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Phonological similarity in free and serial recall: The effect of increasing retention intervals

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The phonological similarity effect (or acoustic confusion effect) consists of poor serial recall performance for lists composed of similar-sounding words compared to lists of dissimilar-sounding items. Building on the work of Nairne and Kelley (1999), the extent to which this classical verbal short-term memory effect changes over the course of a retention interval was investigated. The impact of the phonological similarity on memory performance over time was compared in three paradigms: order reconstruction, serial recall, and free recall. Participants were presented with two blocks of 15 lists composed of five monosyllabic words, one block containing phonologically similar words and the other phonologically distinct words. Recall occurred either after 2, 8, or 24 seconds retention interval filled with a digit shadowing task. Our results confirmed and extended those of Nairne and Kelley. In order reconstruction and serial recall tasks, a classical phonological similarity effect (i.e., decrement in performance with similar lists) was observed for the 2-s retention interval. This effect disappeared after a brief period of digit shadowing (i.e., 8-s delay) and a beneficial effect of similarity was observed for the 24-s retention interval. In the free recall task, the phonological similarity produced better performance whatever the delay between presentation and recall. Those results are discussed in the light of Nairne's (1990a) feature model and confirm the role of item-specific and inter-item processes in order reconstruction, serial recall, and free recall.

L'effet de similarité phonologique se manifeste par une performance de rappel plus faible lorsque les listes sont composées de mots dont la sonorité est proche que lorsque les mots sont de sonorité éloignée. Sur la base de la recherche de Nairne et Kelley (1999), nous nous sommes intéressés à la manière dont évolue cet effet classique de mémoire à court terme verbale dans le temps, c'est-à-dire à l'issue d'intervalles de rétention de durées variables. L'impact de la similarité phonologique sur la performance mnésique a été évaluée sur la base de trois paradigmes, la reconstruction de l'ordre, le rappel sériel et le rappel libre. Les participants ont été soumis à deux blocs de 15 listes comportant 5 mots monosyllabiques, un bloc comprenant des mots similaires phonologiquement et un bloc comprenant des mots dissimilaires phonologiquement. Le rappel est demandé après un intervalle de rétention d'une durée de 2, 8 ou 24 secondes durant lequel une tâche de *shadowing* de chiffres est proposée. Nos résultats confirment et étendent ceux obtenus par Nairne et Kelley. Pour les tâches de reconstruction de l'ordre et de rappel sériel, un effet de similarité phonologique classique (i.e., chute des performances pour les listes similaires) est observé avec un intervalle de rétention de 2 secondes. Cet effet disparaît après une courte période consacrée au *shadowing* de chiffres (i.e., 8 secondes) et un effet bénéfique de la similarité est observé pour un intervalle de rétention de 24 secondes. En rappel libre, la similarité phonologique provoque une amélioration des performances quel que soit le délai entre présentation et rappel. Ces résultats sont discutés à la lumière du modèle des traits de Nairne (1990a). Ils confirment le rôle des traitements spécifiques à l'item et des traitements inter-items lors de tâches telles que la reconstruction de l'ordre, le rappel sériel et libre.

El efecto de la similitud fonológica (o efecto de confusión acústica) se manifiesta en fallas en el recuerdo de series para las listas compuestas por palabras que tienen sonidos similares en comparación con aquéllas que poseen elementos distintos. Con base en el trabajo de Nairne en Kelley (1999), se investigó la medida en la que este efecto clásico de memoria reciente cambia a lo largo del curso de un intervalo de retención. El impacto de la similitud fonológica sobre el desempeño de la memoria a lo largo del tiempo se comparó en tres paradigmas, reconstrucción del orden, recuerdo de series y recuerdo libre. Se presentó a los participantes dos bloques de 15 listas compuestas por 5 palabras monosilábicas, un bloque contenía palabras fonológicamente similares y, el otro, palabras fonológicamente distintas. El

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recuerdo ocurrió después de un intervalo de retención de 2, 8 ó 24 segundos lleno de una tarea digital de sombreado. Los resultados confirmaron y extendieron los de Nairne en Kelley. En las tareas de reconstrucción del orden y en la recuerdo de series, se observó un efecto clásico de similitud fonológica para el intervalo de retención de 2 segundos (es decir, disminución de la ejecución con listas similares). Este efecto desapareció después de un breve periodo de sombreado digital (es decir, un retraso de 8 segundos) y se observó un efecto benéfico de similitud para el intervalo de retención de 24 segundos. En la tarea de recuerdo libre, la similitud fonológica produjo mejor ejecución independientemente del retraso entre la presentación y el recuerdo. Tales resultados se discuten a la luz del modelo de Nairne (1990a) y confirman el papel que desempeñan los procesos de reactivo específico e interreactivo en la reconstrucción del orden, y en el recuerdo de series y libre.

