Semantic Convergence in the Bilingual Lexicon

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Abstract

Two studies investigated how convergence between linguistic representations in Dutch-French bilinguals affects the centers and boundaries of lexical categories for common household objects. In Study 1, correlations between typicality ratings for roughly corresponding categories were higher for bilinguals in their two languages than for monolinguals in each language, indicating that bilingual prototypes converge. In Study 2, fewer dimensions were needed to linearly separate bilingual than monolingual categories, and bilinguals showed fewer violations of similarity-based naming. Implications for theories of the bilingual lexicon are discussed.

Keywords: Bilinguals; lexicon; convergence; prototypes; linear separability.

Introduction

Languages map words onto referents in different ways. For instance, the linguistic boundary between chairs and sofas is not the same in Dutch as in English. In English, a large stuffed seat for one person is given the same label as a wooden chair, but Dutch speakers give the stuffed one the same label that they would give a stuffed multi-person seat -- what English speakers call *sofa*.

Malt et al. (1999) studied naming for a set of 60 common household containers (mostly called *bottle* or *jar* in English) by speakers of English, Chinese and Spanish and found rather different ways of carving these familiar objects up by name. These results were later replicated for Dutch- and French-speaking Belgians (Ameel et al., 2005).

The differing patterns of naming across languages raise the question of how bilinguals name these objects in their two languages. To become fully native-like in both languages, they must attend to the distinctions between the two languages' naming patterns for the same set of referents, acquire both patterns, and maintain them as distinct over time. Are they able to do so?

The *two-pattern hypothesis* states that bilinguals acquire and maintain two distinct sets of connections of word forms to their referents and that, for each language, the naming pattern parallels that of the corresponding monolinguals. Presumably this is what bilinguals strive to achieve.

The *one-pattern hypothesis* holds that bilinguals are not able to maintain two separate, monolingual-like mappings of words to the same objects. Interactions between the two languages yield patterns of connections between the word forms and referents in the two languages that differ from either monolingual naming pattern.

Evidence suggests that the two lexicons of bilinguals are not isolated from one another. For instance, cross-language priming occurs in lexical decision and in categorization (e.g., De Groot & Nas, 1991). Stroop-like between-language picture-word interference points to activation spreading from one language to the other through access to a shared meaning representation system (Costa, Miozzo, & Caramazza, 1999). If there are interconnections of some sort, it may be difficult or impossible for bilinguals to maintain two separate and distinct patterns of mappings from word forms to referents.

Ameel, Storms, Malt and Sloman (2005) studied the naming patterns of Belgian Dutch- and French-speaking monolinguals and Dutch-French bilinguals. They found that the Dutch and French naming patterns of bilinguals did not fully parallel the patterns of Dutch- and French-speaking monolinguals, respectively. Instead, the bilingual naming patterns converged on a common naming pattern in the two languages. Bilinguals agreed better on naming in their two languages than monolinguals of the two languages did. For example, the nesting relation found for monolinguals between Dutch *fles* on the one hand and French *bouteille* and *flacon* on the other hand was found in bilinguals as well, but in contrast to the equal distribution of *fles* objects among the French monolingual categories, bilinguals speaking French called a majority of *fles* objects *bouteille* (21/30) and only a minority *flacon* (6/30). Thus, *bouteille* for them more closely resembled their Dutch *fles* category.

It is possible that the manifestation of convergence in naming is different in the category centers and the category boundaries because centers and boundaries differ in the type of exemplars that mostly contribute to their formation. Given the strong correlation between typicality and production frequency (Barsalou, 1985; Hampton, 1979; Mervis, Catlin, & Rosch, 1976), category centers are likely to be determined by high-frequency items, while the boundaries should mainly reflect exposure to lower-frequency items. Hence, category

boundaries may be more vulnerable to convergence than the category centers, although convergence in the category centers cannot be excluded. In the present paper, we further investigate the nature of bilingual semantic convergence evident in the names for household objects (Ameel et al., 2005). We ask how convergence is manifested in two aspects of lexical category structure: the category centers and the category boundaries.

