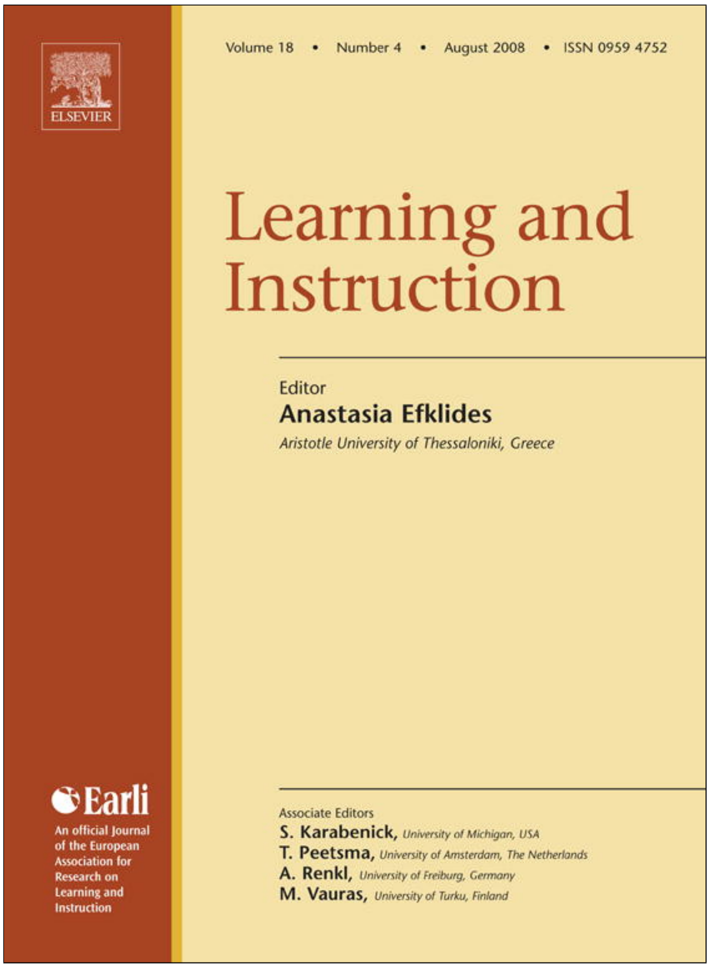
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Cognitive and linguistic constraints on phoneme isolation in Dutch kindergartners

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Abstract

This study investigated whether task instructions affect sound-isolation performance. The effects of phoneme class and phoneme position were also assessed. Two hundred Dutch kindergartners were presented with a free-sound-isolation task and its constrained counterparts: an initial-, a middle-, and a final-sound-isolation task. All tasks contained 17 CVC words. Children's performance on the free-sound-isolation task was better than on the constrained tasks. On all four tasks, children made fewer errors in isolating the initial phoneme than the final phoneme. Isolating the middle phoneme proved to be the most demanding. The effect of phoneme class depended on the type of task and on phoneme position. Findings were placed against the background of sonority and word-final phoneme vocalization in Dutch.

Keywords: Phonemic awareness; Phoneme class; Phoneme position; Kindergartners; Sonority

1. Introduction

Phonological awareness is widely accepted as one of the most important predictors of beginning reading (Patel, Snowling, & De Jong, 2004). According to the psycholinguistic grain-size theory, a novel theoretical framework to explain cross-language data concerning reading and its development (Goswami, 2006; Ziegler & Goswami, 2005), phonological development appears to follow a language-universal sequence. Phonological awareness at large grain sizes (syllables, onsets, and rhymes) develops before literacy acquisition, and phonological awareness at smaller grain sizes (phonemes) develops largely in response to alphabetic instruction. In this paper, we focus on awareness at the smaller grain size: phonemic awareness. A diversity of tasks has been constructed to measure this ability. We will examine two factors that determine performance on these tasks: task properties and phoneme properties.

