Journal of Experimental Psychology:
Learning, Memory, and Cognition
2001, Vol. 27, No. 6, 1430–1450

0278-7393/01/$5.00 DOI: 10.1037//0278-7393.27.6.1430

The Specific-Word Frequency Effect: Implications for the Representation of Homophones in Speech Production

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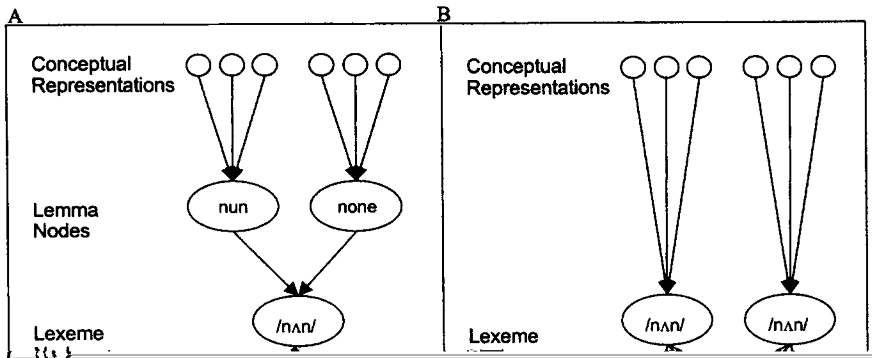
In a series of experiments, the authors investigated whether naming latencies for homophones (e.g., /nΛn/) are a function of specific-word frequency (i.e., the frequency of *nun*) or a function of cumulative-homophone frequency (i.e., the sum of the frequencies of *nun* and *none*). Specific-word but not cumulative-homophone frequency affected picture-naming latencies. This result was obtained in 2 languages (English and Chinese). An analogous finding was obtained in a translation task, where bilingual speakers produced the English names of visually presented Spanish words. Control experiments ruled out that these results are an artifact of orthographic or articulatory factors, or of visual recognition. The results argue against the hypothesis that homophones share a common word-form representation, and


A
B
Conceptual Representations
Lemma Nodes
nun
none
Lexeme
/nʌn/
Conceptual Representations
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homophonic content words (e.g., *knot*) better than the frequency of the content words themselves.

Dell (1990) interpreted these results as support for the SR hypothesis. However, unlike Jescheniak and Levelt (1994), he ascribed the locus of the frequency effect to the lemma level. This is possible in Dell's model because of the interactivity of activation between lemma and lexeme levels. The shared word-form node of a homophone (e.g., /nΛn/) sends activation back to its lemma cohort (*nun*, *none*), which in turn sends activation down to its shared lexeme node (*/nΛn/*), and so on for a number of iterations. In this way, a nontarget lemma node affects the activation level of the lexeme node that it shares with the target lemma. Given the further assumption that frequency modulates the level of activation transmitted by a node, a high-frequency lemma will

model's assumptions would have to be modified. For example, we could retain the SR assumption, and locate the frequency effect at the lemma level. With this modification, we would not expect a cumulative-homophone frequency effect, because the speed of lexical access would be determined by specific-word frequencies and not by cumulative-homophone frequencies. Alternatively, we could give up the SR assumption, and keep the frequency effect at the lexeme level, where homophonic words would be represented by distinct lexemes for each word (e.g., separate lexemes for *nun* and *none*). This model also predicts the absence of a cumulative-homophone frequency effect.

Because of its interactive nature, predictions about the locus of frequency effects are more complex in the case of Dell's (1990) model. However, as already noted, the interactivity assumption effects reported by Jescheniak and Levelt (1994) nor the error effects reported by Dell (1990) have been replicated. Therefore it is crucial to establish the reliability of the phenomenon. Here we report several experiments that investigate the effect of homophone frequency on naming time.

In the following experiments we investigate the extent to which there is a cumulative-homophone frequency effect in picture naming. We follow Jescheniak and Levelt (1994) in assuming that the frequency effect in picture naming arises (primarily) during lexical access. In their Experiment 2, Jescheniak and Levelt asked participants to perform a picture recognition task. They used the same

names in English have higher frequency homophone mates (*none*), (b) controls matched on specific-word frequency (e.g., *owl*), and (c) controls matched on cumulative-homophone frequency (e.g., *tooth*). The issue addressed here is whether picture-naming latencies are determined by a picture's specific-word frequency or by its cumulative homophone frequency. Operationally, this translates into the following question: Are HomName pictures named as fast as specific-word frequency controls or are they named as fast as cumulative-homophone frequency controls? The SR hypothesis predicts that naming latencies for the HomName condition should be comparable with those for the cumulative-homophone fre-