Study 1: Prototype Convergence

This study evaluates how convergence is manifested in the prototypes of corresponding categories in the two languages of a bilingual by looking at typicality ratings. We compared the extent to which bilinguals agree on typicality ratings for roughly corresponding categories across their two languages with the extent to which monolingual speakers agree on typicality ratings for the same categories. For example, we compared the judged typicality of objects as examples of Dutch *fles* with their judged typicality as examples of French *bouteille* for the bilinguals and for the monolinguals. If bilinguals agree better than monolinguals, the bilingual prototypes can be inferred to be more similar to each other than the monolingual prototypes.

Method

Participants. The participants were 28 Belgian Dutch speaking and 24 Belgian French-speaking monolinguals and 21 Dutch-French balanced bilinguals. The bilinguals had a Dutch-speaking mother and a French-speaking father or vice versa, and from childhood onward, each parent had consistently been speaking their own language to them.

Materials. The categories studied were derived from the naming data of Ameel et al.'s (2005) study, where two sets of common household objects were used. The 'bottles' set contained 73 objects that were likely to receive the name *bottle*, *jar*, or *container* in American English, or else to have one or more salient properties in common with those categories. The 'dishes' set consisted of 67 objects that were likely to be called *dish*, *plate*, or *bowl* in American English, or else to share one or more salient properties with those categories. Objects were photographed on a neutral background that preserved relative size. (For examples, see Ameel et al., 2005.)

In order to compare the typicality ratings of different language groups, pairs of frequently generated category names from Ameel et al. (2005) were selected that were considered sufficiently good (but not perfect) translation equivalent in Dutch and French. For the bottles set, the selected pairs were *fles-bouteille* and *pot-pot*. For the dishes set, the pairs were *kom-bol*, *tas-tasse*, *schaal-plat*, and *bord-assiette*.

Procedure. Participants were instructed to rate the typicality of each object with respect to a specified category name on a 7-point rating scale (1 = 'very atypical', 7 = 'very typical'). Monolinguals gave ratings in one language and bilinguals rated the stimuli in both languages, with language order counterbalanced. Stimulus photos were presented in a random order on a computer screen. The complete set was presented as many times as there were category names for the set. At the top of the screen appeared the category name for which typicality was rated.

Results and Discussion

The split-half reliability was above 0.96 for all rated categories in all participant groups. For each language group, ratings were averaged across participants for each object in each category. Next, the correlation between the mean Dutch and French ratings of the bilinguals was computed for each category pair and compared to the correlation between the ratings of the two monolingual groups for the same pair. The correlations between typicality ratings were, for bilinguals and monolinguals respectively, for *fles-bouteille:* .98 and .91; for *pot-pot,* .98 and .94; for *kom-bol,* .88 and .70; for *tas-tasse,* .99 and .99; for *schaal-plat,* .95 and .91; and for *bord-assiette,* .99 and .94. A two-sample paired t-test showed that the mean Z-transformed correlation between the ratings of the bilinguals was significantly higher than the mean Z-transformed correlation for monolinguals, $t(5) = 3.514$, $p < .01$. For each pair of category names separately, we found that the improvement in correlation for the bilinguals, in comparison with the monolinguals, was significant.

The significantly better values for the bilinguals was not just the result of the fact that the ratings being compared for the bilinguals came from the same people. To demonstrate this, for each pair of bilinguals, correlations were computed between Dutch and French typicality ratings, under the condition that the ratings in the two languages did not belong to the same individual (i.e., 21*21- 21 = 420 pairs). Likewise, ratings were correlated for each pair of Dutch- and French-speaking monolinguals (i.e., 28*24 = 672 pairs). For both stimulus sets, the mean Z-transformed correlation between Dutch and French bilingual ratings was significantly higher than the mean Z-transformed correlation between ratings of the Dutch- and French-speaking monolinguals: $t(1090)=29.3$, $p<.0001$ for the bottles set and $t(1090)=18.6$, $p<.0001$ for the dishes.

In sum, the results showed higher correlations between Dutch and French typicality ratings of bilinguals than between typicality ratings of Dutch-speaking and French-speaking monolinguals, suggesting that bilinguals' prototypes of corresponding categories are more similar to each other than monolinguals's are. Although this outcome may seem surprising given that typical exemplars tend to be high frequency bilinguals might incorporate exemplars of the categories of one language into the corresponding categories of the other language as well, resulting in a higher overlap of corresponding categories in the two languages of a bilingual and hence, more similar prototypes.