In immediate serial recall, lists composed of similar-sounding items are remembered less well than lists of dissimilar items (Baddeley, 1966; Conrad, 1964). This phonological similarity effect (PSE) is one of the classical short-term memory effects (Baddeley, 1986, 1990). In this context, the PSE would account for the existence of a verbal working memory system, the phonological loop, consisting of an acoustic store (the phonological store) and an articulatory mechanism for subvocal rehearsal. Verbal memory traces would be dependent on a phonological (speech-based) code, thus explaining the span reduction when list items sound similar (Baddeley, Lewis, & Vallar, 1984).

Nairne (1990a) proposed an alternative to Baddeley's interpretation of the PSE observed in immediate recall. According to Nairne's feature model, list items are represented in both primary and secondary memory as a series of features (e.g., phonological, lexical, and semantic features for verbal stimuli). Features are encoded in primary memory and degradation occurs due to retroactive interference. Recall is achieved by sampling a particular secondary memory trace with a degraded trace from primary memory. In this context, phonological similarity could be modelled by assuming that if list items sound similar, their mnemonic representations would contain many overlapping phonological features leading to incorrect trace interpretation at retrieval.

Nairne and Kelley (1999) showed that when the retention intervals are short, a PSE is observed because recovering an item's correct position within a list is more difficult when list items sound similar. As the delay increases, the list dimension would play a more important role in determining final performance: Phonological similarity could help in list discrimination by providing a list-based retrieval cue (e.g., a common consonant sound).

Many researchers (Healy, 1974; Hunt & McDaniel, 1993; Murdock, 1982; Shortridge, 1999; Tversky, 1977) defined two essential processes in STM tasks: item-specific information (item information) and inter-item information (order information, i.e., the serial position of an item in a list). Serial recall could be interpreted as underlying those processes: Temporal positions occupied by items (order information) along with items themselves (item information) must be recalled. In this view, span performance in immediate serial recall can be reduced because the presented item is not recalled (item error) or because it is recalled at the wrong serial position (order error) (Saint-Aubin & Poirier, 1999).

Nairne and Neumann (1993) described two types of discrimination processes involved in retrieval: within-list discrimination (allowing the recovery of an item's correct position in a list) and the list-dimension discrimination (allowing the differentiation of the correct list representation from other list representations held in memory). The discrimination process (within-list process or process based on the list dimension) used for retrieval might change over time. When the retention interval is short, the list representation is temporally distinct, so performance will depend primarily on the location of an item's position in the list. However, when delay is increased, the list representation is more distant in time, so the discrimination based on the list dimension become more important. In this case, similarity can help participants to discriminate the current list from prior lists, leading to a reversed PSE (Nairne & Kelley, 1999).

According to Nairne and Neumann (1993), manipulations of within-list discrimination will impair performance when the participant has to discriminate an item's correct position along the list dimension. But the similarity will enhance performance if the list dimension is more important. In free recall, the important feature would be the list dimension discrimination, the within-list discrimination being less important as items may be encoded without regard to their original serial position (even if serial-order information should influence free recall in some way; Hunt & McDaniel, 1993; Kelley & Nairne, 2001). Free recall tasks are not based on order information recall, so the prediction is that phonological similarity would enhance performance whatever the delay. Indeed, in free recall, the phonological similarity gives a retrieval cue (such as a common consonant sound) that will help the list discrimination.

Although Coltheart (1993) showed that the PSE occurred both when list words were repeatedly sampled from a small set and when they were new on every trial, according to Nairne and Kelley (1999) it is necessary for the lists of items to employ different items across trials. Indeed, repeating the same items across trials (lists based on a restricted set of items) would lead to difficulty in discriminating the correct list along the list dimension, as the cue information may be consistent with many lists that occurred in the experiment. In this view, provided that different items are used on every trial, a reversed PSE should be observed whatever the delay in free recall.

