A Joint Investigation of Semantic Facilitation and Semantic Interference in Continuous

Naming

Michele Scaltritti, Francesca Peressotti, Eduardo Navarrete

Università degli Studi di Padova

WORD COUNT: 4876 (reference included, abstract and footnotes excluded)

Author Note

Michele Scaltritti, Francesca Peressotti, and Eduardo Navarrete, Dipartimento di

Psicologia dello Sviluppo e della Socializzazione, Università degli Studi di Padova, Padova,

Italy.

Michele Scaltritti is now at Aix Marseille Univ, CNRS, LPC, Marseille, France.

Correspondence concerning this article should be addressed to: Michele Scaltritti,

LPC-UMR 7290, Aix Marseille Univ, CNRS, 3 Place Victor Hugo 13100 – Marseille,

France. Phone: +33 4 13550970. e mail: michele.scaltritti@univ-amu.fr

Abstract

When speakers name multiple semantically related items, opposing effects can be found. Semantic facilitation is found when naming two semantically related items in a row. In contrast, semantic interference is found when speakers name semantically related items separated by one or more intervening unrelated items. This latter form of interference is cumulative, as it increases as a function of the number of related items that have been named beforehand. Semantic facilitation has therefore been envisaged as a product of transient and fast-decaying activation of related representations, while semantic interference has been linked to longer-lasting changes in the connections between semantic and lexical representations. In this work we attempted to explore and compare the two phenomena jointly, by means of contrasting naming sequences with non-contiguous semantically related items and sequences with contiguous semantically related items. Results provide evidence that mechanisms responsible for semantic facilitation and interference may jointly occur in parallel, producing opposing influences on behavior. Importantly, semantic facilitation may exhibit cumulative features too, though these are immediately disrupted when unrelated items intervene.

Keywords: semantic facilitation, semantic priming, semantic interference, continuous naming, word-production

Introduction

Theories of word production converge on the notion that multiple semantically related lexical entries are initially activated during lexical access. If the speaker has to name the picture of a cat, not only lexical-semantic representations of "cat", but also other related representations such as "dog" and "mouse" will be activated through spreading activation (Collins & Loftus, 1975) among related representations. Importantly, these different representations would retain some amount of activation for a certain period of time. In this scenario, the production of a word could be affected by previous lexicalization events.

There exists evidence congruent with these assumptions. In spoken production tasks such as picture naming, naming latencies for a given target are shorter when a semantic coordinate item (picture or word) has previously been processed compared to when an unrelated item has been processed (e.g., Carr, McCauley, Sperber, & Parmelee, 1982; Henderson, Pollatsek, & Rayner, 1987; Huttenlocher & Kubicek, 1983). This represents the semantic priming effect. As the semantically related prime pre-activates the representation for the target via spreading activation (e.g., Neely, 1991), conceptual processing of the latter will be facilitated. This effect of semantic facilitation vanishes if an unrelated item is presented between the two semantically related ones (Damian & Als, 2005; Navarrete Del Prato, & Mahon, 2012; Wheeldon & Monsell, 1994).

More precisely, semantic facilitation does not simply vanish when an unrelated item is presented between two semantic coordinate items, but it turns into an interference effect. Semantic interference in a given trial (n) is observed when a semantic coordinate word has been named, not in the preceding trial (n-1), but a few trials back (e.g., n-2). Important evidence regarding this interference effect has been provided by Brown (1981) and, more recently, by Howard and colleagues (Howard, Nickels, Coltheart, & Cole-Virtue, 2006). In their continuous naming paradigm, Howard and colleagues presented pictures arranged in an

unpredictable sequence. Different exemplars from the same semantic categories were presented in the sequence, separated by unrelated intervening items. Reaction times (RTs) grew linearly as a function of the number of previously named pictures in the same category (cumulative semantic interference effect), irrespective of the number of items intervening between two exemplars of the same category (but see Schnur, 2014). This evidence clearly characterizes semantic interference as a long-lasting phenomenon, in sharp contrast with semantic facilitation.

While different theories of lexical access agree on the notion that facilitation emerges as a consequence of spreading activation between related representations, there is still debate on the origin of the semantic interference effect. There is a general consensus on the notion that semantic interference in continuous naming involves long-lasting modifications of the links between conceptual and lexical representations. However, some models posit lexical locus of the phenomenon through a mechanism of lexical selection by competition between co-activated representations (Howard et al., 2006). In these models, when an item is named, the link between its conceptual and lexical representations is strengthened. When a semantic-coordinate item is eventually presented, the previously named exemplars would thus represent stronger (i.e., more active) lexical competitors. Differently, other models do not implement any competition at the lexical level, and suggest that interference is produced by the weakening of the semantic-to-lexical connections for co-activated but unselected representations through an incremental learning mechanism (Oppenheim, Dell, & Schwartz, 2010). When these representations have to be named later on, latencies will be slower due to this previous weakening of the semantic-to-lexical connections.

