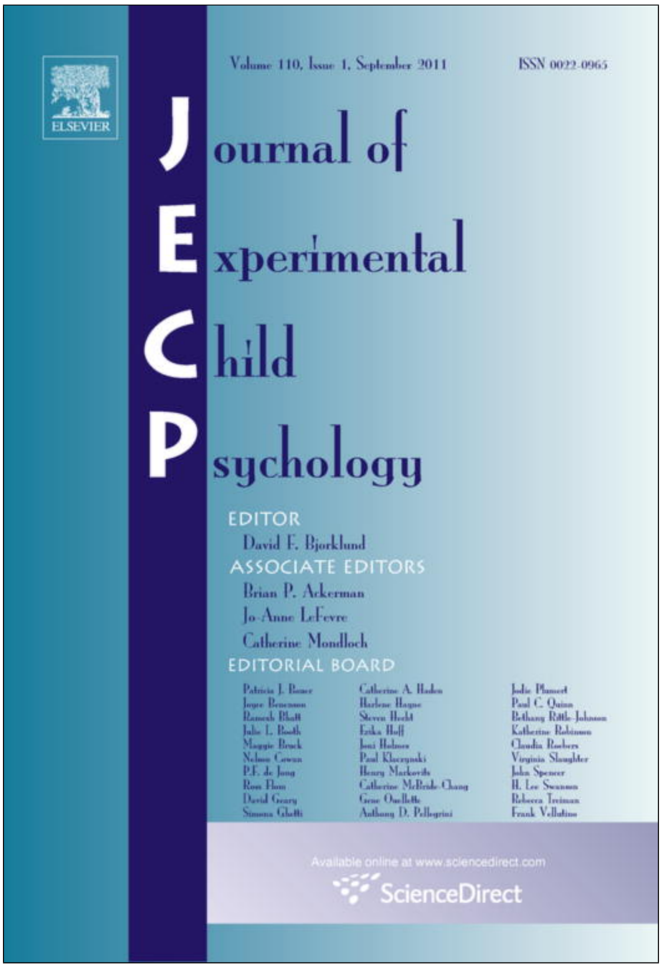
Volume 110, Issue 1, September 2011
ISSN 0022-0965
ELSEVIER
Journal of
Experimental
Child
Psychology
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Journal of Experimental Child Psychology 110 (2011) 125–132

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Brief Report

Is the go/no-go lexical decision task preferable to the yes/no task with developing readers?

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ARTICLE INFO

Article history:
Received 6 November 2010
Revised 10 April 2011
Available online 11 May 2011

Keywords:
Lexical decision
Word recognition
Word frequency
Task effects
Response decision
Developing readers

ABSTRACT

The lexical decision task is probably the most common laboratory visual word identification task together with the naming task. In the usual setup, participants need to press the "yes" button when the stimulus is a word and the "no" button when the stimulus is not a word. A number of studies have employed this task with developing readers; however, error rates and/or response times tend to be quite high. One way to make the task easier for young readers is by employing a go/no-go procedure: "If word, press 'yes'; if not, refrain from responding." Here we conducted a lexical decision experiment that systematically compared the yes/no and go/no-go variants of the lexical decision task with developing readers (second- and fourth-grade children). Results showed that (a) error rates for words and nonwords were much lower in the go/no-go task than in the yes/no task, (b) lexical decision times were substantially faster in the go/no-go task, and (c) there was less variability in the latency data of the go/no-go task for high-frequency words. Thus, the go/no-go lexical decision task is preferable to the "standard" yes/no task when conducting experiments with developing readers.

Introduction

Since its introduction by Rubenstein, Garfield, and Millikan (1970), the lexical decision task, together with the naming task, has become the most commonly used laboratory visual word identification task, and a myriad of experiments have shown that it provides relevant insights into the structure of the internal lexicon. As such, all recent mathematical/computational models of visual word

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0022-0965/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.jecp.2011.04.005

Table 1
Percentages of error (across conditions) in published lexical decision experiments with the usual yes/no setup on developing readers (Grades 1–4).