Study 2: Boundary Convergence

In Study 2 we focused on evaluating convergence in the category boundaries. Atypical member of lexical categories may often be language-specific, gaining category

membership through historical cultural and linguistic influences not transparent to current speakers of a language (see Malt et al., 1999). It is in principle possible that bilinguals learn the language-specific complexity at the category boundaries in both languages, in which case bilingual and monolingual categories will be equally complex. If so, the observed convergence must arise entirely from other aspects of the lexical representations, such as the prototype convergence demonstrated in Study 1.

A more plausible possibility, given the lower frequency and atypical nature of boundary cases, is that bilinguals do not fully master language-specific complexities at the category boundaries in their two languages. Convergence would therefore occur. Convergence of category boundaries could be manifested either in more complex or simpler category boundaries for bilinguals as compared to monolinguals. On the one hand, it is possible that the boundaries of bilingual categories are more complex than those of monolingual categories if bilinguals are unable to keep boundary exemplars of each language separate. Instead, they incorporate the boundary exemplars of a category in one language into the roughly corresponding category in the other language as well, and vice versa. As a result, the categories of each language of a bilingual acquire language-specific complexities of both languages and will be more complex than the categories of monolinguals of either language.

On the other hand, it is possible that the boundary exemplars of each language get only poorly encoded as a member of the relevant category in either language. As a consequence, bilinguals may drop (some of) the boundary exemplars in both languages. In other words, language-specific idiosyncrasies will not (or only to a smaller degree) be appreciated in either language, resulting in less complex categories for bilinguals as compared to monolinguals. Under this scenario, bilinguals may be more likely to assign the boundary exemplars to the category to which they are most similar, rather than to the category to which they are assigned by monolinguals.

To discriminate among these possibilities, we first evaluated the complexity of bilingual categories compared to monolingual ones by determining how many dimensions it takes to separate the categories. The more complex the categories are, the more dimensions are needed to separate the categories linearly. To provide more direct evidence for whether bilinguals incorporate or drop boundary exemplars, we also compared the proportion of outliers (i.e., objects that are more similar to the prototype of another category than to their own category prototype) for bilinguals and monolinguals.

Method

The same materials described in Study 1 were used. The naming data of Dutch- and French-speaking monolinguals and Dutch-French bilinguals described in Ameel et al. (2005) were used as well as the MDS representations, based on their aggregated sorting data over the three participant groups.

LINSEP (Van Assche, 2006) is a method that allows us to determine whether two categories are linearly separable in a given number of dimensions by looking for a linear function that perfectly divides the extensions of the two categories when projected onto the specified number of dimensions. LINSEP assumes an underlying *M*-dimensional geometrical representation in which the exemplars belonging to different categories of a semantic domain are embedded. The more dimensions that are needed to separate the categories linearly, the more complex the categories are.

For the category pairs in the present study, we selected the most frequently generated names that were used for at least 10 percent of the objects of a stimulus set. (The percentage of objects varied between 12% and 34%.) For the bottles set, the pairs *fles-bus*, *fles-pot*, and *bus-pot* were selected for Dutch and the pairs *bouteille-flacon*, *bouteille-pot*, and *flacon-pot* were selected for French. For the dishes set, the pairs *kom-tas*, *kom-schaal*, *kom-bord*, and *schaal-bord* were selected for Dutch and the pairs *bol-tasse*, *bol-plat*, *bol-assiette*, and *plat-assiette* were selected for French. For the dishes set, not all possible pairs of category names were selected. The Dutch pairs *tas-bord* and *tas-schaal* and their French approximate equivalents *tasse-assiette* and *tasse-plat* were not used, since the category of *tas* (*tasse*) objects was rather isolated from the categories of *bord* (*assiette*) objects and *schaal* (*plat*) objects in the MDS representation. The category of *kom* (*bol*) objects is more interrelated to the category of *tas* (*tasse*) objects, at least in the studied dimensionalities.