For the purpose of the present study it is relevant that facilitation and interference effects have traditionally been investigated separately (but see Navarrete, Del Prato, Peressotti, & Mahon, 2014), coherent with evidence suggesting that the two stem from

different mechanisms operating with different time-courses (Wheeldon & Monsell, 1994; Howard, et al., 2006). Interestingly, available theoretical perspectives suggest that the two effects may be related. Howard and colleagues suggest that the same mechanisms of shared activation (e.g., spreading activation) underlying the semantic priming effect are also responsible for the re-activation of previously named coordinate representations that compete with the target, thereby producing semantic interference. Similarly, Oppenheim and colleagues predict that the interference effect is graded as a function of semantic similarity. In their model, the connections between the semantic and the lexical nodes of non-target representation are weakened as a function of the amount of semantic features shared with the target. Shared semantic features may also represent the basic mechanism for explaining semantic priming effects.

The aim of the present study is to explore the unfolding of semantic facilitation and semantic interference concurrently, in order to investigate their joint influence on behavior, their time-course, and the extent to which interference and facilitation are related phenomena. We used the continuous naming paradigm, in which the two effects can be concurrently explored.

Rationale for the experiment

In the continuous naming paradigm, different exemplars of the same categories are presented separated by intervening items belonging to different categories in order to investigate multiple accesses to the same semantic categories without the contamination of semantic priming effects. In contrast, in the present experiment, we were specifically interested in investigating how these semantic priming effects may show up in a continuous naming paradigm, and how they would relate to the interference dynamics. In other words: what happens when the conditions for both facilitation and interference are met?

As the two phenomena are thought to stem from different (albeit potentially related) mechanisms, the two should develop concurrently, with opposing effects on performance. If this is the case, the following predictions can be put forward. First, when two pictures of the same semantic category are presented in a row (e.g., car, truck) the overlap of semantic features should speed-up the retrieval of the second one. Yet, at the same time, naming the first picture should impair the retrieval of the second one. As such, naming of the second item (truck) would be concurrently facilitated and delayed when a semantic coordinate (car) has just been named in the previous trial. We may thus expect differences in terms of naming latencies when a given item (truck) is presented, for instance, as the second within-category exemplar immediately after the first within-category exemplar (car) in comparison to when the same item (truck) is presented as the second within-category exemplar immediately after an unrelated item (e.g., dog).

A second prediction focuses on the different time course of the two phenomena. If interference accumulates across trials, its effects should be detected even when the related trials are named in a row (with no intervening items form other categories in between). Instead, facilitation should vanish even after a sequence of related items, as soon as unrelated items are presented. To test these predictions we devised naming sequences with four members of the same semantic category in a row, followed by a series of intervening unrelated items and a final fifth related member. The four related members presented in a row should provide insight into the joint influence of facilitation and interference, eventually showing differential prevalence of the two effects as a function of ordinal position. The performance on the final fifth related member should offer a direct test of our predictions: no facilitation - given the presence of intervening unrelated items- and a cumulative interference produced by the sequence of multiple related members.

Experiment

Method

      Participants. Twenty-four undergraduate students from the University of Padova participated in the experiment. All of them were native Italian speakers.

      Materials. One hundred eighty-eight pictures (color photographs) were selected. Many of them were taken from the set used by Navarrete, Mahon and Caramazza (2010), while others were taken from the internet. Experimental items consisted of 120 pictures belonging to 24 different semantic categories, with 5 exemplars in each category (mostly taken from Runnqvist, Strijkers, Alario, & Costa, 2012). The others were filler items and none of them belonged to any of the categories of the experimental items. Four of these filler items were used only in the practice session at the beginning of the experiment, while 8 of them served as buffer items to be placed at the beginning of the experimental session or after each break (see the procedure below).