A paradigm is thought to rely more heavily on memory for order: the order reconstruction task. Although this hypothesis has been discussed (Neath, 1997), it is typically assumed that performance on order reconstruction tasks mainly reflect order retention, because, at recall, the presented words are made available to the participants in a new random order (Healy, 1974; Nairne, 1990b, 1991; Nairne, Whiteman, & Kelley, 1999; Whiteman, Nairne, & Serra, 1994). If order memory causes the presence of a phonological similarity effect, one should expect such an effect with short duration, but a reversed effect with longer retention intervals.

An experiment was conducted in order to replicate Nairne and Kelley's results (1999) in order reconstruction and serial recall tasks and to confirm the role of item-specific and inter-item processes in serial and free recall. According to Nairne's "feature model," serial immediate recall would necessitate the differentiation of each specific item in order, and free recall would necessitate the retrieval of a search set constituted by list items. So the prediction is that a detrimental PSE should be observed in serial recall and order reconstruction paradigms with short delays, this effect being reversed with longer delays, but a facilitating effect of phonological similarity should be observed whatever the delay in a free recall paradigm.

EXPERIMENT

Method

Participants

Fifty-four young (mean age 20 years), male and female, adult undergraduates, all of whom were French native speakers, participated in the experiment. Participants were assigned to three groups before the experimental session. These groups were equated relative to their score on the digit span subtest of the WAIS-R (Wechsler, 1989) in order to control for short-term memory capacity.

Materials and design

Two sets of 15 lists (A and B sets) were first constructed, each list comprising five phonologically similar French words. The rhyme changed from list to list. The words were one-syllable concrete nouns of medium to high frequency. Frequency measures for the experimental words were obtained from the BRULEX psycholinguistic database (Content, Mousty, & Radeau, 1990). These two similar sets were used to generate two distinct sets of 15 lists each comprising five words (A' and B' sets). Dissimilar set A' was constructed from similar set A by selecting words at random and without replacement, with the constraint that no two words could rhyme within a given list. Dissimilar set B' was generated in the same way from the similar set B. The order of words within each list was fixed. In the experiment, participants were confronted by 30 lists (15 similar and 15 dissimilar), comprising sets A and B' for one group and sets A' and B for another. Consequently, the same set of 150 words was presented to everyone, these words being combined differently according to the participant group. Two practice lists were constructed, a similar and a dissimilar one. Words used for the practice lists were not included in the experimental material.

Three retention intervals were proposed to each participant (2, 8, and 24 seconds). A Latin square was used to counterbalance the order of retention intervals across participants. Five similar and five dissimilar lists were associated with each interval condition. They were blocked according to similarity condition and the order of the blocks was randomly determined.

Testing was controlled on a PC computer (Dell Optiplex GX100). The experimental program Polyspan (Roulin, 1998) was used to conduct items presentation.

Procedure

Participants were tested individually and were given one of the three memory tasks (order reconstruction, serial recall or free recall task). The experimental session lasted approximately 30 minutes.

The five list items were presented sequentially and visually in the centre of the computer screen. Each word was displayed for 750 ms with a 250 ms interstimulus interval. Participants were instructed to read aloud each word as soon as it appeared on the screen. Immediately after the last item, a retention interval of 2, 8, or 24 seconds, filled with a digit shadowing task, was introduced. In this task, participants had to read aloud sequences of digits that were presented rapidly in a random order. As soon as the retention interval was over, participants were required to recall verbally the five list words. In the order reconstruction task, all the list items

were visually re-presented to the participant on the screen, but in a new random order. The task was to verbally produce these words in the order of presentation. In the serial recall task, the items were not re-presented. Participants were required to repeat the five words in the order in which they had been read. They were instructed to substitute the word "*passe*" for any item they could not recall. Finally, in the free recall condition, participants were asked to recall the five words from the list in any order. Response time was not limited, the next trial being initiated by the experimenter. Before the testing proper, two practice lists were used to ensure that participants understood the memory task.

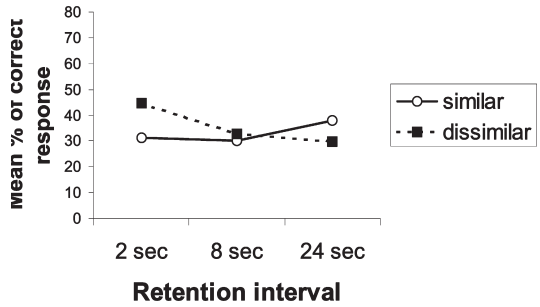

Figure 2. Mean % of correct response observed in serial recall as a function of retention interval (2 s, 8 s, or 24 s) and similarity of words in the list.

