propose linguistic solutions to problems in phonology that are cognitively plausible. The use of such external evidence is particularly recommendable in cases in which the solutions to classic classification problems have proved to be psycholinguistically implausible, such as either "phonetic similarity"–based or archiphonemic accounts of allophones occurring in so-called positions of neutralization whose category membership has been the focus of much debate.

Psycholinguistic evidence showing how speakers classify sounds has never been seriously taken into account by autonomous and "disembodied" phonological theories like Bloomfieldian phonemics or Prague School phonology. These theories are not to blame because, after all, they did not really seek any psychological validity for phonological descriptions. However, psycholinguistic evidence has also been most frequently ignored by supposedly mentalistic theories of phonological structure like classical generative phonology (and its offspring), whose terminological reintroduction of concepts like "psychological reality" has seldom been accompanied by a methodological innovation and experimental testing of psycholinguistic hypotheses (e.g., Derwing 1979; Wheeler 1980). Therefore, if the psychological validity of phonological descriptions is to be pursued, phonological analyses must be informed by empirical evidence. As Eddington claimed, "once phonological analyses are based on empirical evidence which is obtained by psychological means, their psychological validity will be less often challenged" (1996: 18). Failure to have recourse to speakers to obtain evidence on the psychological validity of phonological units and solutions is one of the strongest reasons for doubting the psychological reality of phonological analyses (Eddington 1996; see also Bertinetto 1992; Black and Chiat 1981; Campbell 1979; Derwing 1979; Fromkin 1980; Ohala 1986; Wheeler 1980 for further discussions of similar issues). It appears, then, that cognitive phonology has the opportunity to overcome the methodological limitations of previous approaches to phonology and to evolve into a truly psychologically plausible phonological theory. This may happen if cognitive phonology takes into account speakers' actual classifications of speech sounds and the type of information that they use.

Received 20 June 2001
Revision received 15 February 2003

University of Murcia

Notes

* Earlier versions of this article have benefited from the invaluable feedback and assistance of Joseph Hilferty, Andrew Wedel, Mar Vilar, and Javier Valenzuela. The article has also benefited from the financial support of Project PB–98–0375, financed by the Spanish Ministry of Education. Contact address: Dept. of English Philology, University of Murcia, Santo Cristo 1, CP: 30071 Murcia, Spain; e-mail: ⟨mompean@um.es⟩.

1. A standard account of the categorization process can be found in Barsalou (1990: 268–269; 1992: 25). In this process, there are two general phases, "access" and "inference". In the access phase, the perception and classification of stimuli as members of a particular category is accomplished. In the second phase, inferences relevant to understanding and interacting with an already classified entity are drawn from category knowledge. For example, after having perceived and classified an entity as a chair, inferences can be drawn like "it is a chair, it can be sat upon", etc. The second phase shows that classification is not usually an end in itself and that the purpose of categorization is not simply to identify what something is.
2. Since the emergence of the theory-based view of concepts (see also Heit 1997; McCauley 1987), various studies have empirically examined the relationships between background knowledge and concepts. These studies have examined the effects of knowledge on concept (or category) learning (e.g., Heit 1994; Nakamura 1985; Pazzani 1991; Spalding and Murphy 1996; Wisniewski 1995; Wisniewski and Medin 1994), conceptual combination (e.g., Rips 1995), item classification after the category is well learned (e.g., Lin and Murphy 1997; Pazzani 1991; Wattenmaker 1995), conceptual development (e.g., Hayes and Taplin 1992), etc. This body of literature constitutes the best rationale for the "theory" view.
3. The figure represents some but not all of the possible realizations of the phoneme /t/ in different accentual varieties of English (General American, Received Pronunciation, Cockney, etc.) and from different stylistic levels (emphatic, formal slow colloquial, rapid, etc.).
4. However, it is not always possible to abstract a viable, psycholinguistically plausible schema that is fully compatible with all the members of a category. For example, not every member of the phoneme category /t/ shares the features "alveolar", "voiceless", and "stop", so the abstraction of a highly abstract schema which contains a feature common to all members of the category and distinguishes the category from others is impossible (Taylor 1990). The model permits, however, the abstractions of local schemas embodying the commonality of many but not all members of the category (Bybee 1999). Some commonality between certain members of a phoneme category may exist but the commonality may not extend to the totality of the members. One such local schema for /t/ could contain the features [voiceless], [alveolar], and [stop], shared by many but not all members of the category (Taylor 1990).
5. Most accounts of why something acquires the status of "prototype" are really accounts of the sources of "typicality", also called "prototypicality", "goodness-of-example", "representativeness", etc. (see Loken and Ward 1990; Segalowitz and Poulin-Dubois 1990 for reviews). However, typicality refers to behavior, not to conceptual structure. It refers to how people order the members of a category according to how good or representative of the category they think those members are. In addition typicality ratings do not reflect a supposedly invariant structure of a category as represented in long-term memory (Barsalou 1987; Rosch 1978), despite such early interpretations (e.g., Rosch 1975). In fact, an important lesson from research on categorization is that the same group of people (or different populations) generate statistically significantly different

typicality ratings for the members of the same categories depending on a host of factors (e.g., Barsalou 1987). It is not appropriate then to identify the most typical member of a category (rated as such in typicality judgments) with the supposedly invariant prototype of a conceptual category. Phonetic and phoneme categories are no exception. The generation of typicality ratings for different members of phonetic and phonological categories, an extensively demonstrated phenomenon (e.g., Davis and Kuhl 1992; Grieser and Kuhl 1989; Kuhl 1991; Lotto 2000; Massaro and Cohen 1983; Samuel 1982), has been shown to vary as a function of changes in syllable-internal rate (e.g., Miller and Volaitis 1989; Miller et al. 1997; Volaitis and Miller 1992; Wayland et al. 1994), in syllable-external rate (e.g. Wayland et al. 1994), in some of the multiple acoustic properties specifying any given phonetic segment (Hodgson 1993; Hodgson and Miller 1996), or explicit knowledge about a category's features (Mompeán-González 2001).