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1.1. Effects of task properties

Task properties have a quantitative and a qualitative aspect. That is, they pertain to the number of operations that must be fulfilled to complete a task, and to the nature of operations (e.g., isolation, deletion, or substitution of phonemes). Yopp's (1988) study about the validity and reliability of phonemic-awareness tasks is clarifying in this respect. She compared 10 tasks and concluded on the basis of a factor analysis that two factors underlie the construct of phonemic awareness. Tasks that loaded highly on the first factor only required one mental operation to complete the task and were referred to as simple phonemic-awareness tasks. Tasks that loaded highly on the second factor required more than one mental operation at a time and were referred to as compound phonemic-awareness tasks. Compound phonemic-awareness tasks appeared to be more difficult than simple phonemic-awareness tasks.

Performance also varied with the nature of the task operations. In Yopp's (1988) study, for example, phoneme blending was easier than phoneme segmentation, and phoneme segmentation was easier than phoneme deletion, albeit all tasks belonged to the simple phonemic-awareness cluster. Stanovich, Cunningham, and Cramer (1984) compared phonemic tasks that belonged to the compound phonemic-awareness cluster and also reported differences in task performance. For example, stripping the initial phoneme was more difficult than substituting it.

1.2. Effects of phoneme properties

Phoneme properties also appear to affect task performance and pertain to the position of the phoneme in a word and to the class of the phoneme.

1.2.1. Phoneme position

Based on phonological-awareness and beginning-spelling studies, it is established that manipulations with word-middle phonemes are more demanding than those with word-initial and word-final phonemes. Treiman, Berch, and Weatherston (1993), for example, argue that it is more difficult to spell the middle phoneme because it is encompassed by two or more other phonemes and is thus more difficult to access. Stage and Wagner (1992) have put forward a similar explanation when they state that considerable co-articulation may occur during both onset and offset of articulation of word-middle phonemes. Treiman et al. (1993) further argue that primacy and recency effects, characteristics of short-term memory, may explain the relative difficulty of word-middle phonemes. The initial phoneme may be easier to access compared to the middle phoneme because it benefits from the primacy effect. The final phoneme may be easier to access compared to the middle phoneme because it benefits from the recency effect.

Mixed findings are reported regarding initial and final phonemes. Spelling studies revealed that kindergartners spell the initial phoneme with fewer errors than the final phoneme (Stage & Wagner, 1992; Treiman et al., 1993). Treiman et al. (1993) propose an explanation for this phenomenon in terms of the hierarchical onset-rime structure of the syllable. They argue that it is more difficult to access the final phoneme because it forms a phonological-rime unit together with the preceding vowel. The initial phoneme, on the other hand, may be easier to access because it acts like a phonological unit on its own, that is, the onset. Content, Kolinsky, Morais, and Bertelson (1986) found a similar pattern of results in kindergartners on a classification task in which children had to determine whether CVC syllables shared an initial or a final consonant with a target syllable: Scores tended to be higher for phonemes in initial than for phonemes in final position. McBride-Chang (1995) found no difference in the manipulation of the initial or final phoneme on a position-analysis task in which children had to determine which sound comes before or after another sound in a nonword. In the same study, however, deletion of the final phoneme in a phoneme-deletion task was easier than deletion of the initial phoneme. Content et al. (1986) reported the same result on a phoneme-deletion task administered to kindergartners. They based their explanation on the sequential character of speech. One could perform a final segment-deletion task by monitoring one's articulation and stop just before the last articulatory gesture. Adopting such a strategy seems to require only one mental operation to perform the task, namely monitoring. In the case of the initial phoneme-deletion task, the articulatory program cannot be used. More mental operations are necessary: one has to locate and delete the first phoneme before it is possible to pronounce the remaining part of the word. However, in the case of the classification task, Content et al. (1986) argue that the early part of the articulatory program is more accessible so that attention will be more directed to the initial than to the final phoneme.