      Pictures were presented within a pseudo-randomized sequence, in which twelve categories were assigned to the non-contiguous condition, and the other twelve to the contiguous condition. For the 12 categories assigned to the non-contiguous condition, items within the same category were separated by lags of 2, 4, 5, or 6 intervening items. For the contiguous condition, the first four items of each of the 12 categories were presented in a row, while the last one was separated from the fourth again by lags of 2, 4, 5, or 6 intervening items. Twelve lag orderings were selected. Each lag was equally represented across different ordinal positions in the non-contiguous condition, and each lag was represented equally often across fifth items of the contiguous condition. The pseudo-random sequence was repeated twice for each participant. In the second presentation, semantic categories were assigned to the opposite condition: categories that appeared in the non-contiguous condition in the first presentation were presented in the contiguous condition during the second one, and vice versa. Semantic categories were rotated so that, for all participants, each category

was assigned equally often to non-contiguous and contiguous conditions. Furthermore, for the non-contiguous condition, all the semantic categories appeared equally often across all the possible lag orderings. For the contiguous condition, each semantic category had the fifth item presented equally often across the possible lags. The ordinal position of the exemplars within their semantic category was randomly determined in the first presentation, and the same order was kept in the second presentation (note that by switching the condition, their position within the sequence was different with respect to the first presentation).

Apparatus and procedure. Participants were seated in front of a computer monitor, at a distance of approximately 50 cm, wearing a headset microphone. They were instructed to name each picture aloud. Accuracy and speed were equally emphasized. The experiment began with a short practice (4 trials) to familiarize participants with the procedure and the experimental setting. A short break occurred at intervals of 88 trials. The breaks occurred only after all the exemplars of a given category were presented in the previous trials. The experimental session started with 2 buffer trials, and 2 buffer trials were presented after each break.

In each trial, a fixation cross was shown in the center of the screen for 500 ms and was followed by a blank interval lasting 250, 200, or 150 ms. The picture was presented for 2000ms, and disappeared as soon as the response onset triggered the microphone. Figures were scaled to fit a square of 300X300 pixels and were presented against a white background. Stimulus presentation was controlled by the DMDX program (Forster & Forster, 2003). Onset latency and accuracy were checked offline using the CheckVocal software (Protopapas, 2007)

Results

RTs. Responses with verbal dysfluencies, responses in which participants produced an incorrect name (semantic superordinates such as "fish" instead of "shark"; semantic

coordinates such as "rifle" instead of "machine gun"), and missing responses were considered

errors (8.33%) and excluded from the analysis. For the remaining observations response

latencies 2.5 SDs above or below each participant's mean latency were removed, thus

eliminating a further 3.05% of the responses.

In the ANOVAs, we considered two factors: condition (2 levels: non-contiguous vs.

contiguous) and ordinal position within category (five levels: 1 to 5). Mean RTs as a

function of condition and ordinal position are represented in Figure 1. Separate analyses

were conducted treating participants (F_1/t_1) and semantic categories (F_2/t_2) as random factors.

Both experimental factors were considered as within-participants and within-items factors.

Greenhouse-Geisser correction was applied when the assumption of sphericity was violated.

In case of multiple comparisons, reported p values were adjusted using false discovery rate

(Benjamini & Hochberg, 1995), as implemented in the p.adjust function in R (R Core Team,

2014).

(Figure 1 about here)

The main effects of condition (F_1 [1, 23] = 14.85, $p < .01$, $MSE = 1146.89$, $\eta^2_p = .39$;

F_2 [1, 23] = 12.23, $p < .01$, $MSE = 1677.88$, $\eta^2_p = .35$) and ordinal position (F_1 [3.05, 70.26] =

23.64, $p < .001$, $MSE = 1994.11$, $\eta^2_p = .51$; F_2 [4, 92] = 15.21, $p < .001$, $MSE = 2361.56$, $\eta^2_p =$

.4) were significant. The interaction was significant as well (F_1 [4, 92] = 7.31, $p < .001$, MSE

= 1300.75, $\eta^2_p = .24$; F_2 [4, 92] = 8.24, $p < .001$, $MSE = 948.51$, $\eta^2_p = .26$). The effect of

ordinal position was different across the two experimental conditions: while in the non-

contiguous condition RTs increased with ordinal position, in the contiguous condition the

first four items (which were presented in a row, with no intervening items) appear to display

rather similar RTs, while there is a steep increase only for the responses to the fifth ordinal

position. As a result, RTs in the two conditions are similar for the first and the last ordinal

position, while they appear to differ in ordinal positions 2 to 4.

   To formally support these considerations, we ran further analyses. Multiple

comparisons showed that RTs did not differ across the two conditions either in the first (t_1

[23] = - 1.4, p = .22; t_2 [23] = -1.29, p = .26), or in the last ordinal position (both t_s < 1).