Table 1
Mean Frequency (Specific and Cumulative), Familiarity, and Length for the Pictures of Experiment 1A

Picture set	Example	Specific frequency	Cumulative frequency	Familiarity	Length
Homophone name pictures	nun	28.2 (0–195)	142.0 (15–906)	3.2	4.3
Specific-word frequency matched pictures	owl	28.0 (1–160)	28.2 (1–160)	3.4	4.6
Homophone frequency matched pictures	tooth	116.8 (16–393)	117.9 (16–393)	3.9	4.4

Note. Frequency ranges shown in parentheses.

participants were asked to name the pictures as fast as possible without making errors. Order of presentation was randomized with the constraint that pictures of a given experimental condition would not appear in more than three consecutive trials. Block order was randomized for each participant. Each trial had the following structure: a fixation point (a cross) was shown in the center of the screen for 700 ms, and was then replaced by the picture. The picture remained on the screen for 600 ms. Participants initiated the next trial by pressing the space bar. Response latencies were measured from the onset of the stimulus to the beginning of the naming response by means of a voice key (Lafayette Instrument Company, Lafayette, IN). Stimulus presentation was controlled by the PsychLab program (Bub & Gum, University of Victoria, British Columbia, Canada). Response accuracy was manually recorded by the experimenter.

Analyses. Responses scored as errors included (a) names that were not the ones designated as target responses, (b) verbal dysfluencies (stuttering,

for 3.6% of the data. Mean errors and mean response latencies for each picture set are shown in Table 2. Analyses of variance (ANOVAs) on the naming latencies revealed a significant effect of picture set, $F1(2, 56) = 68$, $MSE = 878.4$, $p < .0001$; $F2(2, 72) = 4.1$, $MSE = 12{,}670$, $p < .02$, and presentation, $F1(2, 56) = 3.4$, $MSE = 4{,}341$, $p < .05$; $F2(2, 144) = 18$, $MSE = 675$, $p < .001$. We did not find signs of interaction between these variables ($ps > .29$), suggesting that the size of the effect of frequency remained constant across picture repetitions. Jescheniak and Levelt (1994) and Levelt, Praamstra, Meyer, Helenius, and Salmelin (1998) previously reported the lack of interaction between repetition and frequency in picture naming (but see Griffin & Bock, 1998).

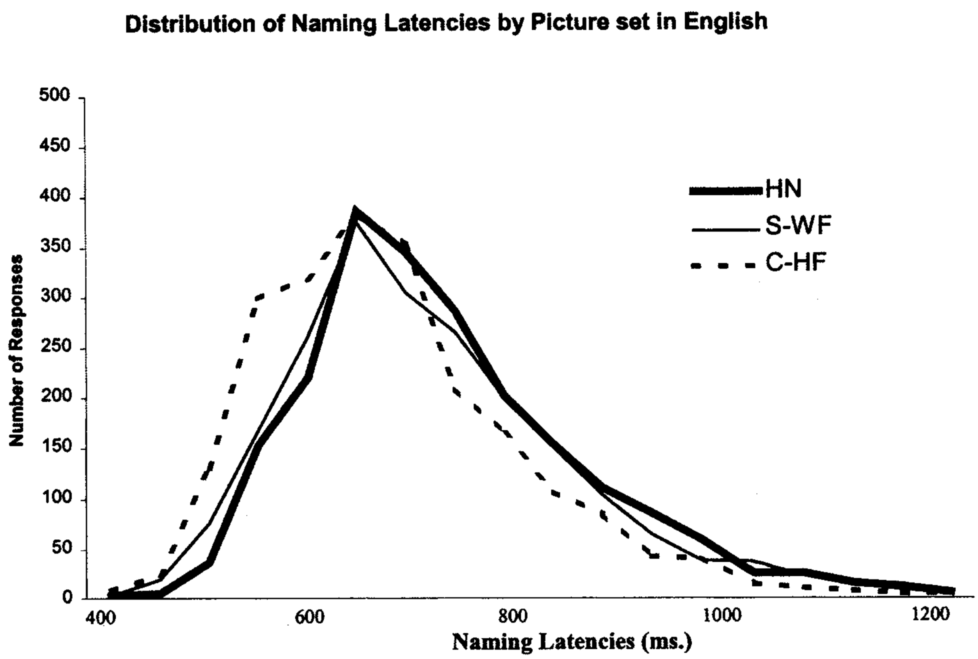

Figure 2. Distribution of naming latencies in Experiment 1A. The size of the interval is 50 ms. The lower interval begins at 400 ms, the highest interval ends at 1,300 ms. HN = homophone name; S-WF = specific-word frequency; C-HF = cumulative-homophone frequency.