The onset-rime explanation proposed by Treiman et al. (1993) is perhaps also applicable to the classification task. It may be easier to compare the onset of a syllable with an onset of a target syllable than with a final phoneme since the latter is part of a cohesive unit, namely the rime. But why does this explanation not apply to the phoneme-deletion task? Based on the onset-rime hypothesis, it is expected that it is easier to delete the initial phoneme (i.e., the onset) than the final phoneme. However, the opposite is true: it is harder to delete the onset than the final phoneme of a word. The number of mental operations is perhaps responsible for this effect. As said, deleting the initial phoneme requires more mental operations than deleting the final phoneme. If the underlying onset-rime structure of a word exerts an effect, it is probably overruled by the effect of the larger number of mental operations needed to perform the task. To perform the classification task, that is, comparing the initial or the final phoneme of a syllable with an initial or final phoneme of a target syllable requires the same number of mental operations. Thus, the effect that emanates from the underlying onset-rime structure is maintained. In sum, differences in task performance associated with phoneme position can be ascribed to the number of mental operations, short-term memory, the underlying onset-rime structure of the syllable, and (co)articulation.

1.2.2. Phoneme class

In addition to the position of the phoneme in a word, its class also affects task performance. In the classification of phonemes, the sonority hierarchy plays an important role. Sonority or vowel-likeness is most often defined as ''the degree of openness of the vocal apparatus during production, or the relative amount of energy produced during the sound'' (Goldsmith, 1990, p. 110; see Parker, 2002 for a number of other definitions). On this scale, each phoneme or segment is assigned a sonority index. Vowels are most sonorant and therefore assigned the highest value, followed by glides, liquids, nasals, fricatives, affricatives, and plosives, which are the least sonorant, and, thus, are assigned the lowest value (Selkirk, 1984). Sonority imposes constraints on the sequencing of multiple onsets and codas in spoken language which is captured in the principle of Sonority Sequencing Generalization. This principle implies that the ''sonority of consonants must decrease towards the edges of a syllable'' (Booij, 1995, p. 24).

Findings from studies that examine the effect of phoneme class of consonants are generally mixed and difficult to compare, because compound as well as simple phonemic-awareness tasks were the object of analyses. The position of the phoneme in the word also differed between studies. These mixed findings were revealed in a series of studies in which the effects of plosives and fricatives were examined. Yavas and Gogate (1999) and Yavas and Core (2001) found that performance on a final-consonant-deletion task was better for plosives than for fricatives. In other studies, however, exactly the opposite result was obtained: items containing fricatives made children perform better than items containing plosives. For example, Byrne and Fielding-Barnsley (1990) found relatively poor performance on a phoneme-identity task for plosives compared to fricatives in both initial and final position. Treiman and Baron (1981) found the same result on a phoneme-counting task: fricatives were easier to count than plosives in three-phoneme syllables. McBride-Chang (1995) also found that performance on position analysis was better for items containing fricatives than for items containing plosives. In this study, the position of the phoneme in the word was not taken into consideration. Content et al. (1986), however, did study phoneme position and reported that phoneme class interacted with phoneme position on both a classification and a deletion task. That is performance tended to be better for fricatives than for plosives in word-initial position, and better for plosives than for fricatives in word-final position. In contrast to these results, Treiman, Broderick, Tincoff, and Rodriguez (1998) found no difference between fricatives and plosives when they asked preschoolers and kindergartners to perform a phoneme-recognition task. On phoneme segmentation no such differences were found either (Byrne & Fielding-Barnsley, 1990; McBride-Chang, 1995).

Taking a closer look at these findings, there seems to be a tendency that in word-final positions plosives are easier to manipulate and in word-initial positions fricatives. At least two explanations can be put forward. The first is related to the reduced degree of co-articulation that is found in post-vocalic compared to pre-vocalic plosives (Sussman, Bessell, Dalston, & Majors, 1997), thus facilitating manipulations with word-final plosives. The second explanation relates to the notion of sonority. Due to their larger vowel-likeness, high-sonority codas cohere to a greater extent to the preceding vowel than phonemes lower in sonority and are thus harder to perceive and manipulate (Treiman, 1989; Yavas & Gogate, 1999).

