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First-order sequential effects in the go/no-go lexical decision task

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Abstract

A go/no-go lexical decision experiment was conducted to examine the influence of the lexical status and item-frequency of trial *N-1* on trial *N* when the trials are not related to each other. In the go/no-go task, participants are instructed to makes responses to words, but not to nonwords. Recent research has found small sequential effects with the yes/no task for low-frequency words (Perea & Carreiras, 2003). However, the direction of the effects was not consistent with the analyses provided by Gordon (1983) with the go/no-go task. To examine the potential discrepancy between the two task procedures, the present study was a go/no-go replication of the yes/no experiment of Perea and Carreiras (2003). The results showed a sequential item-frequency effect in the error rates for nonwords and in the leading edge of the response time distribution. These findings add support to the idea that participants shift their decision criteria on a trial-by-trial basis.

Key words: Decision criteria, lexical decision, go/no-go tasks

The most popular laboratory word identification task is the yes/no lexical decision task. In this task, participants are to decide as rapidly and as accurately as possible whether a letter string presented on a computer screen is a word or not by pressing either the “word” or the “nonword” key on a response box. Despite its frequent use, the yes/no lexical decision task has been widely criticized because of its allegedly decision, task-specific components (e.g., Balota & Chumbley, 1984). Further, the yes/no lexical decision task may imply an unnecessary “response selection” stage: after deciding whether the letter string is a word or not, the participant must remember which response to make for the words and which response to make for the nonwords.

In order to minimize the impact of task-specific, decisional factors on response times (RTs), Gordon (1983) proposed the use of a go/no-go procedure applied to the lexical decision task (see Dijkstra, Timmermans, & Schriefers, 2000; Peressotti & Grainger, 1995; Siakaluk, Buchanan, & Westbury, 2003, for applications of the go/no-go procedure to other binary tasks). In the go/no-go procedure applied to the lexical decision task, the participant is instructed to respond as quickly as s/he can when a word is presented, but to refrain from responding if a nonword is presented. One advantage of the go/no-go lexical decision task is that the error rates for words are much lower than in the yes/no procedure (e.g., Gómez, Ratcliff, & Perea, in press; Hino & Lupker, 1998; Perea, Rosa, & Gómez, 2002, 2003, 2005; Perea & Rosa, 2003). This is hardly surprising: participants in a go/no-go lexical decision task have 1.5-2 seconds to make a (word) response, whereas participants in the yes/no lexical decision task have time pressure for both word and nonword responses (i.e., the decision criterion for a “nonword” response can be reached before the decision criterion for a “word” response; see Grainger & Jacobs, 1996; Ratcliff, Gómez, & McKoon, 2003). Furthermore, participants in a yes/no lexical decision task often report making errors, not because they have misclassified the letter string, but because once they have classified the letter string they have executed the wrong response. It is worth noting that the higher accuracy in the go/no-go task usually goes accompanied by faster RTs (see Gómez et al., in press; Perea et al., 2002).

It is possible to obtain the typical effects both with the yes/no and with the go/no-go lexical decision tasks: word-frequency (Gómez et al., in press; Hino & Lupker, 1998; Perea et al., 2002, 2003), associative/semantic priming (Perea et al., 2002), masked homophone/pseudohomophone priming (Davis, Iakovidis, & Castle, 1998), masked form priming (Mathey, Robert, & Zagar, 2003), neighborhood size (Perea, Rosa, & Gómez, 2003), neighborhood frequency (Perea, 2001), pseudoword frequency (Perea et al., 2005), syllable frequency (Baquero & Carreiras, 2002), or regularity effects (Gibbs & Van Orden, 1998). The magnitude of these effects is similar in the two tasks, although we should note that the word-frequency effect is sometimes greater in the go/no-go lexical decision task than in the yes/no lexical decision task (e.g., Hino & Lupker, 1998; Perea et al., 2003). The larger word-frequency effect in the go/no-go lexical decision task can be explained in terms of the components of the two procedures (Hino & Lupker, 1998): when a low-frequency word is encountered in a yes/no lexical decision task, participants could make a “nonword” response and these trials would not contribute to the mean RT for that condition; in the go/no-go lexical decision task, participants could eventually realize that the unfamiliar item is a word (i.e., participants cannot say “no”), producing a slow response and, thereby, a larger word-frequency effect. Thus, prior research suggests that the yes/no and the go/no-go lexical decision tasks essentially tap the same processes, except for the faster responding and fewer errors with the go/no-go procedure. (NOTE 1) On the basis of these findings, it has been suggested that the go/no-go lexical decision task is an excellent alternative to the yes/no lexical decision task (Perea et al., 2002). Further, the go/no-go lexical decision task, but not the yes/no lexical decision task, can be easily applied to experiments with children or special populations (Yelland, 1993).