Author(s)	Grade	Error rate for words (%)	Error rate for nonwords (%)
Pratarelli, Perry, and Galloway (1994)	4	18.2	17.5
Castles et al. (1999)	2	8.9	N/A
	4	7.7	N/A
Burani et al. (2002)	3	4.6	12.5
	4	4.1	10.1
Goikoetxea (2005)	1	45.5	N/A
Castles et al. (2007)	3	15.1	N/A
Duñabeitia and Vidal-Abarca (2008)	1	21.0	N/A
	2	18.0	N/A
	3	12.0	N/A
Acha and Perea (2008)	3	25.1	45.0
Casalis et al. (2009)	4	1.4	N/A
Ratcliff, Love, Thompson, and Opfer (in press)	3	8.1	13.7

Note. N/A, not available.

recognition have been designed to simulate lexical decision data (e.g., Coltheart, Rastle, Perry, Ziegler, & Langdon, 2001; Davis, 2010; Grainger & Jacobs, 1996; Ratcliff, Gomez, & McKoon, 2004), and researchers have developed large databases with lexical decision times for an ample subset of words (e.g., English Lexicon Project: Balota et al., 2007; French Lexicon Project: Ferrand et al., 2010). The usual setup in a lexical decision experiment is quite straightforward: Participants need to press the "yes" button when the stimulus is a word and the "no" button when the stimulus is not a word; response time (RT) and error rate are the dependent variables.

Not surprisingly, a number of studies have employed the yes/no lexical decision task with developing readers (e.g., Acha & Perea, 2008; Burani, Marcolini, & Stella, 2002; Casalis, Dusautoir, Colé, & Ducrot, 2009; Castles, Davis, Cavalot, & Forster, 2007; Castles, Davis, & Letcher, 1999; Laxon, Coltheart, & Keating, 1988). One common problem in these studies is that lexical decision times are much more elevated and show larger variability than the adult data (see Feldman, Rueckl, Pastizzo, Diliberto, & Vellutino, 2002). With skilled readers, accuracies in the lexical decision task are usually high, allowing researchers to analyze the RT data separately from the accuracy data. However, when the error rates are high, it is more difficult to make firm conclusions on the locus of an effect by analyzing the RT data (see Perea, Rosa, & Gómez, 2002). In fact, some of the above-cited studies examined only accuracy data (e.g., Laxon et al., 1988); note that analyzing only accuracy data is also not desirable because researchers lose information on the underlying cognitive processes under scrutiny (see Ratcliff, Perea, Colangelo, & Buchanan, 2004). As shown in Table 1, lexical decision experiments with the usual yes/no setup produced, in the vast majority of cases, high error rates for words and (when reported) for nonwords, especially for beginning readers.[1] Clearly, young readers have some difficulty in performing the yes/no lexical decision task.

The lexical decision task presumably involves selecting the correct unit in the lexicon ("lexical selection" stage) and then carrying out whatever decision-making processes are required to make sure that it is the appropriate lexical unit ("response decision" stage) (see Perea et al., 2002). One reason why the yes/no lexical decision task might be difficult for children is that they need to remember which button to push for "yes" and "no". This assignment is arbitrary, and it may produce some additional variability in the responses as a result of deciding what response to make. How can we minimize the response selection stage? One possibility is to instruct the participants to say aloud

[1] There were two studies in which error rates were quite low (Burani et al., 2002; Casalis et al., 2009). In Casalis and colleagues' (2009) study, the same set of 12 target words was repeated across sessions, and no information was provided on the error rates to nonwords. In Burani and colleagues' (2002) study, error rates for words were very low but were accompanied by rather long RTs (more than 2 s); when these same items were employed with adults, error rates for words and nonwords were 3.2% and 15.6%, respectively (Experiment 4). Error rates for adult skilled readers are typically much lower than those for young children (e.g., see Acha & Perea, 2008).

"yes" or "no" so that they do not need to remember which button to push (see Laxon et al., 1988; Martens & de Jong, 2006). However, leaving aside that this option involves the mandatory activation of a phonological code, and that measuring with precision the pronunciation times from a voice key requires extensive work (see Protopapas, 2007), a vocal yes/no response does not guarantee low error rates; in Laxon and colleagues' (1988) study, overall error rates for words and nonwords in second- and third-grade children were 23.4% and 31.9%, respectively.