However, compared to the non-contiguous condition, RTs in the contiguous condition were

significantly faster in ordinal position 2 (t_1 [23] = 2.99, p < .05; t_2 [23] = 3.71, p < .01),

ordinal position 3 (t_1 [23] = 4.07, p < .001; t_2 [23] = 3.34, p < .01), and ordinal position 4 (t_1

[23] = 4.22, p < .001; t_2 [23] = 3.77, p < .01). We further explored the effect of ordinal

position by running separate ANOVAs in the two conditions. For the non-contiguous

sequences, the effect of ordinal position was significant (F_1 [4, 92] = 15.25, p < .001, MSE =

1360.35, η^2_p = .4; F_2 [4, 92] = 10.7, p < .001, MSE = 1943.81, η^2_p = .32), and RTs increased

as a function of ordinal position (linear trend: F_1 [1, 23] = 34.65, p < .001, MSE = 2203.99,

η^2_p = .6; F_2 [1, 23] = 47.44, p < .001, MSE = 1559.6, η^2_p = .67). The increase in RTs tends to

level-off in the last positions, as suggested by the presence of a significant quadratic trend (F_1

[1, 23] = 5.63, p < .05, MSE = 840.09, η^2_p = .2; F_2 [1, 23] = 5.12, p < .05, MSE = 1288.11, η^2_p

= .18). For the contiguous condition, the effect of ordinal position was significant when

considering all the ordinal positions (F_1 [4, 92] = 18.75, p < .001, MSE = 1230.17, η^2_p = .45;

F_2 [4, 92] = 16.79, p < .001, MSE = 1366.27, η^2_p = .42). When limiting the analyses to the

first four positions, the effect failed to reach significance (F_1 [3, 69] = 2.11, p = .11, MSE =

1253.57, η^2_p = .08; F_2 [3, 69] = 1.49, p = .22, MSE = 1419.7, η^2_p = .06), suggesting that RTs

were similar across the positions from 1 to 4.

   We ran additional analyses to evaluate an eventual effect of lag. In these analyses we

considered only ordinal positions 2 to 5 for the non-contiguous condition. The effect of lag

(F_s < 1), as well as the lag by ordinal position interaction (F_s < 1), were not significant.

When considering the contiguous condition, the effect of lag failed to exert any significant influence on the RTs for responses in ordinal position 5 (F_1 [3, 69] = 1.35, p = .27, MSE = 7065.37, η^2_p = .05; F_2 [1.77, 40.82] = 1.04, p = .35, MSE = 17939.39, η^2_p = .04). When limiting the analyses to ordinal position 5 across the two conditions, the effect of lag (F_s < 1), as well as the lag by condition interaction failed to reach significance (F_1 [3, 69] = 2.16, p = .10, MSE = 5587.81, η^2_p = .09; F_2 [2.18, 50.18] = 1.94, p = .15, MSE = 7863.89, η^2_p = .08).[1]

Finally, we estimated the magnitude of the semantic facilitation effect by directly comparing the first four ordinal positions across the contiguous and non-contiguous sequences of our experiment. To this end, separately within each of the ordinal positions from 1 to 4, we subtracted the average latencies in non-contiguous sequences from those of contiguous sequences. As contiguous sequences are deemed to be concurrently affected by interference and facilitation combining additively, subtracting RTs in the non-contiguous sequences form contiguous ones should cancel out interference from the latter, thus enabling us to track the unfolding of semantic facilitation as a function of ordinal position. As can be seen in Figure 2 semantic facilitation increases as a function of ordinal position, as signaled by the presence of a significant linear trend (F_1 [1, 23] = 15.26, p < .01, MSE = 2421.16, η^2_p = .4; F_2 [1, 23] = 25.76, p < .001, MSE = 1323.82, η^2_p = .53; For a similar result see Navarrete et al. 2014). This results suggests that the facilitation effect is cumulative.[2]

(Figure 2 about here)

We performed additional analyses to test an alternative account according to which facilitation is not cumulative, but simply larger than interference.[3] If facilitation is larger than interference, in contiguous sequences we should expect faster responses in ordinal position 2 than in ordinal position 1. The prediction is not met, as the difference between ordinal

position 1 and 2 of contiguous sequences was not reliable (t_1 [23] = 1.65, p = .33; t_2 [23] = 1.31, p = .60). Additionally, a non-cumulative facilitation account would predict that within contiguous sequences, at least in ordinal position 4 responses should be slower than ordinal position 1. This is so because the items in position 4 should be affected by the interference generated by three items (i.e., the items in ordinal positions 1, 2, and 3), while benefiting from the facilitation produced by one single items (i.e., the previous item in ordinal position 3). However, RTs in ordinal position 4 were no different compared to position 1 (ts < 1, ps > .60). The same was true for ordinal position 3 (ts < 1, ps > .60).[4]