specific-word frequency was a significant predictor (specific-word AoA). For example, the MinHomophone AoA of the pair *bear/*

expect the difference in naming latencies between the HomName and specific-word frequency controls to be larger for the Italian

names of HomName, specific-word frequency, and cumulative-homophone frequency pictures were comparable in terms of frequency

1A and 3A; N = 182). Words were printed in upper case, with Geneva 20-point bold font. In each trial, a fixation point (a cross) was shown for 700 ms, and was immediately replaced by the written word, which remained in view for 600 ms. Following a blank interval, a cue (an asterisk) appeared and participants named the word. The interval lasted 1 s for the words of Sets A and B, and 700 or 1,300 ms for the words of Set C. Intervals varied to prevent participants from anticipating the appearance of the cue. Participants were instructed to prepare their response and, when the cue appeared, to name the word as fast as possible. Participants proceeded to the next trial by pressing the space bar. The results of the stimuli of Set B will be presented in Experiment 3C. Fillers were not included in the analyses.

Results and Discussion

In the analyses that follow, we only considered the data from the 75 words analyzed in Experiment 1, excluding therefore the 3 words that were also excluded in that experiment (one from each condition). Errors, responses that were too fast ($<$ 200 ms) or too slow ($>$1,800 ms) and those that exceeded participants' means by three standard deviations were excluded from the analyses (2.6% of the data). The same exclusionary criteria were applied to the other delayed-naming experiments we report below. As can be seen in Table 4, production latencies were not statistically different for the names of the HomName, specific-word frequency, and cumulative-homophone frequency pictures ($ps < .2$). Our results are in line with those of other delayed-naming tasks, which also demonstrated an absence of word frequency or AoA effects (e.g., Ellis & Morrison, 1998; Jescheniak & Levelt, 1994; Monsell et al., 1989;

prudent to attempt to replicate our picture-naming experiment with a new set of stimuli. Unfortunately, we could not find a sufficient number of pictures whose names, in English, met the constraints for designing a properly controlled experiment. We decided instead to carry out a replication in Chinese.

Experiment 2A: Picture Naming in Chinese

In Experiment 2A, we examined the effect of homophone frequency on picture naming in Chinese (Mandarin). The experiment was modeled after Experiment 1A and thus included three sets of stimuli: HomName, specific-word frequency, and cumulative-homophone frequency pictures. The experimental question ad-

homophone frequency best predicts naming latencies. We addressed this question by creating three sets of words that differed in the degree to which they were comparable on the dimension of specific-word frequency versus cumulative-homophone frequency. That is, we constructed word sets that met two criteria: (a) the specific-word frequencies of HomName and specific-word frequency controls were similar, but lower than that of the cumulative-homophone frequency controls (see means in Table 5), and (b) the cumulative-homophone frequencies of HomName and cumulative-homophone frequency pictures were high compared with that of specific-word frequency pictures.

Method

Participants. Twenty-eight native Mandarin speakers who were stu-

Table 5
Mean Frequency (Specific and Cumulative) for the Pictures of Experiment 2A

Picture set	Chinese name	Specific frequency	Cumulative frequency
Homophone name pictures	桃 (peach)	46 (8–145)	1,327 (218–4,329)
Specific-word frequency matched pictures	刷 (brush)	61 (3–145)	118 (12–262)
Homophone frequency matched pictures	床 (bed)	737 (223–2,202)	1,897 (252–19,372)

Note. English translations of Chinese names are shown in parentheses. Frequency ranges are shown in parentheses.

distribution of mean response latencies and errors, as a function of picture set (HomName vs. specific-word frequency vs. cumulative-homophone frequency pictures) and presentation (first vs. second vs. third). Both the main effects of picture set, $F1(2, 54) = 100$, $MSE = 831$, $p < .0001$; $F2(2, 93) = 5.6$, [illegible] $MSE = 18{,}142$, $p < .005$, and presentation, $F1(2, 54) = 64$, $MSE = 1{,}917$, $p < .0001$; $F2(2, 186) = 183$, $MSE = 847$, $p <$ .0001, were significant. There was no evidence of interaction

the two variables together is not significantly larger than that explained by specific-word frequency alone (Model 1, specific-word frequency: $R^2 = .15$; Model 2, specific-word frequency and cumulative-homophone frequency: $R^2 = .174$).