Results and Discussion

Testing linear separability. Analyses were based on naming data from every participant separately to avoid biases due to averaging. Analyses on aggregated data (i.e., the most frequently generated names) could lead to wrong conclusions (under-estimation or over-estimation of the number of dimensions), since aggregated data contain information about a (non-existent) 'average person'. For each participant of a language group, LINSEP determined for each pair of category names of each stimulus set the lowest dimensionality at which the pair was linearly separable. This yielded for each participant seven different values, one for each pair of the studied category names. Next, for each language group (Dutch- and French-speaking monolinguals, and bilinguals in Dutch and French) and for each pair of category names, the minimum dimensionalities at which the pair was linearly separable were averaged across participants. Figures 1A and 1B display the averaged minimum dimensionality for the selected pairs of category
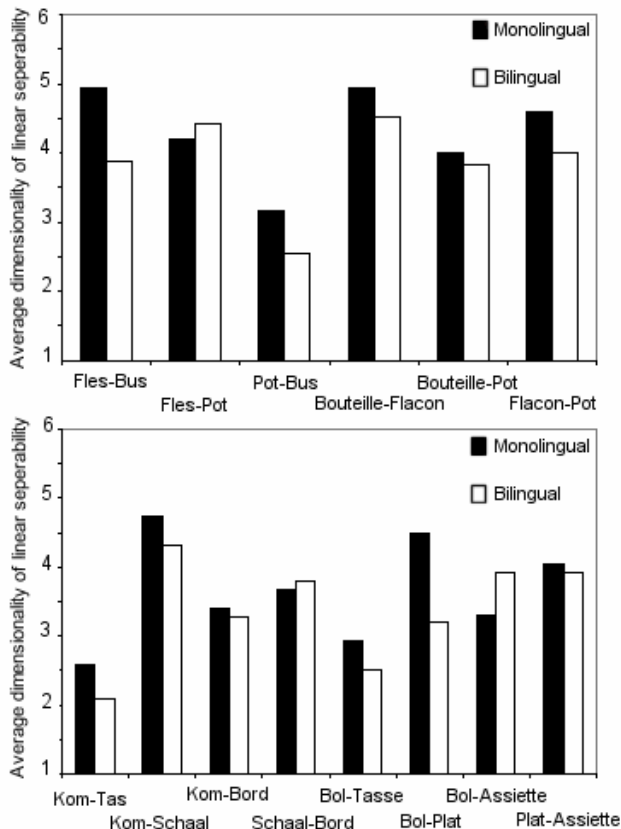
Figure 1: Average dimensionality of linear separability for bilinguals and monolinguals in the bottles set (upper panel) and dishes set (lower panel)

names for the different language groups for the bottles and the dishes set, respectively.

To test whether bilingual categories are linearly separable in an equal, higher, or lower dimensionality than monolingual categories, a two-sample paired t-test for the means of bilinguals and monolinguals was calculated. Overall, the minimum dimensionality at which perfect linear separability was found was significantly lower for bilinguals than for monolinguals ($3.6 < 3.9$, $t(13) = -2.59$, $p < .05$). The same result was found for the two stimulus sets separately, although significance was only reached for the bottles set ($3.9 < 4.3$, $t(7) = -2.43$, $p < .05$). As can be seen in Figure 1, there were three exceptions to this general pattern: the categories *fles-pot*, *schaal-bord*, and *bol-assiette* were linearly separable in a higher dimensionality for bilinguals than for monolinguals (respectively, $4.4 > 4.19$, $3.8 > 3.7$, and $3.9 > 3.3$).

In sum, the finding that bilingual categories are linearly separable in lower dimensionalities on average than monolingual categories implies that the categories of bilinguals tend to be less complex than the corresponding monolingual categories, since bilinguals need fewer features to separate their categories linearly than monolinguals. This finding suggests that language-specificities of both languages

are poorly encoded in memory, resulting in less complex categories for the bilinguals.

This outcome indirectly suggests that boundary exemplars, which are more likely determined by idiosyncrasies than centrally situated exemplars, are dropped by bilinguals in both their languages, and instead, are assigned to categories according to their similarity. However, the linear separability analyses do not provide direct evidence for this conclusion. A more direct way to evaluate whether bilinguals drop boundary exemplars from the categories relative to monolinguals (and instead assign them to similarity-based categories) is to compare the proportions of outliers for bilinguals and monolinguals, with outliers defined as objects that are more similar to the prototype of another category than to the prototype of their own category.