One more promising option is to use a go/no-go procedure: participants are not instructed to make a distinct response to each of several possible stimuli (i.e., "yes" vs. "no"); instead, they need to press the "yes" button in response to words and refrain from responding to nonwords. Thus, the response decision process is simpler than in the yes/no task (Gordon, 1983; Perea et al., 2002; Yelland, 1993). Furthermore, it removes the chances of "no" responses as the result of momentarily forgetting which buttons correspond to "yes" and "no" or in terms of hastily giving a "no" response when the presented word has an unusual spelling or low familiarity (e.g., *yacht*) (see Perea et al., 2002). Not surprisingly, prior research with adult skilled readers comparing the go/no-go and yes/no lexical decision tasks has shown that (a) error rates for word stimuli are substantially *lower* in the go/no-go task than in the yes/no task and (b) lexical decision times for "word" responses are *faster* in the go/no-go task than in the yes/no task (see Gordon & Caramazza, 1982; Perea, Rosa, & Gómez, 2003; Perea et al., 2002).

At the theoretical level, it is important to assess whether or not the components of processing differ from one task to another. This was the goal of the study of Gómez, Ratcliff, and Perea (2007), who employed a quantitative model, the diffusion model (Ratcliff, 1978), in a series of yes/no and a go/no-go experiments—including the lexical decision task—and examined the potential differences in the parameters corresponding to the quality of information (i.e., does the go/no-go task provide more efficient processing than the yes/no task?), the decision criteria (i.e., are participants more conservative in the yes/no task than in the go/no-go task?), and the nondecisional component (i.e., does the response stage take longer in the yes/no task than in the go/no-go task?). Gómez and colleagues found that the advantage of the go/no-go task over the yes/no task in RTs and error rates could be explained in terms of changes in the nondecisional components of the RT combined with changes in the decision criteria (participants were more likely to make the "go" response even for nonwords) rather than in changes in the quality of information. That is, the underlying cognitive processes of interest are essentially the *same* in the two tasks. Consistent with this view, the go/no-go lexical decision task is sensitive to the same effects as the yes/no lexical decision task (e.g., semantic priming, repetition priming, word frequency, neighborhood size) (see Perea, Gomez, & Fraga, 2010; Perea et al., 2002, 2003). We believe that there is no a priori reason why this should be different in a child population.

The evidence concerning the go/no-go procedure with developing readers is very scarce. In a couple of conference presentations, Yelland (1993, 1995) claimed that the go/no-go variant of the lexical decision task should be the preferred procedure when conducting experiments on developing readers. To our knowledge, only one published study has employed the go/no-go lexical decision task with young readers (Davis, Castles, & Iakovidis, 1998). Davis and colleagues (1998) justified the use of the go/no-go lexical decision because "it has been argued that it places fewer task demands on children than the [yes/no] lexical decision task (Yelland, 1993)" (p. 631). In Davis and colleagues' study, the error rate for words in fourth graders with the go/no-go task was indeed very low at 2.5% (the error rate for nonwords was not reported). In a subsequent experiment with another sample of fourth graders, Davis and colleagues (Experiment 4) conducted a yes/no lexical decision task with another manipulation (and another set of stimuli), and the error rate was 11.5% for words (the error rate for nonwords was not reported). Importantly, the pattern of masked priming effects obtained in Davis and colleagues' study was similar in the go/no-go and yes/no experiments.

The goal of the current study was to examine whether the go/no-go task is preferable to the yes/no task when conducting lexical decision experiments on developing readers. To examine whether the go/no-go task gives the same—or better—measures of the variables of interest as the yes/no task, we manipulated the most well-known factor in single-word recognition research: word frequency (high vs. low). We examined several critical criteria (see Perea et al., 2002, for use of these same criteria with adult skilled readers): (a) whether error rates (for both words and nonwords) are lower in the go/no-go task than in the yes/no task, (b) whether RTs are shorter in the go/no-go task than in the yes/no task, and (c) whether the go/no-go lexical decision data produce less noisy data than the yes/no data. To explore whether the differences between the yes/no and go/no-go lexical decision tasks are modulated by age and/or by grade in school, half of the participants were second graders (average age = 7.3 years) and the other half were fourth graders (average age = 9.2 years).

Method

Participants

A total of 24 second-grade children (13 girls and 11 boys, mean age = 7.3 years, *SD* = 0.46, range = 7–8) and 24 fourth-grade children (12 girls and 12 boys, mean age = 9.2 years, *SD* = 0.43, range = 9–10) took part voluntarily in the experiment. The children came from above-average socio-economic backgrounds in a private school in Valencia, Spain. The test took place at the beginning of the academic year. All participants had normal or corrected-to-normal vision and were native speakers of Spanish. Participants were excluded if they had sensory, neurological, or other problems traditionally used as exclusionary criteria for learning disabilities. Three second-grade participants were replaced because they did not follow the instructions and error rates were more than 50%.