The results show that HomName pictures were named slower [illegible] than the cumulative-homophone frequency controls. This result parallels that found in English (Experiment 1A). However, HomName pictures were also named slower than the specific-

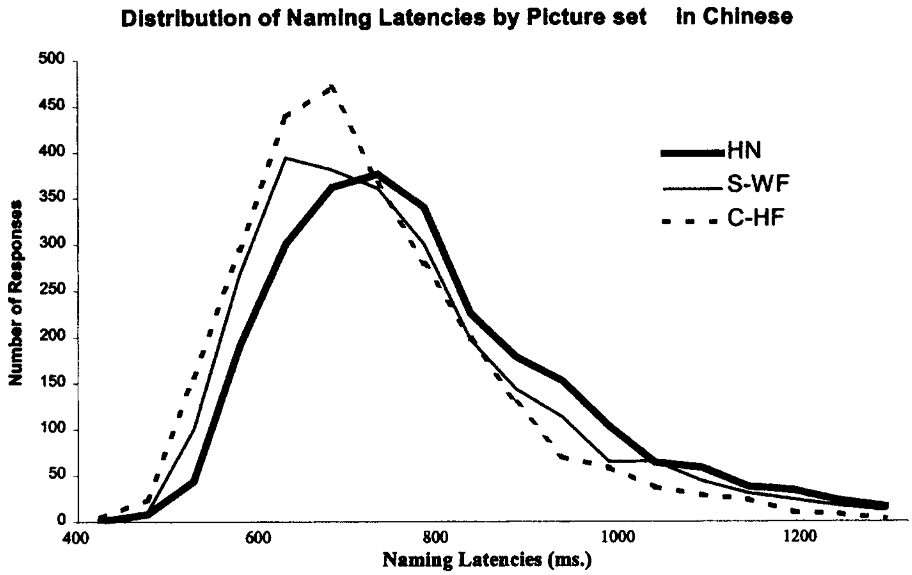

Figure 3. Distribution of naming latencies in Experiment 2A. The size of the interval is 50 ms. The lower interval begins at 400 ms, the highest interval ends at 1,300 ms. HN = homophone name; S-WF = specific-word frequency; C-HF = cumulative homophone frequency.

Experiment 2B: Picture Naming in English

Method

Participants. Seventeen native English speakers who were students at Harvard University participated in Experiment 2B.

Materials. One picture used in the Chinese version of the experiment was excluded because there were two equally plausible alternative names in English (the picture *bean* could be named either *bean* or *peas*). The stimuli paired with it were also removed from the experimental set. Thus, the sets of HomName, specific-word frequency, and cumulative-homophone frequency pictures were each composed of 31 items. Because many of the English picture names are homophones, we examined the

periment 2B are summarized in Table 8. As in the preceding experiments, we examined two variables: picture set (HomName vs. specific-word frequency vs. cumulative-homophone frequency) and presentation (first vs. second vs. third). The main effect of presentation was significant, $F1(2, 32) = 16$, $MSE = 26{,}367$, $p < .0001$; $F2\ (2, 180) = 45$, $MSE = 54{,}788$, $p < .0001$, a result reflecting a decrease of response latencies with repetition. The main effect of picture set was also significant, $F1(2, 32) = 45$, $MSE = 91{,}251$, $p < .0001$; $F2(2, 90) = 7.8$, $MSE = 172{,}461$, $p < .001$. There was no evidence of interaction between the two variables ($Fs < 1$). Pairwise comparisons showed that

Table 8
Mean Naming Latencies (and Error Rates) for the Pictures of Experiment 2B

Picture set	Example	Presentation 1	2	3	Average
Homophone name pictures	peach	767 (3.0)	732 (2.1)	713 (1.3)	737 (2.1)
Specific-word frequency matched pictures	brush	726 (4.1)	703 (1.9)	676 (1.0)	702 (2.3)
Homophone frequency matched pictures	bed	673 (1.9)	649 (1.3)	632 (1.2)	651 (1.5)

to play a role in naming latencies, the difference between the HomName and the specific-word frequency controls would have been expected to be smaller in Experiment 2A than in Experiment 2B. The results show that the difference in naming latencies between the two sets of pictures is independent of their difference in cumulative-homophone frequency. Therefore, this result allows us to dismiss the hypothesis that the lack of a homophone frequency effect in Chinese is an artifact of uncontrolled differences in relative difficulties in recognizing the pictures in the three sets of stimuli.

Experiment 2C: Delayed Naming in Chinese

In Experiment 2C, we presented Chinese speakers with the written names of the pictures used in Experiment 2A and instructed them to name them when a cue appeared. This task served as a control for possible effects of articulation difficulty in naming the experimental pictures.

Method

Participants. Sixteen Mandarin Chinese native speakers who were students at Beijing Normal University, Beijing, China, participated in Experiment 2C.