However, there is one previous finding that may be taken to suggest that the yes/no and the go/no-go lexical decision tasks may differ in a substantial way. It refers to the direction and magnitude of the first-order sequential effects reported by Gordon (1983) with the go/no-go lexical decision task and by Perea and Carreiras (2003) with the yes/no lexical decision task. But before describing these discrepancies, it is important to examine briefly the phenomenon under scrutiny, that is, sequential effects in word recognition tasks. Despite the fact that most researchers would agree that the response times corresponding to trial *N-1* and trial *N* are not independent, most models of visual-word recognition do not have a mechanisms for accommodating trial-by-trial dependencies (see Bradley & Forster, 1987). The reason is that, for simplicity's sake, these (static) models are regarded as models for the psychological process occurring on any one trial (Laming, 1973). However, there is empirical evidence that the adjustments in the criteria placements for responding can occur on a trial-by-trial basis in lexical decision (Lima & Huntsman, 1997; Perea & Carreiras, 2003; see also Gordon, 1983) and naming (Taylor & Lupker, 2001). Of course, these effects can be magnified when there are many trials of the same type in one experimental block: when only high-frequency words are presented in the word list, an aggressive response criterion can be adopted that produces faster responding for approximately the same error rate (i.e., "frequency-blocking" effect; see Grainger & Jacobs, 1996; Plaut, 1997). A frequency-blocking effect has also been obtained with a within-subjects design in the yes/no lexical decision task (Perea, Carreiras, & Grainger, 2004), which implies that participants adjust their criterion settings in the experiment.

Gordon (1983) conducted a post hoc analysis of his go/no-go frequency-blocking experiment and examined whether the decision criteria for "word" responses could depend on the single preceding item. Gordon found that low-frequency words were responded to 80 ms faster when the precursor item was a high-frequency word (685 ms) than when the precursor item was a low-frequency word (765 ms). Gordon also reported that low-frequency words were responded to 27 ms faster when the precursor item was a high-frequency word (685 ms) than when the precursor item was a nonword (713 ms). However, no further statistical analyses were provided (see Gordon, 1983, Table 4). Clearly, these "small" adjustments in the decision criteria seem abnormally large. Indeed, as Gordon acknowledged, his experiment "was not explicitly designed to test for conditional effects" (p. 43). More recently, Perea and Carreiras (2003) manipulated factorially the item-frequency of the precursor trial with the yes/no lexical decision task. The sequential item-frequency effect for low-frequency words was much smaller (a significant 9.5-ms effect) and in the opposite direction (656 vs. 665 ms for words preceded by a low-frequency word and for words preceded by a high-frequency word, respectively). Perea and Carreiras (2003) also reported that word responses on trials following a word were around 10-21 ms faster than the responses of trials following a nonword (see also Lima & Huntsman, 1997, for a similar pattern). (NOTE 2)

We believe that it is important to resolve the apparent discrepancy between the sequential item-frequency effects reported by Perea and Carreiras (2003) with the yes/no lexical decision task and the sequential item-frequency effects reported by Gordon (1983) with the go/no-go lexical decision task. Bear in mind that the go/no-go procedure is gaining popularity among researchers in several areas (e.g., bilingualism, Dijkstra et al., 2000; neuropsychology, Goldberg et al., 2001; speech production, Schiller, 2002; semantic categorization, Siakaluk et al., 2003) and it is important to examine any potential differences between these two procedures. Although the more parsimonious view is that the go/no-go and the two-choice procedures involve essentially the same underlying cognitive processes (i.e., the only difference being the response requirements), it is possible that differences between the two procedures may affect the underlying cognitive processes.