Other comparisons than the one between fricatives and plosives are also made. Stanovich et al. (1984) compared continuants with plosives and reported similar error rates for both categories on a variety of tasks in which the initial and the final phoneme had to be manipulated. Byrne and Fielding-Barnsley (1990) reported better performance on both an initial and a final phoneme-identity task for nasals than for plosives. Yavas and Core (2001) and Yavas and Gogate (1999) found that performance on a final-consonant-deletion task was better for plosives and fricatives compared to nasals and liquids and that performance was better for nasals compared to liquids. Geudens (2004; Geudens &

Sandra, 2003) found that segmentation of CV and VC syllables containing obstruents was better than that of CV and VC syllables containing sonorants. These effects are explained in terms of sonority. Due to their larger vowel-likeness, sonorants (liquids and nasals) appear to cohere more strongly with their preceding vowels than obstruents (plosives and fricatives) and are thus harder to manipulate. Nasals have an intermediate degree of cohesiveness with vowels and are thus easier to delete than liquids.

2. The present study

Putting these results together, we conclude that performance on phonemic-awareness tasks depends on (a) the nature and the number of operations within a task, (b) interactions of phoneme class with nature and number of task operations, (c) interactions of phoneme position with nature and number of task operations, and (d) interactions of phoneme class with phoneme position. In addition to these influences, we posit that differences in the nature of task operations, due to instruction differences, will also affect task performance. The focus of our study is therefore the phoneme-isolation task, which is classified by Yopp (1988) as a simple phonemic-awareness task requiring just one mental operation to fulfil the task. However, one could argue that even this test requires more than one mental operation. First, one has to be able to grasp the idea of initial, middle, or final sounds and direct one's attention to the position, before one can isolate and name the sounds. Observations made by the first author while administering sound-isolation tasks in kindergartners revealed that children, when asked to isolate the initial sound, occasionally correctly isolated the middle or last sound rather than the initial. Although these children do not fulfil task requirements, they do not totally lack a sense of phonemic awareness, because they were able to isolate and name phonemes. A misunderstanding of the concept of initial, middle, and final sounds appears to put a cognitive constraint on their ability to correctly isolate the sounds.

Therefore, the objective of this study was to determine whether a sound-isolation task with an alternative instruction, in which children do not need to consciously locate initial, middle, and final sounds, will lead to a different pattern of performance. In this task, the so-called free-sound-isolation task, children are instructed to freely name the sounds that they hear in a word in any order they want. The task paradigm is partly comparable to that of a free-segmentation task of Fox and Routh (1975) who asked children to say "just a little bit" of sentences, words, and syllables. Our task differs from the free-segmentation task of Fox and Routh (1975). Our instruction was more explicitly focussed on the phonemes. In Fox and Routh's (1975) study, four- and five-year-olds succeeded in differentiating about 70 and 85% of the phonemes, respectively. It remains unclear, however, whether children also named all of the phonemes separately. That is, in a practice example they were presented with the word "Pete" and told that if they say just a little bit of "Pete", they would have to respond with "Pe". Subsequently, they are told to say just a little bit of "Pe". Thus, the phoneme /t/ is actually not named by the child (nor one of the phonemes of the syllable "Pe"), but following the author's terminology "differentiated". Content et al. (1986) made minor changes to the same task to assess the effects of a segmentation-training procedure. They found that four-year-olds could segment CVC utterances into sub-syllabic parts, while the same participants did not show improvement on an initial-consonant-deletion task. These sub-syllabic parts also included parts equal to segments that would have remained after initial-consonant deletion.

None of these results provide conclusive evidence for the assumption that it is the non-constrained part of the task that facilitates children in segmenting or isolating sounds. Fox and Routh (1975) did not compare their free-segmentation task with comparable tasks, and Content et al. (1986) compared results of the free-segmentation test with that of a consonant-deletion task, which deviates in more than one dimension from the free-segmentation task. To determine whether a different instruction actually leads to a different task performance, in the present study the free-sound-isolation task was compared with its constrained counterparts, that is, the initial-sound-isolation task, the middle-sound-isolation task, and the final-sound-isolation task.

2.1. Hypotheses

Based on the above, we formulated the following two hypotheses and an explorative question. The first hypothesis concerns task-instruction effects as a function of cognitive constraints on phoneme isolation. Children will perform better on the free-sound-isolation task than on its constrained counterparts, because a lower degree of abstraction ability is needed for the free-sound-isolation task than for the constrained tasks (Hypothesis 1).