Materials and procedure. The Chinese characters for the names of the HomName, specific-word frequency, cumulative-homophone frequency, and filler pictures used in Experiment 2A were included in the experiment (see Appendix B). The same procedure as in Experiment 1C was used. Participants were instructed to name the characters (in Mandarin) at the presentation of a cue (an asterisk). The stimulus–cue interval varied: It was [illegible]

Results and Discussion

Following the same criteria as in Experiment 1C, 3.9% of the data points were discarded. Table 9 shows the mean naming latencies and error rates for HomName, specific-word frequency, and cumulative-homophone frequency characters. Naming latencies were not statistically different across stimuli sets ($Fs < 1$), a result that suggests that all articulatory routines were similarly accessible for the three sets of Chinese words used in Experiment 2A.

Summary of Experiments 2A–2C

As in English, picture-naming latencies in Chinese are determined by specific-word frequency rather than cumulative-homophone frequency. This pattern of results is not due to uncontrolled differences in picture recognition or ease of articulation among stimulus sets. When we assessed these possibilities, we found no indications that they could account for the Chinese data. The fact that analogous results were obtained in two languages (English and Chinese) increases our confidence in the conclusion that homophone frequency does not affect picture naming. This conclusion is at variance with Jescheniak and Levelt (1994), who observed a homophone frequency effect with a word translation paradigm. In an attempt to clarify the source of this discrepancy, we carried out a replication of the translation experiment of Jescheniak and Levelt (1994).

Experiment 3A: Spanish–English Translation Task

Table 10
Mean Frequency and Length for the English Words and Their Spanish Translations Used in Experiment 3A

Picture set	Examples	Specific frequency	Cumulative frequency	Familiarity
		English words		
Homophone name pictures	hare	21 (0–95)	1,478 (67–6,990)	4.4
Specific-word frequency matched pictures	plum	20 (0–95)	22 (0–127)	4.5
Homophone frequency matched pictures	tree	1,559 (54–8,996)	1,580 (54–9,362)	4.2
		Spanish translations		
Homophone name pictures	*liebre*	123		5.8
Specific-word frequency matched pictures	*ciruela*	99		6.1
Homophone frequency matched pictures	*árbol*	5,934		5.2

Note. Frequency ranges are shown in parentheses.

matched for cumulative-homophone frequency (e.g., *tree*).[8] The principal aim of the experiment was to examine whether the translation latencies for HomName words were comparable with those of the control stimuli matched for cumulative-homophone frequency, and faster than the translation latencies of the control stimuli matched for specific-word frequency.

Procedure. At the beginning of the experiment, participants read the printed list of Spanish words and their English translations. They were then instructed to produce the English words included in the list. Instructions were written in English and were read by the participants. Before the experiment proper, participants translated once the whole set of 216 words as fast as they could, without making mistakes. These words were shown a second time during the experiment. On each

Results and Discussion

Following the same criteria as in Experiment 1A, 8.6% of the data were discarded from the analyses. Mean translation latencies and error rates for the various word sets are presented in Table 11. There was a significant effect of word set, $F1(2, 38) = 51$, $MSE = 5{,}601, p < .001$; $F2(2, 57) = 15, MSE = 21{,}688, p < .001$. Pairwise comparisons revealed that naming latencies were faster for cumulative-homophone frequency words than for both specific-word frequency words and HomName words ($ps < .001$). There was no difference between the translation times for HomName words and specific-word frequency words ($Fs < 1$). Errors were unequally distributed across word sets, $F1(2, 38) = 15$, $MSE = 1.5, p < .001$; $F2(2, 57) = 5.6, MSE = 4.2, p < .002$. The latter result is in part explained by the fact that cumulative-homophone frequency words induced fewer errors than the words of the other conditions (for all Fs, $p < .05$). The difference in error rate between HomName (14.6%) words and specific-word frequency words (8.1%) was significant in the $F1$ analysis, $F1(1, 19) = 8.0$, $MSE = 1.9, p < .01$, but not in the $F2$ analysis, $F2(1, 38) = 2.7$, $MSE = 5.7, p < .1$.

As in the previous experiments, we carried out a regression analysis on naming latencies with specific-word frequency and cumulative-homophone frequency as predictors. Specific-word frequency is a better predictor ($R^2 = .48$) than cumulative-homophone frequency ($R^2 = .16$). Furthermore, when specific-word frequency was introduced first in the regression model, there was essentially no gain in explained variance by adding cumulative-homophone frequency (Model 1, specific-word frequency: $R^2 = .48$; Model 2, specific-word frequency and cumulative-homophone frequency, $R^2 = .49$).