Thus, the goal of this study is to examine the presence of first-order sequential effects in a go/no-go lexical decision task when the trials are not related to each other, and whether these effects are in the same direction as in the yes/no lexical decision task. To that end, the experiment is a go/no-go replication of the yes/no experiment by Perea and Carreiras (2003, Experiment 1). The target word (or the target nonword) could be preceded either by an unrelated high-frequency word or an unrelated low-frequency word. For comparison purposes, the target word (or the target nonword) could also be preceded by a nonword. If “word” responses in the go/no-go lexical decision task occur much in the same way as “word” responses in the yes/no lexical decision task (as suggested by Gómez et al., in press), one would expect (slightly) faster latencies for low-frequency words preceded by a low-frequency word than for low-frequency words preceded by a high-frequency word, replicating the yes/no lexical decision experiment of Perea and Carreiras (2003); that is, participants would lower their decision criterion for “word” responses after a low-frequency word (compared with a high-frequency word). In contrast, if latencies for low-frequency words are faster when preceded by a high-frequency words than when preceded by a low-frequency word (as suggested by Gordon, 1983), this would indicate that the decision processes in the yes/no and the go/no-go procedures would be less similar than previously thought. If the pattern of sequential item-frequency effects changes completely from the yes/no to the go/no-go lexical decision task, this would strongly suggest that different task-specific response criteria are at play in these two tasks.

In the present experiment, we chose low-frequency word targets rather than high-frequency word targets because the parallel yes/no lexical decision experiment (Perea & Carreiras, 2003, Experiment 2) showed that high-frequency word targets were unaffected by the frequency of the preceding word. (Gordon, 1983, also suggested that first-order sequential effects should be more pronounced with lower-frequency words because the slow growth of activation of these words might magnify changes in the RTs produced by shifts in the response criteria.) The different pattern of results with high- and low-frequency words in the lexical decision task can be caused by the fact that responses to high-frequency words are mainly based on unique word identification (M criterion, in the multiple read-out model; Grainger & Jacobs, 1996; "fast guess" criterion, in the dual-route cascaded model, Coltheart, Rastle, Perry, Ziegler, & Langdon, 2001), whereas responses to low-frequency words can be based on unique word identification (M criterion) or on global activation in the lexicon (Σ criterion). Note that, according to Grainger and Jacobs (1996), the Σ criterion (but not the M criterion) can be strategically modified as a function of the difficulty of the list. If we assume that the mechanisms underlying frequency-blocking and sequential item-frequency effects are very much the same (see Perea & Carreiras, 2003), low-frequency words will also be more sensitive to sequential item-frequency effects than high-frequency words.

Experiment

Method

Participants. Fifty-four psychology students from the University of València took part in the experiment for course credit. All of them had normal or corrected-to-normal vision and were native speakers of Spanish.

Materials. The materials were the same as in Experiment 1 of Perea and Carreiras (2003). Specifically, the target words were forty-two low-frequency Spanish words (mean frequency: 11 per million; range: 5-14), which were selected from the Spanish word pool of Alameda and Cuetos (1995). Target words could be preceded by three types of precursor (unrelated) trials: 1) high-frequency words (words with at least 50 occurrences per million), 2) low-frequency words (words in a range of 2-9 occurrences per million), and 3) nonwords. The target nonwords were forty-two stimuli constructed by changing an interior letter from a Spanish word other than one from the experimental set. The manipulation for the nonword targets was the same as that for the word targets.