Accuracy. The main effect of condition was not significant (F_1 [1, 23] = 2.55, p = .12, MSE = .001, η^2_p = .1; F_2 [1, 23] = 2.36, p = .14, MSE = .001, η^2_p = .09). The effect of ordinal position approached conventional levels of significance only in the analyses by participants (F_1 [4, 92] = 2.16, p = .08, MSE = .003, η^2_p = .09; F_2 [2.55, 58.72] = 1.1, p = .35, MSE = .012, η^2_p = .05), and the interaction was not significant (Fs < 1). When examining the effect of lag, for the non-contiguous condition we limited the analyses to ordinal positions 2 to 4. Here, the effect of lag failed to reach significance (F_1 [3, 69] = 2.2, p = .1, MSE = .014, η^2_p = .09; F_2 [3, 69] = 2.17, p = .1, MSE = .016, η^2_p = .09), and the interaction lag by ordinal position was not significant (Fs < 1). For the contiguous condition, the effect of lag was not reliable for items presented in the fifth ordinal position (Fs < 1). Finally, when limiting the analysis to ordinal position 5 for both conditions, the main effect of lag (F_1 [3, 69] = 1.03, p = .38, MSE = .023, η^2_p = .04; F_2 < 1), as well as the condition by lag interaction (Fs < 1), were not significant.[5]

General Discussion

We compared two types of sequences within a continuous naming paradigm. The first type of sequence, *non-contiguous sequence*, was the one typically explored in this paradigm, in which multiple semantic coordinate pictures are presented separated by intervening items of

other categories. The second type of sequence, *contiguous sequence*, presented four pictures belonging to the same semantic category in a row, and a fifth one separated from the previous ones by intervening trials belonging to other categories. In regards to these latter sequences, we predicted that 1) facilitation and interference would be able to jointly influence naming performance of the first 4 items, and 2) only interference should influence the RTs in ordinal position 5.

In terms of results, non-contiguous sequences replicated the classic pattern of cumulative semantic interference. Contiguous sequences yielded two main results: 1) as long as semantic coordinates were presented with no intervening unrelated trials in between, no sizeable interference was detected and 2) when intervening unrelated trials were named, semantic interference was displayed in its full blown magnitude (i.e., reflecting cumulative interference from all the 4 previous items of the same category). We argue that this pattern confirms the predictions detailed above. The absence of any effect (interference or facilitation) when 4 items of the same category are displayed in a row is apparently puzzling. However, it is congruent with the prediction that each of these items should be jointly facilitated and inhibited by all the previous ones, that is, with the notion that interference and facilitation should be able to occur in parallel, jointly influencing behavior in opposing directions. Regarding this latter claim, it is crucial to consider within facilitation sequences the results from items in ordinal position 5, which were preceded by exemplars from other categories. Here, we found comparable latencies with respect to those measured in the same ordinal position within traditional interference sequences. This confirms that the mechanisms responsible for interference were operative even for items of the same category presented sequentially within contiguous sequences. The lack of any detectable interference effect within these first 4 items presented in a row thus strongly suggests that interference phenomena were counteracted by an equal and opposing force: semantic facilitation.

If we accept this latter claim, we must also endorse two additional arguments. First semantic facilitation, like semantic interference, can display cumulative features (see also Navarrete et al., 2014). This contrasts with the traditional view claiming that semantic facilitation represents a transient, short-lived phenomenon. It is transient, in the sense that is disrupted by the intervention of unrelated items, but it is not short-lived because, if appropriate conditions are met (i.e., there are no intervening unrelated items) it can linger across multiple trials. Second, semantic facilitation must have the same magnitude as semantic interference. For the net effect to be null, the counteracting influence of semantic facilitation must have the same magnitude as semantic interference (see also Figure 7B in Navarrete et al. 2014; Damian & Als, 2005). This latter conclusion is congruent with semantic graded effects as a function of semantic similarity reported in the cyclic naming paradigm in which items are named more slowly in blocks containing more semantically similar items than in blocks containing less similar items (Vigliocco, Vinson, Damian, & Levelt, 2002; Navarrete et al., 2012). Also, the first time items are named in the blocks (i.e., first cycle) the effect reverses, and items are named faster in blocks containing more semantically similar items than in less similar ones (Navarrete et al., 2012). This additional parallel between semantic interference and facilitation effects further highlight the relationships between the two.