We also analyzed the relation between AoA and translation latencies. As in Experiment 1A, we considered both specific and MinHomophone AoA. Specific-word AoA is a better predictor of naming latencies than MinHomophone AoA ($R^2 = .45$ vs. .16, we found that translation latencies for HomName words were not statistically different from words matched for specific-word frequency (e.g., *plum*). However, the complexity of the translation task is such that interpretation of our results must proceed cautiously, at least until we have ruled out the contribution of possible confounding factors. One factor relates to differences in word recognition. For example, if it took disproportionately longer to recognize the Spanish words for the HomName items, we might not be able to detect a homophone frequency effect, even if it were present. This possibility was examined in Experiment 3B, in which the Spanish words of Experiment 3A were presented to Spanish speakers for lexical decision. If the failure to observe a homophone frequency effect was because the Spanish stimuli for the HomName words were recognized relatively slowly, these words should produce slower decision latencies than their matched specific-word frequency controls.

Alternatively, it could be that our failure to replicate the effect of homophone frequency is attributable to differences in the ease of articulation of the three word sets; namely, perhaps it is more difficult and it takes longer to articulate HomName words than their specific-word frequency controls. As in Experiments 1 and 2, we used a delayed-naming task (see Experiment 3C) to assess the possibility that differences in articulation difficulty are responsible for the effects obtained in Experiment 3A.

Experiment 3B: Lexical-Decision Task With Spanish Words

Method

Participants. Twenty native Spanish speakers who were students at the University of Barcelona, Barcelona, Spain, participated in the Experiment

Results and Discussion

Responses shorter than 200 ms, longer than 1,500 ms, or that

specific-word frequency (e.g., *plum*), and were significantly slower than those found for control words matched on cumulative-

Table 13
Mean Naming Latencies and Error Rates in Experiment 3C

Written word	Example	Naming latency	Error rate
Homophone words	hare	375	1.0
[illegible]	[illegible]	[illegible]	[illegible]
Homophone frequency matched words	tree	379	1.3

The effects observed in the factorial analyses of the data

found a homophone frequency effect in a single experiment with

(ANOVAs) are supported by the results of regression analyses. In the latter analyses, it was consistently found that naming latencies are better predicted by the specific-word frequency than the cumulative-homophone frequency variable. Furthermore, the gain in explained variance was never significant when cumulative-homophone frequency was included as a factor in the regression model.

Dutch speakers. That result was obtained with a complicated translation task, and with an especially small number of items (11 items per set). In contrast, we have systematically failed to replicate this result with two different tasks, and with larger numbers of stimulus items (between 20 and 32). Furthermore, we have ob-

Table 14
Mean Naming Latencies for the Pictures of Experiment 1A

		Presentation			
Picture set	Example	1	2	3	Average
Homophone name pictures	nun (watch)	755 (743)	782 (764)	754 (746)	764 (751)
Specific-word frequency matched pictures	owl (piano)	748 (750)	768 (770)	741 (743)	752 (754)
Homophone frequency matched pictures	tooth (table)	709 (714)	724 (726)	708 (706)	714 (716)

Note. Numbers represent the naming latencies combining heterographic (e.g., *nun/none*) and homographic (e.g., *watch*) homophones in Experiment 1A; numbers in parentheses represent naming latencies for only the homographic homophones included in that experiment.

Another possible reason for the different results obtained in our Experiment 1A and the experiment reported by Jescheniak and Levelt (1994) is that we included in our study homonyms that are [illegible] related in meaning (e.g., *the anchor/to anchor; the nurse/to nurse; seven out of twenty-five*). It might be argued that these words are somehow processed differently from other homophones. However, a reanalysis of the data excluding these items did not affect the pattern of results (HomName: 763 ms; specific-word frequency: 761 ms; cumulative-word frequency: 715 ms).

Our results also contrast with those reported by Dell (1990). Dell investigated the occurrence of sound errors for homophone pairs formed by high-frequency function words and low-frequency content words, such as *him/hymn* and *would/wood*. In a post hoc analysis, Dell found that homophone frequency predicted the rate of sound errors for the lower frequency members of the homophone pairs. The reason for the contrasting results in Dell's experiment and in ours is not clear. We can point to obvious differ- [illegible]

tivation model of lexical access (see also Jescheniak & Levelt, 1994). The model assumes that homophones are represented by distinct lemma representations that converge onto a single lexeme [illegible] node for each homophone cohort (see Figure 1A). The model also assumes that the locus of the frequency effect in naming is at the level of lexeme representations. This combination of assumptions predicts that naming latencies are a function of cumulative-homophone frequency and not specific-word frequency. The results of our experiments, which show that naming latencies are not a function of cumulative-homophone frequency but instead are determined by specific-word frequency, indicate that at least one of the assumptions of the model may be incorrect. There are various ways in which the model could be modified to accommodate our results.