Materials

We selected a set of 120 words of five letters from the Spanish database (Davis & Perea, 2005). Of these 120 words, 60 were of high frequency (mean = 146.7 per million, range = 30.9–675.6) and the other 60 were of low frequency (mean = 10.2 per million, range = 0.7–23.2). All of these words were familiar to beginning readers and appeared in the Spanish word frequency count for first graders of Corral, Goikoetxea, and Ferrero (2009); for high-frequency words the average count was 75.3 (range = 40–185), whereas for low-frequency words the average count was 17.4 (range = 8–30). The numbers of orthographic neighbors (i.e., one-letter different words) were similar across conditions (3.0 and 3.4 for high- and low-frequency words, respectively). For the purposes of the lexical decision task, 120 pronounceable nonwords of five letters were created by changing two or three letters from Spanish words other than the ones in the experimental set. The number of orthographic neighbors for the nonwords was 0.9. Two lists of stimuli were created, with 60 words and 60 nonwords being randomly assigned to List 1 and the other 60 words and 60 nonwords being assigned to List 2. For those participants who were initially were presented with List 1 in Block 1, the second block would be List 2 and vice versa.

Design

Both word frequency (high vs. low) and task (go/no-go vs. yes/no) were varied within participants. In addition, age/grade was varied between participants. In each grade, 12 participants, selected at random, performed the go/no-go task in the first block and the yes/no task in the second block, whereas the other 12 participants performed the yes/no task in the first block and the go/no-go task in the second block. Each participant was given a total of 60 experimental trials in each block. Each block was preceded by 16 practice trials (16 go/no-go practice trials in the go/no-go block and 16 yes/no practice trials in the yes/no block). The stimuli in the practice trials had similar characteristics to those in the experimental blocks.

Procedure

Participants were tested in a quiet room in groups of three or four. Presentation of the stimuli and recording of RTs were controlled by Windows computers running DMDX (Forster & Forster, 2003). On each trial, a fixation point (+) was presented for 500 ms in the center of the screen. Next, the target stimulus was presented until participants responded or 2500 ms had elapsed. Target stimuli were presented in lowercase 14-point Times New Roman. In the go/no-go blocks, participants were told that words and nonwords would be displayed on the monitor in front of them and that they should press one button (labeled "sí" [yes]) if the stimulus was an existing Spanish word and should refrain from

Table 2
Mean lexical decision times (in ms), standard deviations, and percentages of error for words and pseudowords in the experiment.

	Go/no-go		Yes/no	
	Words	Nonwords	Words	Nonwords
Second graders				
Go/no-go first				
High frequency	1041 *248* (3.6)	–(11.7)	1167 *293* (11.4)	1341 *315* (33.2)
Low frequency	1174 *290* (6.7)		1274 *273* (18.9)	
Word frequency effect	113 (3.1)		107 (7.5)	
Yes/no first				
High frequency	1079 *294* (4.1)	–(9.6)	1212 *287* (10.0)	1513 *242* (26.5)
Low frequency	1166 *285* (9.6)		1342 *288* (17.4)	
Word frequency effect	87 (5.5)		130 (7.4)	
Fourth graders				
Go/no-go first				
High frequency	825 *218* (1.4)	–(8.6)	951 *236* (7.6)	1114 *262* (16.1)
Low frequency	882 *241* (4.0)		1002 *236* (12.4)	
Word frequency effect	57 (2.6)		51 (4.8)	
Yes/no first				
High frequency	798 *197* (2.7)	–(9.7)	883 *245* (4.7)	1138 *258* (15.7)
Low frequency	860 *238* (5.0)		960 *246* (10.3)	
Word frequency effect	62 (2.3)		77 (5.6)	

Note. Mean lexical decision times are in milliseconds (ms). Standard deviations are in italics. Percentages of error are in parentheses. Word frequency effect refers to the difference between low-frequency words and high-frequency words.

responding if the stimulus was not a word. In the yes/no blocks, participants were told that words and nonwords would be displayed on the monitor in front of them and that they should press one button (labeled "sí") if the stimulus was an existing Spanish word and should press another button (labeled "no") if the stimulus was not a word. In the two blocks, participants were instructed to respond as quickly as possible while maintaining a reasonable level of accuracy. Participants employed their dominant hand to make the "word" responses. Each participant received a different random order of stimuli. The session lasted approximately 16 min.