We thus claim that facilitation and interference in picture naming are related phenomena as both effects are cumulative and have a similar magnitude. These observations can be accommodated within current models of cumulative effects in continuous naming when considering the mechanisms of *shared activation* they implement. When naming a given item, co-ordinate semantic representations (Howard et al., 2006) or semantic features shared by multiple representations (Oppenheim et al., 2010) will be activated, providing foundations for both semantic interference and facilitation. For the facilitation effect, shared

activation would determine the amount of semantic priming. For the interference effect, shared activation would determine the activation of non-target lexical competitors (Howard et al., 2006) or the extent to which the connections between semantic and lexical representations of non-target representations are weakened (Oppenheim et al., 2010). The similar size of facilitation and interference phenomena might thus be linked to the mechanisms they share at the conceptual level of processing.

A novel and critical aspect outlined by our findings is the temporal dynamics of semantic facilitation. The results suggest that the related semantic representations activated via shared activation within contiguous sequences can remain (partially) active across multiple trials (four, in our experiment). This *residual activation* would linger across trials only while semantically related representations are sequentially presented, and it would vanish once an unrelated item is presented, as testified by the full-blown interference detected in the fifth position of our contiguous sequences. Under this perspective, the lack of residual semantic activation across trials within current models of cumulative semantic interference is justified by the type of sequences they examine, where co-ordinate exemplars are presented separated by intervening unrelated items. There may not be any residual semantic activation under these conditions. Yet, if conditions similar to our contiguous sequences were to be examined, it might be needed to implement residual activation at the conceptual level to account for cumulative semantic facilitation.

In conclusion, we would argue that both facilitation and interference effects are relevant phenomena for the understanding of language production. Models of word production should then be able to account for both of them, as well as for their differences and similarities. Our current study suggests some important elements under this perspective. Whereas interference resists many intervening trials, dynamics of semantic facilitation are immediately disrupted by the presentation of unrelated representations. However, when

multiple semantic co-ordinates are presented in a row, semantic facilitation can display

cumulative features too, suggesting that residual activation at the semantic level can persist

across multiple trials. Finally, interference and facilitation effects have a similar magnitude,

coherently with the idea that both effects involve common mechanisms, namely shared

activation at the conceptual level.

References

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects

Models Using lme4. *Journal of Statistical Software, 67*, 1-48.

Brown, A. S., (1981). Inhibition in cued retrieval. *Journal of Experimental Psychology:

Human Learning and Memory, 7*, 204–215.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate: A practical and

powerful approach to multiple testing. *Journal of the Royal Statistical Society, 57*, 289–

300.

Carr, T. H., McCuley, C., Sperber, R. D., & Parmelee, C. M. (1982). Words, pictures, and

priming: On semantic activation, conscious identification, and the automaticity of

information processing. *Journal of Experimental Psychology: Human Perception and

Performance, 8*, 757-777.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing.

Psychological Review, 82, 407–428.

Damian, M. F., & Als, L. C. (2005). Long-lasting semantic context effects in the spoken

production of object names. *Journal of Experimental Psychology: Learning, Memory,

and Cognition, 31*, 1372–1384.

Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond

accuracy. *Behavior Research Methods, Instruments & Computers, 35*, 116–124.

Henderson, J. M., Pollatsek, A., & Rayner, K. (1987). Effects of foveal priming and

extrafoveal preview on object identification. *Journal of Experimental Psychology:

Human Perception and Performance, 13*, 449–463.

Huttenlocher, J., & Kubicek, L. F. (1983). The source of relatedness effects on naming

latency. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9*,

486–496.

Howard, D., Nickels, L., Coltheart, M., & Cole-Virtue, J. (2006). Cumulative semantic

inhibition in picture naming: experimental and computational studies. *Cognition, 10*,

464e482.

Navarrete, E., Del Prato P., Mahon, B. Z. (2012). Factors determining semantic facilitation

and interference in the cyclic naming paradigm. *Frontiers in Psychology, 38*, 1–15.

Navarrete, E., Mahon, B. Z., & Caramazza, A. (2010). The cumulative semantic cost does

not reflect lexical selection by competition. *Acta Psychologica, 134,* 279-289.

Navarrete, E., Del Prato, P., Peressotti, F., & Mahon, B.Z. (2014). Lexical selection is not by

competition: Evidence from the blocked naming paradigm. *Journal of Memory and

Language, 76*, 253–272.