Jescheniak and Levelt (1994) pointed out that in their model there are at least three possible loci for the frequency effect in naming: the lemma level, the lexeme level, or the lemma–lexeme [illegible] with which lexical nodes are selected, as well as its further impact

[illegible]

accounts for the word frequency effect in naming by postulating some activation advantage to higher frequency words, the model would also then predict a homophone frequency effect. This is because any advantage that accrues to a high-frequency lexical node is shared by nodes that are connected to it (see the introduction). Thus, it is not unreasonable to argue that Dell's model predicts a homophone frequency effect on naming latencies, and that the absence of such an effect in our experiments shows that some aspect of the model needs to be modified.

We have already noted that without explicit simulation, predictions about the behavior of interactive models can only be made very tentatively. That is because the actual behavior of a model depends on the specific values chosen for the various parameters of the model. This point can be easily appreciated by considering the consequences of progressively increasing (or decreasing) the feedback connection strength in such a model. When the feedback value is very small, the effects of interactivity can be quite insignificant. As the feedback connection strength increases, the effects of interactivity become progressively more important. It is possible, therefore, to find parameter values for an interactive activation model that predict only very small and not easily detectable effects of homophone frequency. This model would then be able to

(Figure 1A), and against the single lexical layer model proposed by

[illegible]

in the present article). However, our results cast serious doubt on the existence of a homophone frequency effect. Instead, the results we have reported provide clear evidence in favor of a specific-word frequency effect in lexical access. This effect undermines the empirical motivation for the SR hypothesis of homophones. If we give up the SR hypothesis, we also remove perhaps one of the strongest arguments cited in favor of the lemma–lexeme distinction. Of course, there are other grounds on which one may want to motivate this distinction (for extensive discussion of these other data, see Dell, 1986; Garrett, 1988; Levelt et al., 1999; but also see Caramazza, 1997, for an opposing view). The point here is simply that the homophone frequency effect cannot be counted in the ledger of those facts that require an assumption of a lemma–lexeme distinction in lexical representation and access.

To conclude, in three sets of experiments we have shown that naming latencies are determined by specific-word frequency rather than by cumulative-homophone frequency. The specific-word frequency effect documented in this study raises difficulties for interactive activation models of lexical access and for models of lexical access that assume shared representations for homophones (and locate the effect of frequency in naming at the level of the shared homophone representation). The results provide support for

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[illegible]

Appendix A

Pictures Shown in Experiment 1A (Along With Their Italian Names)

Picture set		
HomName	Specific-word frequency	Cumulative-homophone frequency
Nun (*Suora*)	Owl (*Gufo*)	Tooth (*Dente*)
Tower (*Torre*)	Apple (*Mela*)	Barrel (*Botte*)
Bear (*Orso*)	Lion (*Leone*)	Bone (*Osso*)
Tie (*Cravatta*)	Monk (*Frate*)	Box (*Scatola*)
Screw (*Vite*)	Bread (*Pane*)	Bus (*Autobus*)
Sun (*Sole*)	Dog (*Cane*)	Car (*Macchina*)
Deer (*Cervo*)	Goat (*Capra*)	Chain (*Catena*)
Swing (*Altalena*)	Eagle (*Aquila*)	Chair (*Sedia*)
Ark (*Arca*)	Sphynx (*Sfinge*)	Egg (*Uovo*)
Fire (*Fuoco*)	Tree (*Albero*)	Foot (*Piede*)
Train (*Treno*)	Bird (*Uccello*)	Horse (*Cavallo*)
Whistle (*Fischietto*)	Pumpkin (*Zucca*)	Lemon (*Limone*)
Well (*Pozzo*)	Doll (*Bambola*)	Money (*Moneta*)
Dam (*Diga*)	Crab (*Granchio*)	Moon (*Luna*)
Cross (*Croce*)	Shirt (*Camicia*)	Radio (*Radio*)
Safe (*Cassaforte*)	Scarf (*Sciarpa*)	Shoe (*Scarpa*)
Pear (*Pera*)	Cheese (*Formaggio*)	Soldier (*Soldato*)
Watch (*Orologio*)	Piano (*Pianoforte*)	Table (*Tavolo*)
Anchor (*Ancora*)	Ladder (*Scala*)	Tractor (*Trattore*)
Sail (*Vela*)	Maze (*Labirinto*)	Wall (*Muro*)
Whale (*Balena*)	Frog (*Rana*)	Wrist (*Polso*)
Mane[a]	Skunk[a]	Bed[a]
Nurse[a]	Pill[a]	Corn[a]
Stamp[a]	Skull[a]	Cow[a]
Bow[a,b]	Sword[a,b]	Pie[a,b]
Crack[a]	Pig[a]	Roof[a]

[a] These pictures were excluded in the control experiment carried out in Italian (Experiment 1B). [b] These pictures were excluded from the analyses in Experiment 1A.