Three stimulus lists were created by rotating each of the targets with either its corresponding high-frequency precursor trial, its low-frequency precursor trial, or its nonword precursor trial in a Latin square design. Thus, each stimulus list contained fourteen word targets preceded by a high-frequency word, fourteen word targets preceded by a low-frequency word, fourteen word targets preceded by a nonword, fourteen nonword targets preceded by a high-frequency word, fourteen nonword targets preceded by a low-frequency word, and fourteen nonword targets preceded by a nonword. Participants were randomly assigned to one of the three stimulus lists. Fourteen nonword-word filler pairs and fourteen nonword-nonword filler pairs were also included, so that half of the trials were words and the other half nonwords.

Procedure. Participants were tested in groups of four to eight in a quiet room. Presentation of the stimuli and recording of reaction times were controlled by Apple Macintosh Classic II microcomputers. The routines for controlling stimulus presentation and reaction time collection were obtained from Lane and Ashby (1987) and from Westall, Perkey, and Chute (1986), respectively. On each trial, the sequence “>   <“ was presented for 200 ms on the center of the screen. After a 50-ms blank, a lowercase letter string was presented. Participants were instructed to press the mouse if the letter string was a legitimate Spanish word. This decision had to be done as quickly and as accurately as possible. The word (or nonword) remained on the computer screen until the participant's response or until 2 seconds had elapsed (similarly to the experiment of Gordon, 1983). The inter-trial interval was set to 400 ms. Presentation of the pairs was random within each group, and each participant received a different random order. Subjects had to respond to each presented stimulus. Given that the pairs were unrelated and the inter-trial interval was constant, subjects could not notice that they were presented with pairs of items. Each participant received a total of 24 practice trials prior to the experimental phase. The session lasted approximately 20 min.

Results

Incorrect responses on the target words (0.8% for words) were excluded from the latency analysis. To avoid the influence of outliers, all reaction times more than 2.0 standard deviations above or below the mean for that participant in all conditions were also excluded from the latency analysis. (NOTE 2) The mean lexical decision times and the error rates for the words and the error rates for the nonwords in each experimental condition are displayed in Table 1. List (list 1, list 2, and list 3) was included in the statistical analyses as a dummy variable to extract the variance due to the lists.

Table 1

Mean lexical decision time (in ms) and error rates (in parentheses) for the word and nonwords targets with the go/no-go lexical decision task

Type of Precursor Trial

	High-Freq. Word	Low-Freq. Word	Nonword
Low-freq. words	606 (0.5)	600 (0.7)	625 (1.3)
Nonwords:	---- (1.7)	---- (4.6)	---- (2.6)

Word trials

Planned comparisons on the mean RT showed the word trials preceded by a low-frequency word were responded to 6 ms faster than those word trials preceded by a high-frequency word (600 vs. 606 ms, respectively), although this difference was not significant, $\underline{F}1(1,51)=1.29$; $\underline{F}2(1,39)=0.35$. The effect caused by the lexical status of the previous trial was robust: Responses on trials following high-frequency words averaged 19 ms less than responses of trials following nonword trials (606 vs. 625 ms, respectively), $\underline{F}1(1,51)=12.31$, $\underline{MSE}=772$, $\underline{p}<.002$; $\underline{F}2(1,39)=10.04$, $\underline{MSE}=835$, $\underline{p}<.004$. Likewise, responses on trials following low-frequency words averaged 25 ms less than responses of trials following nonword trials (600 vs. 625 ms, respectively), $\underline{F}1(1,51) =21.30$, $\underline{MSE} =754$, $\underline{p}<.001$; $\underline{F}2(1,39)=13.55$, $\underline{MSE} =849$, $\underline{p}<.001$.

The error rates for the word targets were very low (see Table 1) and none of the comparisons yielded any significant effects (all $\underline{p}$s>.10).

Nonword trials

The analyses on the error data (false-positive errors) revealed a sequential item-frequency effect: participants committed more errors to target nonwords when they were preceded by a low-frequency word than when preceded by a high-frequency word (4.6 vs. 1.7%, respectively), $\underline{F}1(1,51)=12.28$, $\underline{MSE}=18.6$, $\underline{p}<.002$; $\underline{F}2(1,39)=5.61$, $\underline{MSE} =31.7$, $\underline{p}<.025$. In addition, participants committed more errors to target nonwords when they were preceded by a low-frequency word than when preceded by another nonword (4.6 vs. 2.6%, respectively), although this difference was significant only in the analysis by participants, $F1(1,51)=4.33$, $MSE=24.5$, $p<.045$; $F2(1,39)=2.44$, $MSE=33.8$, $p=.126$. The difference between nonword trials preceded by a high-frequency word and nonword trials preceded by another nonword was not significant (1.7 vs. 2.6%, respectively), $F1(1,51)=1.91$; $F2(1,39)=0.73$.