Results

In the latency analyses, we excluded those RTs less than 250 ms or greater than 2000 ms (7.9% for second graders and 2.1% for fourth graders) as well as error trials. The mean latencies for correct responses and error rates are presented in Table 2. Analyses of variance (ANOVAs) based on participants' response latencies were conducted on the basis of a 2 (Grade: second or fourth) × 2 (Task: go/no-go or yes/no) × 2 (Word Frequency: high or low) × 2 (Order: go/no-go → yes/no or yes/no → go/no-go) × 2 (List: 1 or 2) design. List was included as a dummy variable in the ANOVAs to extract the variance due to the error associated with the lists.

Word data

The ANOVA on the latency data showed that lexical decision times were, on average, 121 ms faster in the go/no-go blocks than in the yes/no blocks (978 vs. 1099 ms, respectively), $F(1, 40) = 81.21$, $MSE = 8340.0$, $\eta^2 = .67$, $p < .001$, that responses to high-frequency words were, on average, 91 ms faster than responses to low-frequency words, $F(1, 40) = 94.46$, $MSE = 3996.5$, $\eta^2 = .70$, $p < .001$, and that fourth graders produced faster responses than second graders, $F(1, 40) = 25.44$, $MSE = 137762.3$, $\eta^2 = .39$, $p < .001$. The interaction between grade and word frequency was significant, $F(1, 40) = 7.00$, $MSE = 3996.5$, $\eta^2 = .15$, $p < .001$. This reflects that the word frequency effect was greater for second graders than for fourth graders (114 vs. 62 ms, respectively). None of the other effects/interactions approached significance (all *ps* > .15).

The ANOVA on the error data showed that participants made more "word" errors in the yes/no blocks than in the go/no-go blocks, $F(1, 40) = 60.00$, $MSE = 36.6$, $\eta^2 = .60$, $p < .001$, that participants made more "word" errors on low-frequency words than on high-frequency words, $F(1, 40) = 44.94$, $MSE = 23.06$, $\eta^2 = .53$, $p < .001$, and that fourth graders committed fewer "word" errors than second graders, $F(1, 40) = 5.38$, $MSE = 100.84$, $\eta^2 = .12$, $p < .03$. The interaction between task and word frequency was significant, $F(1, 40) = 4.61$, $MSE = 23.07$, $\eta^2 = .10$, $p < .04$. This reflected that the effect of word frequency was greater in the yes/no task than in the go/no-go task. None of the other effects/interactions approached significance (all *p*s > .14).

Nonword data

Latencies could not be analyzed because of the nature of the go/no go task. The ANOVA on the error data showed that participants made more false alarms (i.e., "word" responses to nonwords) in the yes/no blocks than in the go/no-go blocks, $F(1, 40) = 30.76$, $MSE = 118.4$, $\eta^2 = .44$, $p < .001$, and that second graders committed more false alarms than fourth graders, $F(1, 40) = 7.63$, $MSE = 163.3$, $\eta^2 = .16$, $p < .01$. The interaction between task and grade was significant, $F(1, 40) = 4.40$, $MSE = 118.4$, $\eta^2 = .10$, $p < .05$. This reflected that the effect of task was greater for second graders than for fourth graders. None of the other effects/interactions approached significance (all *p*s > .25).

Variability of latency data

If we employ error variance, as measured by *MSE*s, as an estimate of the sensitivity of the technique, the *MSE* for the word frequency effect in the latency data was substantially smaller in the go/no-go task than in the yes/no task (2606.7 vs. 4551.2, respectively). Alternatively, if we run the ANOVA on the participant standard deviations (i.e., within-participant variability), there is more variability in the data from the second graders than from the fourth graders, $F(1, 40) = 12.48$, $MSE = 8498$, $\eta^2 = .24$, $p < .002$. Although the main effect of task did not reach significance, $F(1, 40) = 2.45$, $MSE = 2377$, $\eta^2 = .05$, $p = .12$, the interaction between task and word frequency was significant, $F(1, 40) = 4.69$, $MSE = 2004$, $\eta^2 = .11$, $p < .04$. This reflected more within-trial variability in the yes/no task than in the go/no-go task for high-frequency words, $F(1, 40) = 7.41$, $MSE = 2024$, $\eta^2 = .16$, $p < .01$, but not for low-frequency words ($F < 1$). (Note that this null effect is probably due to the fact that error responses to low-frequency words in the yes/no task typically correspond to relatively long RTs in the go/no-go task; see Gómez et al., 2007; Perea et al., 2002.) None of the other effects/interactions approached significance (all *p*s > .20).