Appendix B

Pictures Shown in Experiment 2A (Along With Their English Names)

Picture set		
HomName	Specific-word frequency	Cumulative-homophone frequency
锹 (Shovel)	勺 (Spoon)	窗 (Window)
帆 (Sail)	梯 (Ladder)	脑 (Brain)
鼠 (Mouse)	琴 (Guitar)	枪 (Gun)
糖 (Candy)	鼻 (Nose)	雪 (Snow)
桃 (Peach)	刷 (Brush)	床 (Bed)
铃 (Bell)	瓜 (Melon)	灯 (Lamp)
斧 (Axe)	塔 (Tower)	画 (Painting)
壶 (Pot)	舌 (Tongue)	桥 (Bridge)
蒜 (Garlic)	蛇 (Snake)	嘴 (Mouth)
碗 (Bowl)	耳 (Ear)	鱼 (Fish)
龟 (Turtle)	钩 (Hook)	手 (Hand)
桶 (Bucket)	兔 (Rabbit)	星 (Star)
裙 (Dress)	袜 (Sock)	脚 (Foot)
剪 (Scissors)	伞 (Umbrella)	衣 (Coat)
叶 (Leaf)	虎 (Tiger)	树 (Tree)
豹 (Leopard)	链 (Chain)	钱 (Money)
鹰 (Eagle)	筐 (Basket)	船 (Boat)
鸭 (Duck)	猫 (Cat)	马 (Horse)
瓶 (Bottle)	牙 (Tooth)	火 (Fire)
狮 (Lion)	鹅 (Goose)	线 (Thread)
梳 (Comb)	熊 (Bear)	花 (Flower)
旗 (Flag)	云 (Cloud)	书 (Book)
岛 (Island)	狗 (Dog)	表 (Watch)
鞭 (Whip)	扇 (Fan)	月 (Moon)
锁 (Lock)	猴 (Monkey)	门 (Door)
鹿 (Deer)	锤 (Hammer)	山 (Mountain)
驴 (Donkey)	钉 (Nail)	车 (Car)
锯 (Saw)	毯 (Rug)	路 (Road)
鲸 (Whale)	虾 (Lobster)	眼 (Eye)
剑 (Sword)	锅 (Pan)	水 (Water)
箭 (Arrow)	尺 (Ruler)	心 (Heart)
豆 [a] (Bean)	鹤 [a] (Crane)	虫 [a] (Worm)

[a] These pictures were excluded in the control experiment carried out in English (Experiment 2B).

(Appendixes continue)

Appendix C

Spanish–English Translations Shown in Experiment 3A

Word set					
HomName		Specific-word frequency		Cumulative-homophone frequency	
Spanish	English	Spanish	English	Spanish	English
Freno	Brake	*Bufanda*	Scarf	*Perdido*	Lost
Monja	Nun	*Buho*	Owl	*Nueve*	Nine
Bruja	Witch	*Pulgar*	Thumb	*Quién*	Who
Haya	Beech	*Levadura*	Yeast	*Rueda*	Wheel
Harina	Flour	*Payaso*	Clown	*Cuchillo*	Knife
Nudo	Knot	*Grua*	Crane	*Para*	For
Abeja	Bee	*Mandíbula*	Jaw	*Con*	With
Colilla	Butt	*Cabra*	Goat	*Ella*	She
Ciervo	Deer	*Cordero*	Lamb	*Alto*	Tall
Caballero	Knight	*Ladrillo*	Brick	*Agua*	Water
Débil	Weak	*Desnudo*	Naked	*Habitación*	Room
Carne	Meat	*Leche*	Milk	*Dios*	God
Madera	Wood	*Viento*	Wind	*Todo*	All
Tomillo	Thyme	*Albahaca*	Basil	*Gente*	People
Ronco	Hoarse	*Podrido*	Rotten	*Río*	River
Mejillón	Mussel	*Grifo*	Faucet	*Nacimiento*	Birth
Crin	Mane	*Cangrejo*	Crab	*Facil*	Easy
Llanura	Plain	*Aguja*	Needle	*Esquina*	Corner
Aqujero	Hole	*Onda*	Wave	*Blanco*	White
Liebre	Hare	*Ciruela*	Plum	*Arbol*	Tree
Criada[a]	Maid	*Ala*[a]	Wing	*Allí*[a]	There
Rocío[a]	Dew	*Babero*[a]	Bib	*Dos*[a]	Two

[a] These words were excluded from the analyses in Experiment 3A.

Revision received March 28, 2001
Accepted March 28, 2001 ■