Comparing proportions of outliers. Proportions of outliers were determined for the category names that were most frequently generated for at least 10 percent of the objects of a stimulus set (the same category names used in the linear separability analyses). For the bottles set, these were Dutch *fles*, *bus*, and *pot* and French *bouteille*, *flacon*, and *pot*. For the dishes set, they were Dutch *kom*, *tas*, *schaal*, and *bord*, and French *bol*, *tasse*, *plat*, and *assiette*. In geometrical representations, an outlier can be defined as an object that is located closer to the prototype of another category than to the prototype of its own category. We computed outliers for the two sets of stimuli in a 2-dimensional MDS representation. We used only a 2-dimensional space because, if there are differences in the number of outliers between bilinguals and monolinguals, these differences can be less pronounced in higher-dimensional spaces, since increasing the dimensionality of a solution may cause an outlier to become a non-outlier.

To avoid biases due to averaging, outliers were computed for each participant separately. For each participant of a particular language group and for each stimulus set, we first selected the objects that were called by the category names selected for the particular stimulus set and the language of the participant. For example, for each Dutch-speaking monolingual participant, the objects that were called *fles*, *bus*, or *pot* by the participant were selected from the bottles set; the object that were called *kom*, *tas*, *schaal*, and *bord* were retained from the dishes set. On average across all language groups, 60% of the objects from the bottles set were selected (varying between 42% and 78%) and 69% of the objects from the dishes set (varying between 37% and 94%). Next, for each participant, the distances were computed between the selected stimuli for a particular stimulus set and the prototypes of the selected category names relevant to the stimulus set and language of the participant. An object was considered to be an outlier if the distance to the prototype of its own category name was larger than the distance to the prototype of another category name. For each participant, the proportion of outliers was calculated for each category name. Finally, for each category name of both stimulus sets, the proportion of outliers was averaged across the participants in each language group. This resulted in 14 averaged proportions for bilinguals and 14 averaged proportions of

outliers for monolinguals; one for each selected category name. In 11 out of the 14 category names (79%), the bilingual proportion of outliers was smaller than the monolingual proportion, which is a significantly larger percentage than would be observed by chance ($p < .05$). The smaller proportion of outliers for bilinguals indicates that bilinguals drop at least part of the boundary exemplars compared to the native categories of both languages. Bilinguals make fewer violations of similarity-based naming than monolinguals, confirming the finding from the linear separability analysis that bilingual naming respects language-specific idiosyncrasies to a smaller degree than than monolingual naming does.

General Discussion

The permeability of the language representations of bilinguals (Ameel et al., 2005; De Groot & Nas, 1991; Kirsner et al., 1984), in combination with meaning representations in a bilingual's two languages that may be less well established than those of a monolingual (Gollan et al., 2005), may yield bilingual representations that are highly vulnerable to convergence. The present paper investigated in which aspects of the bilingual lexical category structure this vulnerability is manifested. Study 1 was designed to find out how bilingual category prototypes were affected by semantic convergence. We found higher correlations between Dutch and French typicality ratings for corresponding categories of bilinguals than between typicality ratings for corresponding categories of Dutch-speaking and French-speaking monolinguals, implying that the prototypes of corresponding categories in the two languages of bilinguals were closer to each other than the prototypes of corresponding monolingual categories.

In Study 2, we examined how the boundaries of bilingual categories were affected by semantic convergence. If convergence is manifested in category boundaries, bilinguals could either have more complex categories by incorporating boundary exemplars of each language in both languages, or simpler categories by dropping boundary exemplars in both languages. We found that fewer dimensions were needed to linearly separate bilingual categories than monolingual categories. Furthermore, the number of outliers (i.e., objects more similar to the prototype of another category than to the prototype of their own category) for bilinguals was smaller than for monolinguals. Together these results indicate that the boundaries of bilingual lexical categories are simplified, and the naming of boundary exemplars in bilinguals is less determined by language-specific idiosyncrasies than the naming of boundary exemplars by monolinguals.