Results

In the order reconstruction and serial recall tasks, each response was scored as correct if it was the correct word recalled in the correct position. In the free recall condition, a response was considered correct if it was part of the presented list, regardless of its position. Mean per cent of correct recall is presented for each memory task in Figures 1, 2, and 3.

An analysis of variance (ANOVA) was performed on the data including two within-subject factors (retention interval and similarity of the words in the list) and a between-subject factor (memory task).

Main effects of Memory Task, $F(2, 51) = 29.32$, $p < .01$; Similarity, $F(1, 51) = 10.03$, $p < .01$; and Retention Interval, $F(2, 102) = 5.74$, $p < .01$, were observed. The Memory Task × Similarity × Retention Interval interaction was significant, $F(4, 102) = 3.40$, $p < .01$. Performance was higher for free recall than for serial recall or order reconstruction.

In the order reconstruction paradigm (cf. Figure 1), the similarity effect depended on the duration of the retention interval: The similarity effect was present for a 2-s retention interval, $F(1, 51) = 20.5$, $p < .05$, with a mean percentage of correct responses more important for lists with similar words (38%) than for lists with dissimilar words (29.78%). The similarity effect was not significant for an 8-s retention interval, $F(1, 51) = 3.19$, n.s., but was present for a 24-s delay, $F(1, 51) = 6.65$, $p < .05$. In this case, the mean percentage of correct responses was less important for lists with similar words (40.22%) than for lists with dissimilar words (58.67%).

In serial recall (cf. Figure 2), the same pattern of results was observed: A detrimental effect of similarity for the 2-s retention interval, $F(1, 51) = 12.86$, $p < .01$ (44.67% mean of correct responses for lists of dissimilar words and 31.11% mean of correct responses for lists of similar words); no effect of similarity was observed at the 8-s retention interval, $F(1, 51) = 0.56$, n.s.; and a beneficial effect of similarity was observed at the 24-s delay, $F(1, 51) = 4.92$, $p < .05$ (29.78% mean of correct responses for lists of dissimilar words and 38% for lists of similar words).

The similarity effect was observed in free recall (cf. Figure 3) for a 2-s retention interval, $F(1, 51) = 24.98$, $p < .01$; for an 8-s retention interval, $F(1, 51) = 27.47$, $p < .01$; and for a 24-s retention interval, $F(1, 51) = 28.47$, $p < .01$. Whatever the delay, lists with similar words were better recalled than lists with dissimilar words.

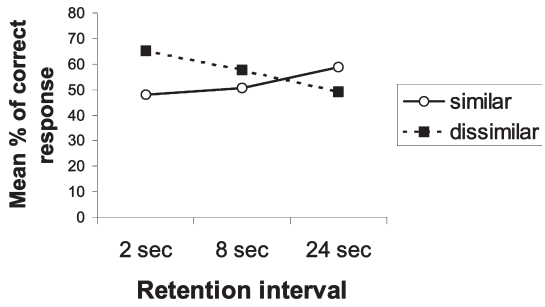

Figure 1. Mean % of correct response observed in order reconstruction as a function of retention interval (2 s, 8 s, or 24 s) and similarity of words in the list.

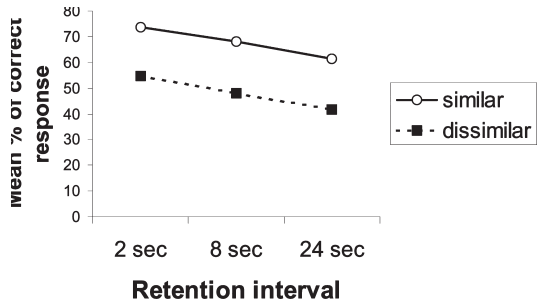

Figure 3. Mean % of correct response observed in free recall as a function of retention interval (2 s, 8 s, or 24 s) and similarity of words in the list.

DISCUSSION

The order reconstruction task evidenced a PSE for a 2-s delay, no effect of similarity for an 8-s delay, and a reversed effect for a 24-s delay. In the serial recall task, a classical phonological similarity effect was observed for a 2-s delay, no effect for an 8-s delay, and a reversed effect (higher performance for the phonologically similar words) for a 24-s delay. In the free recall task, a facilitating effect of similarity was observed whatever the delay.