The second hypothesis, supported by earlier findings in studies on beginning spelling, concerns a linguistic constraint on phoneme isolation: phonemes in initial position will be better isolated than phonemes in final position, and phonemes in final position will be better isolated than phonemes in middle positions (Hypothesis 2).

A final question pertained to the interaction between task instruction, phoneme position, and phoneme class. No specific hypothesis was formulated because the evidence is not conclusive.

3. Method

3.1. Participants

Two hundred Dutch-speaking kindergartners took part in this study, 94 girls and 106 boys, with a mean age of 72.7 months (SD = 4.5 months). The children were recruited from nine regular primary schools. Their mean number of productive letter–sound knowledge was 10.1 letters (SD = 8.2; minimum = 0, maximum = 34).

3.2. Test material

Four different tasks were administered to the children to measure their phonemic awareness (see Appendix A for a list of task items accompanied by the phoneme classes to which the different phonemes belong). The items in all tasks consisted of CVC words that were familiar to kindergartners, selected from the target list of Schaerlaekens, Kohnstamm, and Lejaegere (2000). This list presents rankings for words expected to be known receptively by kindergartners according to a sample of kindergarten teachers. Only words that were judged as such by 80% or more of the teachers were selected for the tasks. To prevent repetition effects, all four tasks consisted of unique words.

To meet the other criteria that were set to compose all four tasks (see below), we needed 17 items for the free-sound-isolation task. To obtain four lists with an equal number of items, two filler items were used in the middle-sound-isolation task and seven in the final-sound-isolation task.

3.2.1. Initial-sound-isolation task

This task was administered to test children's ability to isolate initial sounds and consisted of 17 CVC words. These were chosen such that all Dutch consonants appeared at least once at the beginning of the word. Children had to isolate and pronounce the initial sound of the words after oral presentation, for example, "Which sound do you hear at the beginning of ball?". The task items were preceded by four practice items (*pil*, *sop*, *mier*, *boot*) for which corrective feedback was provided. In the case of an incorrect answer, the feedback was as follows: "At the beginning of pill, you hear the /p/, pill-/p/." The maximum score on this task was 17, one point for each correctly produced sound.

3.2.2. Middle-sound-isolation task

This task was administered to test children's ability to isolate middle sounds and consisted of 17 CVC words. These were chosen such that all Dutch vowels and diphthong appeared at least one time in the middle of the word. Children had to isolate and pronounce the middle sound of the words after oral presentation, for example, "Which sound do you hear in the middle of hot?". The task items were preceded by four practice items (*pil*, *sop*, *mier*, *boot*) for which corrective feedback was provided. In the case of an incorrect answer, the feedback was as follows: "In the middle of pill, you hear the /i/, pill-/i/." The maximum score on this task was 17, one point for each correctly produced sound.

3.2.3. Final-sound-isolation task

This task was administered to test children's ability to isolate final sounds and consisted of 17 words. These were chosen such that all possible Dutch consonants appeared at least one time at the end of the word (except the consonants /v/, /z/, /h/, and /j/, because they never appear at the end in Dutch native words, and the voiced consonants /b/ and /d/, because they become voiceless at the end of Dutch words and thus do not differ anymore from the consonants /p/ and /t/). Children had to isolate and pronounce the final sound of the words after oral presentation, for example, "Which sound do you hear at the end of bus?". The task items were preceded by four practice items (*pil*, *sop*, *mier*, *boot*) for which corrective feedback was provided. In the case of an incorrect answer, the feedback was as follows: "At the end of pill, you hear the /l/, pill-/l/." The maximum score on this task was 17, one point for each correctly produced sound.