Implications for models of the bilingual lexicon. Ameel et al. (2005) considered Van Hell and De Groot's (1998)'s distributed conceptual feature model a useful framework to account for the bilingual naming pattern. We believe that the model can also more specifically account for the simplification that takes place in bilinguals as compared to monolinguals (see Figure 2). In the distributed feature model, a word (on the lexical level) is represented as a pattern of activation across a network of interconnected units or features. In line with most models of bilingual memory, the distributed feature model assumes that the features space representing knowledge of the world is shared across a bilingual's two languages, and features on this level are available to either language. However, how these features combine is language-specific. While this model was developed to account for differences in the extent to which a bilingual's lexical representations overlap for the two languages depending on word-type and grammatical class (e.g., abstract vs. concrete words; nouns vs. verbs), we believe that the model is also a useful framework to understand differences in the extent to which they overlap for two languages depending on the speaker (monolingual versus bilingual). Since similarity perception appears to be shared across languages (Ameel et al., 2005; Malt et al., 1999; at least for concrete objects for which knowledge is heavily determined by direct experience), we assume that featural knowledge is shared, not only across a bilingual's two languages, but also across speakers of different languages.

The upper panel of Figure 2 shows the monolingual situation. The circles on the lexical level represent words in Language 1 and Language 2 that are rough translation equivalents of one another for monolinguals in each. The black circles in the feature space represent features that are relevant to the words of interest in both Language 1 and Language 2. The white circles are language-specific features that are not shared across the words in Language 1 and Language 2. These language specificities for the two languages account for the cross-linguistic differences in naming (Ameel et al., 2005; Malt et al., 1999).
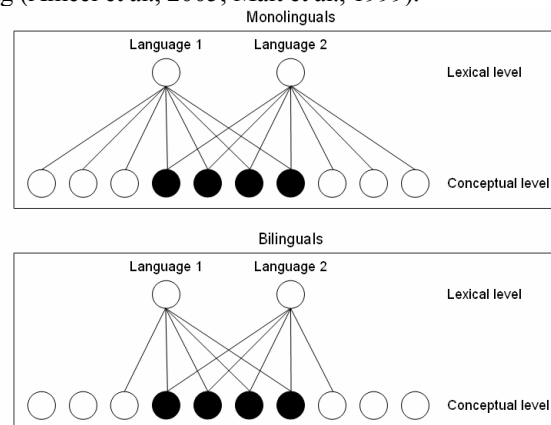

Figure 2. Schematic representation of the monolingual (upper panel) and the bilingual (lower panel) lexicon

The lower panel of Figure 2 shows the bilingual situation. The less complex category structure found for bilinguals can be explained in terms of dropped language specificities. This is represented by the white circles that are not taken into account to represent meaning in any language, and thus these features are not connected to the lexical level. As can be seen, we allowed some language specificity for bilinguals, since there remain subtle differences between the bilingual naming patterns (see the white circles that are connected to the lexical level).

As the examples described above suggest, bilinguals do not necessarily drop language-specific features of both languages. What will be dropped may depend on the level of complexity imposed by the language specificity of the two languages on the category structure. Less complex category structures are more likely to be retained than more complex category structures. Hence, the schematic representation of the bilingual situation (lower part of Figure 2) is too strong, since it assumes that language specificities of both languages are dropped. More moderate versions need to be considered allowing language specificities of one language to be retained, while dropping specificities of the other.

Generalizations to other classes of words. The conclusions about convergence in bilinguals drawn from the studies described in this paper are based on concrete nouns referring to common objects. Can these conclusions be generalized to other classes of words, such as abstract words or verbs? According to Van Hell and De Groot's (1998) distributed feature model, the degree of overlap in semantic features between translation equivalents is much smaller for abstract than concrete words (e.g., Plaut & Shallice, 1993). This means that the meaning of abstract words is even more strongly determined by language-specific features (Van Hell & De Groot, 2003).

In a study with Dutch-English bilinguals who judged how similar two words of translation pairs were, Tokowicz, Kroll, De Groot, and Van Hell (2002) indeed found that abstract translation equivalents were less likely to share meaning than concrete ones. We suggest that abstract words might be less vulnerable to convergence through simplification than concrete words, because it would imply that a larger portion of the meaning (i.e., the language-specific part) is dropped, resulting in a too impoverished meaning in both languages. Similarly, verbs, as compared to (concrete) nouns may vary more across languages than the meanings of nouns (Gentner, 1981). To the extent that that is true, we expect that convergence (in the form of dropping of language-specific features), is less likely to occur in verbs than in nouns. However, the process of grasping the meanings/uses of such lexical items may be delayed relative to monolingual children, due to the added difficulty of acquiring the necessary information from the reduced exposure to each language that a child growing up with two languages will receive.

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