A number of models are able to predict the PSE (Baddeley, 1986) occurring in serial recall tasks. For example, Lewandowsky and Murdock (1989) proposed that associative chaining is a method for building ordered lists by linking together nearest-neighbour items into associative units (represented as a convolution of vector pairs). In this model, called TODAM, a way to model the phonological similarity effect would be to assume overlapping (nonorthogonal) vector representations of the phonological characteristics of items. In this model, phonological similarity is acting on the cueing of items, because repeated phonemes are ambiguous cues for their successors. Chaining of items thus predicts catastrophic errors of mixed confusable (acoustically similar, for example) and nonconfusable (acoustically different) items, as the large overlap between similar items should cause massive interference among cues, and recall of the following items should be impaired.

However, the fact that phonological similarity is acting on cueing has been questioned. Baddeley (1968, Experiment V) tested whether phonological similarity affects the cueing of items, or whether it affects the retrieval of items. He used immediate serial recall of lists of six items, acoustically similar (the confusable items) or acoustically different (the nonconfusable items). He explored the nature of errors in recall, using lists in which confusable and nonconfusable items alternated. Baddeley argued that most errors in recall of alternating lists occurred for confusable items, rather than the nonconfusable items that followed them, and this fact favoured the idea of phonological similarity acting on retrieval rather than on cueing. Indeed, the fact that the confusable items in alternating lists had little to no effect on recall of the nonconfusable items, when compared with those in nonconfusable lists, suggested that there is no effect of phonological similarity on cueing.

Nairne and Kelley (1999) also suggested that phonological similarity has an effect on retrieval in their feature model. The similarity between items in a list would act as a retrieval cue, helping in list discrimination as the delay between the presentation of items and recall is increased, thus explaining the better recall of similar item lists than the dissimilar item lists with longer delays.

Results with the order reconstruction paradigm replicate Nairne and Kelley's results (inversion of the PSE with longer delays in the order reconstruction task). This effect is also observed with a serial recall task. These results suggest that the disrupting factor in both tasks would be associated with order retention.

Other studies also looked at the phonological similarity effect in tasks that are the same or very similar to those used here, albeit without manipulating duration. In particular, Gathercole, Pickering, Hall, and Peaker (2001), have shown that the phonological similarity effect is as strong in a serial order recognition task as it is in serial recall. Although a slightly different task to order reconstruction test is used here, this is essentially a comparison of order versus item (or order plus item) memory. Indeed, it is hardly surprising that the effect persists in order tasks (at least with immediate or very short recall), given that the phonological similarity has been shown to have its effects on order recall (see also Wickelgren, 1965).

The phonological similarity effect occurs in serial recall tasks in spite of the fact that the items themselves are more likely to be recalled when similar, albeit in the wrong order, as can be demonstrated by comparing serial with free recall (Watkins, Watkins, & Crowder, 1974).

This is compatible with results from Fallon, Groves, and Tehan (1999). They presented participants with similar rhyming, similar nonrhyming, and dissimilar lists in a serial recall procedure under immediate recall conditions. They scored immediate serial recall either in terms of item (an item was scored as correct if it was produced anywhere in the output) or of position accuracy. With the correct-in-position scoring, a detrimental effect of phonological similarity was observed both for rhyming and nonrhyming similar lists comparatively to dissimilar lists. They concluded a detrimental effect of phonological similarity on position accuracy. Conversely, with the item scoring, recall was better when the items in the lists were similar (in the rhyming similar lists). This difference between similar rhyming lists and dissimilar lists was attributed in large part to the fact that rhyming lists produced better item information than dissimilar lists. This result seems compatible with the assumption that, in free recall, phonological similarity gives a retrieval cue (named a category cue effect by Fallon et al., 1999) that will help the list discrimination in the feature model's view, as the list dimension discrimination seems more important in a free recall paradigm. The free recall task would necessitate a search set constituted by the list of items, so the phonological shared features would facilitate retrieval. The

reversal of the PSE in free recall would thus be a result of improved discriminability along the list dimension (as the retrieval cue in the phonological similarity condition is different on each trial).

On the contrary, in serial recall or order reconstruction (necessitating the differentiation of each specific item in order) the distinctive features would be more important, leading to a better recall of dissimilar than similar words.

Those results support the notion of dual processing in immediate memory being based on the storage of item-specific and order information, or the distinction proposed by Tversky (1977) between item-specific and inter-item information. However, even if the results do seem to be consistent with Nairne's feature model, they are not opposed to a more traditional view of short-term as opposed to long-term memory. Indeed, Baddeley (1966) has shown that the phonological similarity effect fades over time and can account for this within his theoretical framework.

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