Discussion

The main findings of the current experiment can be summarized as follows. First, the go/no-go lexical decision task produces much faster responding (more than 100 ms faster) and substantially fewer errors (both omission errors and false alarms) than the yes/no lexical decision task. Second, the go/no-go task produces less error variance (i.e., the data are less noisy) than the yes/no task for high frequency words. Third, as in prior work with adult skilled readers, the effect of task (yes/no vs. go/no-go) does not modify the underlying processes of interest,[2] as deduced by the presence of a robust word frequency effect in the two tasks and the lack of a Task × Word Frequency interaction in the

[2] Furthermore, the correlations between the lexical decision time across items and the log of word frequency were similar in the two tasks (second graders: *r*s = 31 and .33 in go/no-go and yes/no tasks, respectively; fourth graders: *r*s = .47 and .41 in go/no-go and yes/no tasks, respectively; all *p*s < .002). In addition, as an anonymous reviewer pointed out, it may be important to explore the influence of another potentially relevant factor in visual word recognition: the number of orthographic neighbors (*N*). The Pearson correlation coefficients between lexical decision times and *N* across items were negligible across task/grade (all |*r*s| < .053). Although one should be cautious about accepting the null hypothesis in a post hoc analysis, this outcome is in line with a recent yes/no lexical decision experiment in Spanish by Duñabeitia and Vidal-Abarca (2008) in which the effect of *N* on lexical decision times was not significant for children from second grade to sixth grade. This is also consistent with the view that there are no genuine effects of *N* on lexical decision times with adult skilled readers when factors such as age of acquisition and imageability are controlled (Davis, 2010).

latency data.[3] Fourth, the advantage of the go/no-go task over the yes/no task occurred for both second graders and fourth graders (note that the benefits are even higher for second graders, but only in terms of accuracy and not speed).

The pattern of data in the current experiment is consistent with the view that that there are different criteria/parameters at play in a lexical decision experiment, as described in the diffusion model (see Gómez et al., 2007; Ratcliff et al., 2004). The benefits of the go/no-go task over the yes/no task for children would occur not because the quality of information of the "core processes" differs (note that the word frequency effect was robust in the two tasks) but rather in terms of changes in the decision criteria settings and the nondecision time. Indeed, the current experiment demonstrated that the go/no-go task produces an advantage over the yes/no task in *all* of the criteria under scrutiny (error rates, rapidity of responses, and variability in the data). This was so with both second graders and fourth graders. With respect to the error rates, an obvious advantage of the go/no-go task over the yes/no task is that infrequent words or words with unusual spellings cannot be hastily labeled as nonwords; instead, children may eventually realize that these items are indeed words. Importantly, the percentage of "yes" responses to nonwords was also substantially lower in the go/no-go task than in the yes/no task (i.e., there was no bias to respond "yes" in the go/no-go task, unlike with the adult participants in Gómez et al., 2007). With respect to the latency of the responses, children had longer RTs in the yes/no task after a block with the go/no-go task, whereas they had shorter latencies in the go/no-go task after a block with the yes/no task. Taken together, these findings strongly suggest that the go/no-go task makes fewer task demands, as hypothesized by Yelland (1993, 1995). Finally, the data also show less noisy data in the go/no-go task than in the yes/no task for high-frequency words.

In sum, the go/no-go lexical decision task should be the preferred choice when conducting lexical decision experiments with young readers. It provides faster responding, fewer errors, and less noisy data than the yes/no task (in particular, for high-frequency words), and at the same time it does not alter the core processes under scrutiny (see Gómez et al. (2007), and Perea et al. (2002, 2003), for further evidence with adult skilled readers). We believe that the use of the go/no-go lexical decision task opens up great opportunities to study the development of word recognition with developing readers in more detail.

Acknowledgments

The research reported in this article was partially supported by Grants PSI2008-04069/PSIC and CONSOLIDER-INGENIO2010 CSD2008-00048 from the Spanish Ministry of Education and Science. We thank Teresa Puchades for her invaluable help at different stages of this work. We also are thankful for the very helpful comments from two anonymous reviewers.

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[3] As in previous experiments with adult readers (e.g., Perea et al., 2002), there was a significant interaction between task and word frequency in the error data. Nonetheless, this merely reflects the existence of a floor effect with the go/no-go lexical decision task.

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