Neely, J.H. (1991). Semantic priming effects in visual word recognition: A selective review

of current findings and theories. In D. Besner & G. Humphreys (Eds.), *Basic processes

in reading: Visual word recognition* (pp. 236–264). Hillsdale, NJ: Erlbaum.

Oppenheim, G., Dell, G., & Schwartz, M. (2010). The dark side of incremental learning: a

model of cumulative semantic interference during lexical access in speech production.

Cognition, 114, 227–252.

Protopapas, A. (2007). CheckVocal: A program to facilitate checking the accuracy and

response time of vocalresponses from DMDX. *Behavior Research Methods, 39*, 859–

862.

R Core Team (2014). *R: A language and environment for statistical computing*. R Foundation

for Statistical Computing, Vienna, Austria. URL http://www.R-project.org

Runnqvist, E., Strijkers, K., Alario, F.-X., & Costa, A. (2012). Cumulative semantic

interference is blind to language: Implications for models of bilingual speech

production. *Journal of Memory and Language, 66*, 850-869.

Schnur, T. T. (2014). The persistence of cumulative semantic interference during naming.

   *Journal of Memory and Language, 75,* 27 - 44.

Vigliocco, G., Vinson, D. P., Damian, M. F., & Levelt, W. (2002). Semantic distance effects

    on object and action naming. *Cognition, 85*, B61-B69.

Wheeldon, L., & Monsell, S. (1994). Inhibition of spoken word production by priming a

   semantic competitor. *Journal of Memory and Language, 33*, 332–356.

Footnotes

1. We conducted additional analyses to explore the potential impact of repetition (first vs.

second presentation) on the results. The three-way interaction between repetition, condition,

and ordinal position was not significant ($Fs < 1$). The repetition by condition interaction was

not significant ($Fs < 1$). The repetition by ordinal position interaction was significant only in

the analysis by semantic categories (F_1 [4, 92] = 1.65, p = .17, MSE = 2063.45, η^2_p = .07; F_2

[4, 92] = 2.52, $p < .05$, MSE = 1922.84, η^2_p = .10). Separate analyses conducted within each

condition revealed that the repetition by ordinal position interaction was not significant either

for non-contiguous (F_1 [4, 92] = 1.44, p = .23, MSE = 3101.89, η^2_p = .06; F_2 [4, 92] = 2.52, p

= .07, MSE = 1950.32, η^2_p = .09) or for contiguous sequences ($F_1 < 1$; F_2 [4, 92] = 1.05, p =

.39, MSE = 2045.24, η^2_p = .04).

2. The quadratic trend only approached conventional significance in the analysis by semantic

categories (F_2 [1, 23] = 4.26, p = .05, MSE = 2208.56, η^2_p = .16).

3. This alternative account was suggested by an anonymous reviewer.

4. It is important to note that the effect of ordinal position was not significant in the first place

when considering positions from 1 to 4 within contiguous sequences, mitigating the validity

of these additional pairwise comparisons.

5. All the analyses reported were replicated using linear mixed effects models (LME). A

reciprocal transformation was applied to RTs to approximate a normal distribution of the

residuals (in the form of -1000/RT to facilitate reading and interpretation of the results).

Accuracy was analyzed using generalized LME with a logistic link function. Due to issues

with convergence, all models implemented just random intercepts for the random factors of

participants, semantic categories, and items. The pattern of results from the LME analyses

were the same as the ones reported in the paper. All LME analyses were conducted using the

package lme4 version 4_1.1-12 (Bates, Maelcher, Bolker, & Walker, 2015) in R (R Core