Discussion

As usual, the present go/no-go lexical decision experiment produced substantially less word errors and faster responding than the parallel yes/no experiment of Perea and Carreiras (2003): 0.8 vs. 5.7% of errors and 610 vs. 663 ms, respectively, which is consistent with previous research (see Perea et al., 2002, for review). But more important, the experiment has shown that participants in a go/no-go task shift their criterion placements for “word” responses on the basis of the lexical status of the previous trial (see Lima & Huntsman, 1997; Perea & Carreiras, 2003, for a similar pattern with the yes/no lexical decision task), and there was also empirical evidence of trial-by-trial adjustments on the basis of the item-frequency of the immediate preceding trial: a significant 2.9% effect in the error data, and a nonsignificant 6-ms effect in the latency data.

The obtained item-frequency sequential effects are inconsistent with the results of the post hoc analysis reported by Gordon (1983), whereas they are in line with the results reported by Perea and Carreiras (2003). As stated in the Introduction, the observed differences in Gordon's analysis were abnormally large: clearly, a sequential item-frequency effect of 80 ms is not a small adjustment in the decision criteria. We believe that Gordon's results could have been caused by the post hoc nature of the analysis, such as the use of a different set of items in each condition and a small (around 17-22) number of data points (see Gordon, 1983, Table 4). Bear in mind that, unlike the present experiment, Gordon's frequency-blocking experiment was not specifically designed to assess first-order sequential effects.

In the present experiment, nonword-elicited activations in the go/no-go lexical decision task exceeded the decision criterion for a “word” response more frequently when the previous trial was a low-frequency word than when the previous trial was a high-frequency word (4.6 vs. 1.7%, respectively). This result suggests that, consistent with Perea and Carreiras’s (2003) view, participants may lower their decision criteria for a “word” response after a low-frequency word (compared to a high-frequency word). However, despite its statistical significance, the small number of false-positive errors limits the scope of this conclusion. Although the 6-ms difference between trials following a low- and a high-frequency word was in the direction predicted by Perea and Carreiras (2003), i.e. shorter latencies for trials following a low-frequency word, the effect was not statistically significant. (Note that this effect was only slightly greater, 9.5 ms, with the yes/no lexical decision task; Perea & Carreiras, 2003, Experiment 1.)

To further examine the sequential item-frequency effect in latency data, we conducted an analysis on the leading edge (.1 quantile) of the RT distribution for *all* correct responses in the go/no-go lexical decision task (see Ratcliff, 1979; Ratcliff et al., 2003; see also Gómez et al., in press). The rationale of this analysis is that if participants use a more lenient criterion for a “word” response when the immediate preceding trial is a low-frequency word than when the preceding trial is a high-frequency word (as suggested in the analysis of false-positives errors), the starting point of that RT distribution would be shifted towards being faster (when compared with the “precursor trial of high-frequency” condition). (Note that this would indicate an increased use of “fast guesses” – Σ criterion– for word responses, which is posited to be strategically variable; see Grainger & Jacobs, 1996; Perea & Carreiras, 2003.) Indeed, the leading edge of the RT distribution corresponding to words preceded by a low-frequency word is shifted 13 ms to the left relative to the leading edge of the RT distribution corresponding to words preceded by a high-frequency word (the .1 quantiles were 474 vs. 487 ms, respectively), $\underline{F}1(1,51)=5.24$, $\underline{MSE}=867.7$, $\underline{p}<.027$ (NOTE 3). This analysis gives further empirical support to the view that participants use a more lenient criterion for “word” responses after a low-frequency word than after a high-frequency word.