6. Flaps involve a single contraction of the muscles so that one articulator is thrown against another. To produce flaps, a tap is made by a flexible organ on a firmer surface. In the voiced and voiceless alveolar flaps, for example, the tongue tip taps once against the alveolar ridge. Although there has been some controversy as to whether the sounds in words like *city* are flaps or taps (assuming a difference exists between both types of articulations), the present discussion is valid irrespective of their phonetic description.
7. The best account of flapping, to our knowledge, is the one provided by Rhodes (1994). His article on flapping in American English contains a detailed analysis of the process including the factors that influence flappability. These include degree of casualness (hypercorrect, careful, normal, casual), the inherent content of the segment being substituted (/d/s flap in a wider class of cases than /t/s), prosodic position (pre- or post-stress position), and word frequency. Rhodes also mentions that flaps generally occupy post-stress positions in words although they may also appear in pre-stress positions. In addition, Rhodes mentions that apart from voiced and voiceless flaps, there is a third main type of flap in the speech of most Americans: the nasal flap.
8. It might be argued that for words in which no phonemic or orthographic representations are previously stored in long-term memory, perceived phonetic similarity, as a criterion for assigning sounds to categories, is not overridden by any other criterion. However, even with the use of accidental gaps, that is, words not attested in the language but acceptable because they satisfy the sequential constraints of the language (e.g., ['sneɪɾi] and ['wɒɾi]), lexical influences are possible. Lexical neighborhood effects are one such influence (e.g., Newman et al. 1997). If, for instance, the end of a nonsense word including a flap is similar to many words, then listeners might classify the flap similarly to the classifications of flaps in the words' lexical neighbors. If speakers classified the flap in ['sneɪɾi] as a /d/, this fact might reflect the influence of lexical neighbors such as *Grady, lady, shady*, etc. Similarly, if they classified the flap in ['wɒɾi] as a /t/, this classification might reflect the influence of words such as *Scotty, dotty, potty, spotty*, etc.
9. As Treiman (1993: 146) puts it, "learning to read and spell may actually change certain aspects of children's phonemic systems". The example she gives is illuminating: "some preliterate children may categorize the second consonant of *sky* as /g/. As children observe that this sound is spelled with 'k' instead of 'g', they may reassign the consonant to /k/".
10. On the contrary, partial phonemic overlapping implies that instances of a given allophone are classified as members of a phoneme category under one set of phonetic conditions but as members of another phoneme category under a different set of phonetic conditions. Voiceless unaspirated alveolar stops, for instance, occur as instances of /t/

after initial /s/ (e.g., in *stock*), and as instances of /d/ in initial position of a word (e.g., in *dock*).

11. Examples like *wating–wading, bedding–betting*, or *kiddy–kitty* are similar to the typical examples of neutralization in German, Russian, etc. found in the phonological literature. A famous example cited is that of voiced syllable-final obstruents in German. While the phonemes /t/ and /d/ contrast initially (e.g., *Tier* [tiːr] 'animal' vs. *dir* [diːr] 'to you') and intervocalically (e.g., *leiten* ['laɪtən] 'to lead' and *leiden* ['laɪdən] 'to suffer'), there is no possible contrast syllable finally. Words like *Rat* 'advice' and *Rad* 'wheel' are both pronounced [raːt]. However, in the plurals, where a suffix is added that changes the vowel as well, the contrast between /t/ and /d/ resurfaces: *Räte* ['rɛːtə] 'pieces of advice' vs. *Räder* ['rɛːdər] 'wheels'. The surprising experimental result that has been obtained is that if you do either a production experiment or a perception experiment using a reasonable number of tokens of minimal pairs in German like *Bund–Bunt, Rat–Rad*, etc., the words can be distinguished with above chance accuracy (e.g., Port 1996; Port and Crawford 1989; Port and O'Dell 1986; Port et al. 1981). The differences are mainly that *Bunt* has a slightly shorter preceding vowel.
12. The most widespread convention for symbolizing archiphonemes is the use of roman capital letters. However, a specific symbol for an archiphoneme need not necessarily be a capital letter. Lowercase letters are also possible and frequently used, provided the symbol is specific to the archiphoneme. The only requirement for symbolizing archiphonemes is some desire to render graphically obvious some kind of distinctness of the archiphoneme from any of the member phoneme of a neutralizable opposition (see Akamatsu [1988: 314–331] for a discussion of different alternatives to represent archiphonemes). In our examples, /M/, /B/, /D/, and /G/ are used following the most common criterion whereby the choice of specific symbols for archiphonemes is made: use of the capital letter of the symbol of any of the phonemes involved in the neutralization whose phonetic manifestations are phonetically similar to those of the archiphoneme. However, this convention does not imply any special status of any of the phonemes involved in the neutralizable opposition. The fact that the oral stops after /s/ have often been represented with the capital letters /P T K/ (our examples would then be /sPɪl/, /sTɪl/ and /sKɪl/) may be due either to the influence of the conventional spelling in the symbolization of archiphonemes or the belief that oral stops are more phonetically similar to /p t k/ than to /b d g/.
13. Taylor and Nathan (2001) claim that no known orthography has separate symbols for archiphonemes, a fact that would be puzzling if archiphonemes were psychologically real categories like other phonemes.

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