Team).
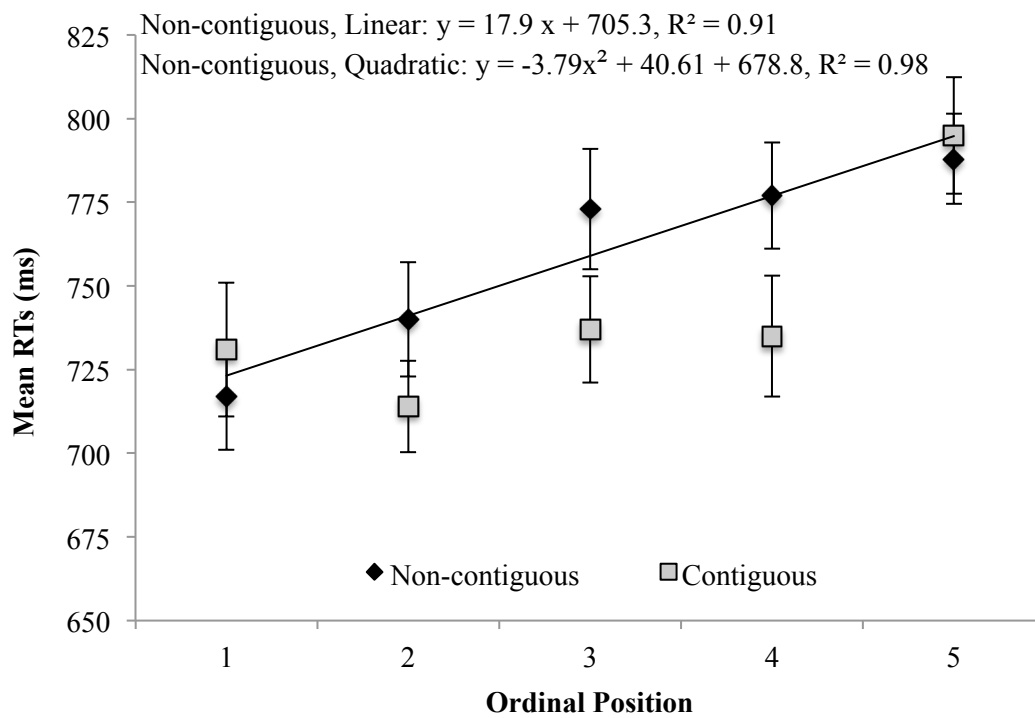
Figure 1. Mean RTs as a function of condition (Non-contiguous vs. Contiguous) and ordinal position. Error bars represent standard errors of the means. The line represents the slope of the linear trend for the ordinal position effect in the non-contiguous condition.
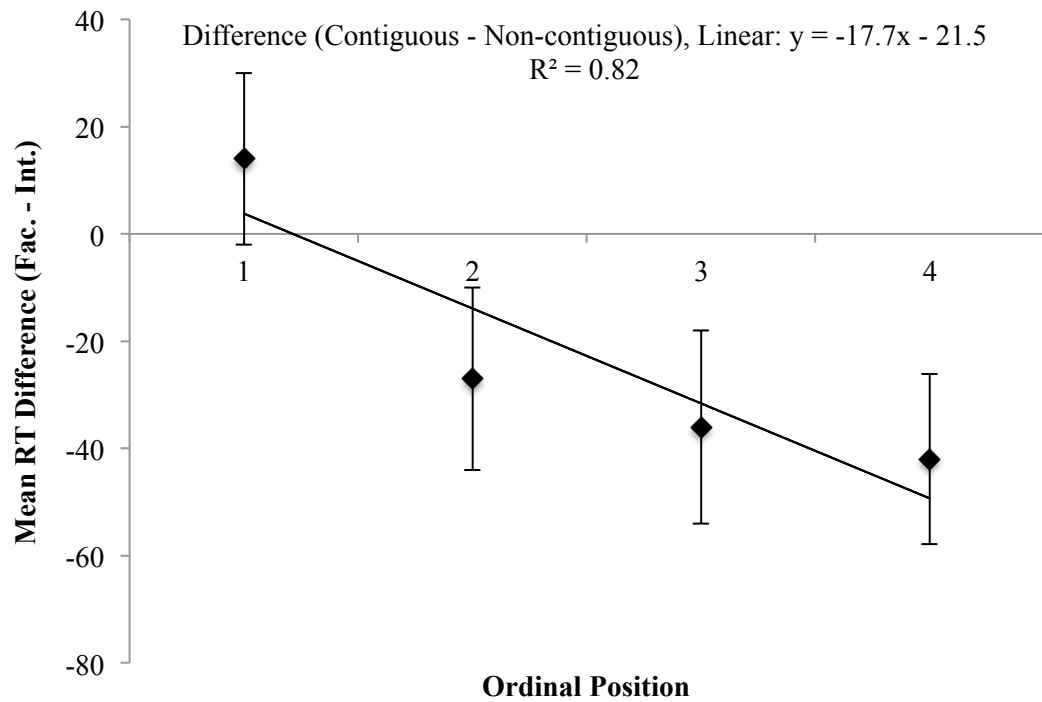
Figure 2. Difference between Mean RTs across conditions (contiguous – non-contiguous) as a function of ordinal position. Error bars represent standard errors of the means. The line represents the slope of the linear trend of the ordinal position effect.