Thus, the present results can be considered a virtual replication of Perea and Carreiras' (2003) Experiment 1, this time with the go/no-go lexical decision task. Our findings support the view that the yes/no and the go/no-go lexical decision tasks tap the same underlying processes (Gómez et al., in press): In the two procedures, participants seem to modify their response criteria for "word" responses in the same direction as a function of the difficulty (lexical status, item-frequency) of the previous trial: participants use a more lenient criterion for "word" responses than after a low-frequency word than after a high-frequency word. It is worth noting that the multiple read-out model (Grainger & Jacobs, 1996) can predict a frequency-blocking advantage for low-frequency words by lowering the criterion based of summed lexical activation (the Σ criterion, see Grainger & Jacobs, 1996, Figure 26). One means of implementing this mechanism would be to adjust the response criteria on a trial-by-trial basis in an attempt to reduce RTs while maintaining an acceptable level of accuracy (Perea et al., 2004). For instance, the Σ criterion on trial *N* could be lowered when this same criterion has been successfully employed on trial *N-1*. This strategy would benefit especially low-frequency words preceded by another low-frequency word rather than low-frequency words preceded by a high-frequency word. Interestingly, increased use of the Σ criterion could also explain the presence of more false-positive errors for nonword targets preceded by a low-frequency word than for nonword targets preceded by a high-frequency word.

One issue that deserves some comments is why the decision criterion to respond "word" is lowered after a low-frequency trial (compared with a high-frequency trial) in the lexical decision task, both in the yes/no and go/no-go procedures. At first glance, one might have predicted the opposite effect: faster responses after an "easy", high-frequency word (i.e., the pattern predicted by Gordon, 1983). However, the direction of the observed sequential item-frequency effect is consistent with the fact that responses to low-frequency words in a yes/no lexical decision task can be shorter in a pure word list of low-frequency words than in a mixed list of high- and low-frequency words (e.g., Dorfman & Glanzer, 1988; Glanzer & Ehrenreich, 1979; Stone & Van Orden, 1993). Further, as indicated above, these results can be predicted in the framework of the multiple read-out model.

To summarize, the results of the present go/no-go lexical decision experiment demonstrate that participants shift their criterion settings for a "word" response on the basis of the lexical status and item-frequency of the immediate preceding trial, confirming and extending previous research. Indeed, trial-by-trial shifts in the decision criteria are probably common to a wide range of cognitive tasks (Taylor & Lupker, 2001). One final point: the present results suggest that the advantage of the go/no-go lexical decision task over the yes/no lexical decision task (in terms of faster responding and less errors) may be due to changes in the decision criteria combined with a faster non-decision component (e.g., a simpler response preparation/selection stage in the go/no-go procedure), but without any fundamental changes in the underlying processes (see Gómez et al., in press).

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Footnotes

1. Indeed, the go/no-go lexical decision task may produce slightly more skewed RT distributions for low-frequency words than the yes/no lexical decision task (Gómez et al., in press; but see Perea et al., 2003); however it consistently produces shorter onsets (as measured by the .1 quantile; Gómez et al., in press; Perea et al., 2002). The net result is typically a faster mean RT in the go/no-go procedure.
2. Lima and Huntsman (1997; Experiment 1) and Perea and Carreiras (2003) found that both word and nonword responses were significantly slower when the previous trial involved a nonword than when it was a word. This implies that the nature of the effects is different to that in simple two-choice tasks (i.e., tasks in which the participant is presented with one of two stimuli which are easy to discriminate and to each of which s/he is required to make a different simple response): in simple two-choice tasks, the repetition of the same response is typically accompanied by a facilitative sequential effect (for a review, see Soetens, 1998).
3. Other cutoffs produced the same pattern of significant results.
4. The effect tended to vanish in the higher quantiles, though (e.g., the results corresponding to the .9 quantile showed, if anything, the opposite trend). Note that the slower responses (i.e., higher quantiles) could have been caused by a unique identification process (M criterion) rather than by a global activation process (Σ criterion).

Authors' notes

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