Feature creation as a byproduct of attentional processing

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Abstract: Attributing the creation of new features to categorization requirements implies that the exemplars displayed are correctly assigned to their category. This constraint limits the scope of Schyns et al.'s proposal to supervised learning. We present data suggesting that this constraint is unwarranted and we argue that feature creation is better thought of as a byproduct of the attentional, on-line processing of incoming information.

In traditional category learning studies, new categories emerge from new combinations of a fixed repertoire of elementary features. Schyns et al. show cogently that low-level features can themselves change with experience, thus altering the immediate appearance of objects. We fully agree with this perspective, which amplifies the impact of learning to the deepest roots of perception and categorization, thus converging with other sources of evidence that the role of learning in cognition has been underestimated (e.g., Bates & Elman 1996, with regard to language).

We believe, however, that one aspect of the Schyns et al. proposal may ultimately limit its implications. They claim repeatedly that feature creation depends on categorization requirements, and that people create features to subserve the representation and categorization of objects. We have no special quarrel with this proposal insofar as it intends to describe the ultimate function of features in adaptive behavior. However, the authors mean something much stronger, namely, that the categorization requirement is the actual driving force in extracting distinctive features. The difference is crucial, as it appears when comparing the hardly disputable claim that mating occurs in the service of species survival, and the contention that individual sexual behavior is initiated and shaped by this ultimate function. Conceiving categorization requirement as the actual causal agent for feature creation undermines the Schyns et al. model.

The restriction to supervised learning. The problem is that the tightly functionalist stance by Schyns et al. limits the relevance of their model to situations in which participants are informed about the nature of the categories. Indeed, in the componential view of cognition to which Schyns et al. seem to subscribe, categories are themselves defined by their distinctive features. It would obviously be circular to simultaneously ground category formation in feature knowledge and feature creation in category knowledge. To avoid circularity, the claim that features are learned insofar as they are needed to achieve categorization requires that displayed exemplars be correctly assigned to their categories by an external informer. Although Schyns et al. allude briefly to the beneficial effects of preexposure without external feedback (sect. 1.2.1; see also the preliminary experiments by Schyns & Rodet 1997), they are aware of this constraint. To quote them, "the individual knows what the categories are from external feedback" (sect. 2.2).

Because feature creation, according to Schyns et al., implies concurrent category knowledge, extending the scope of learning to features paradoxically prevents genuine category discovery. We are then faced with the following alternative: either new categories are formed by combining known features, the conventional view, or new features can be created from the knowledge of fixed categories, as claimed by Schyns et al. Disappointingly, both sides of this alternative rule out the possibility that people faced with a new environment can learn both features and categories by themselves. We subscribe to the view that new features can be created, but we intend to show that the process is functionally independent of categorization requirements. Our proposal is that feature creation makes it possible to form new categories instead of requiring information about categories.

Evidence for feature creation in unsupervised learning. The observation that people may be able to parse complex material according to its relevant parts in unsupervised learning without any surface cues or external information about the deep structure of the material has occasionally been reported in various areas of research (e.g., see Saffran et al. 1997). However, most of the evidence comes from the so-called implicit learning studies. In these studies, subjects are typically faced with complexly structured material, such as a set of letter strings, the order of which is defined by a finite-state grammar. There is evidence that the subjective encoding units of such a complex display, which are initially randomly determined or driven by possibly irrelevant surface features, become increasingly congruent with the deep structure of the material (Perruchet & Gallego 1997; Servan-Schreiber & Anderson 1990). As in the situations described by Schyns et al., learning is responsible for the formation of the building blocks of cognition, instead of dealing with only the storage, processing, and retrieval of preshaped representations. (It may be pointed out that one deals with subjective *units* in the implicit learning context, whereas Schyns et al. deal with *features*. This difference may be terminological, insofar as most of the experimental support cited in the Schyns et al. target article discussed the segmentation of objects into parts in the same way that in implicit learning experiments the training material is segmented into perceptual units.)

The crucial difference between the data provided by Schyns et al. and the results just described lies in the fact that in the latter case, the building blocks of cognition are shaped without any external information about the categorical structure of the material.

To account for this finding, we have proposed a model that relies on simple and ubiquitous attentional and memory processes (Perruchet & Vinter 1997; Perruchet et al. 1997). The initial perceptual units composing the momentary focus of attention are determined at random, or result from various bottom-up influences such as those described by Schyns et al. (sect. 2.5). Some of these perceptual units presumably match the structurally relevant parts of the material, whereas others result from irrelevant fragmentation. The key point is that a given part tends to be repeated only when it is structurally relevant, as a mandatory consequence of the rule-governed structure of the material. This entails that irrelevant units, because they reoccur infrequently, will be forgotten, whereas the initial selection of meaningful units will be progressively reinforced by repetition. With repeated exposure, subjective units become strong enough to shape perceptual processes and alter the immediate appearance of objects. Thus, in this model, the formation of cognitive units matching the meaningful part of the material is a byproduct of the attentional, on-line processing of incoming information.

After their initial exposure to the letter strings in artificial grammar learning, subjects are able to discriminate new grammatical and ungrammatical strings. This shows that feature creation, at least when viewed as a structurally relevant parsing of the environment, can be one basis for the formation of new categories, instead of being grounded in externally induced category knowledge. Our proposal does not entail that categorization requirements are never causal factors in feature creation, as claimed by Schyns et al. However, this form of processing may be limited to the cases in which people are explicitly asked to solve problems or to engage in analytic forms of thought.

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