3.2.4. Free-sound-isolation task

This task was administered to test children's ability to isolate sounds in words without being directed to the position of the sound in the word. The 17 CVC words were chosen such that all Dutch consonants, when possible, appeared at least once at the beginning and once at the end. Dutch vowels and diphthongs appeared at least once in the middle of the word. Children had to isolate and pronounce the sounds of the words after oral presentation, for example, ''Which sounds do you hear in soup?''. Children had to name each of the three sounds (i.e., phonemes) that made up the word in any order they wanted. Thus, the response sequence /s/, /u/, /p/ valued three points, but also the response sequence /p/, /s/, /u/. For each item a maximum of exactly three responses was elicited. If children only gave one or two responses, they were asked whether they could name any more sounds. Task items were preceded by four practice items (*pil*, *sop*, *mier*, *boot*) for which corrective feedback was provided. In case of an incorrect answer, the feedback was as follows: ''In pill, you hear the /p/, pill-/p/, the /i/ pill-/i/ and the /l/, pill-/l/.'' In case of a partly incorrect answer, the child was complimented for the correctly isolated sounds before the remaining phonemes were mentioned by the experimenter in the same way as in the case of totally incorrect answers. The maximum score on this task was 51, one point for each correctly produced sound.

3.3. Procedure

All tasks were administered individually in four separate sessions. To prevent order effects, two measures were taken. One, the items in the four tests were administered in 25 different orders, because in each school approximately 25 children were tested. Two, presentation of the items in each list was presented from top to bottom in half the sample of children, and from bottom to top in the other half.

4. Results

4.1. Effects of task instruction and phoneme position

To improve readability of the results, raw scores of correctly named phonemes were transformed into percentages of the maximum possible number of phonemes that could be named correctly (17 phonemes for each position, initial, middle, and final). Means (with standard deviations in parentheses) for the initial, middle and final positions of the constrained instruction were 68.8 (32.5), 45.1 (38.6), and 59.7 (38.5), respectively. For the free task instruction, they were 74.5 (31.4), 57.7 (37.3), and 69.2 (34.9), respectively.

To test effects of task instruction and phoneme position on performance, a 2×3 MANOVA was conducted with instruction (free vs. constrained) and phoneme position (initial, middle, final) as within subjects factors on the percentages of correctly named phonemes. All main and interaction effects were significant: instruction, Pillai's trace $= 0.18$, $F(1, 199) = 44.01$, $p < 0.01$, partial $\eta^2 = 0.18$; phoneme position, Pillai's trace $= 0.37$, $F(2, 198) = 56.81$, $p < 0.01$, partial $\eta^2 = 0.37$; Instruction $\times$ Position, Pillai's trace $= 0.05$, $F(2, 198) = 5.01$, $p < 0.01$, partial $\eta^2 = 0.05$.

The interaction effect was further examined by computing difference scores of the free minus the constrained task instruction. Paired samples *t*-tests were conducted on all combinations of phoneme positions. Bonferroni adjustment of the alpha level was used to correct for multiple comparisons; the alpha level was set at $0.05/3 = 0.017$. The analyses showed that the effect of task instruction on the percentage of correctly named phonemes was strongest for the initial phoneme position in comparison to the middle position, $t(199) = -3.14$, $p = 0.002$, Cohen's $d = 0.28$. The other position comparisons (initial vs. final and middle vs. final) were not significant (see Fig. 1).

To further explore the origins of the main and interaction effects, paired samples *t*-tests were conducted on all factor levels, with Bonferroni adjustment of the alpha level set at $0.05/3 = 0.017$ for the three groups of comparisons. For all positions, children named significantly more phonemes correctly when the instruction was free. Position: free vs. constrained: initial position, $t(199) = 3.91$, $p < 0.001$, Cohen's $d = 0.18$; middle position, $t(199) = 6.42$, $p < 0.001$, Cohen's $d = 0.33$; final position, $t(199) = 4.45$, $p < 0.001$, Cohen's $d = 0.26$.

Within both types of instruction a similar effect of position emerged. Phonemes in initial position were more often named correctly than phonemes in middle and final positions. Specifically, for free instruction: initial vs. middle position, $t(199) = 8.51$, $p < 0.001$, Cohen's $d = 0.49$; initial vs. final position, $t(199) = 3.26$, $p < 0.001$, Cohen's $d = 0.16$; for constrained instruction: initial vs. middle position, $t(199) = 9.89$, $p < 0.001$, Cohen's $d = 0.67$; initial vs. final position, $t(199) = 4.56$, $p < 0.001$, Cohen's $d = 0.26$. Phonemes in the middle position proved to be most

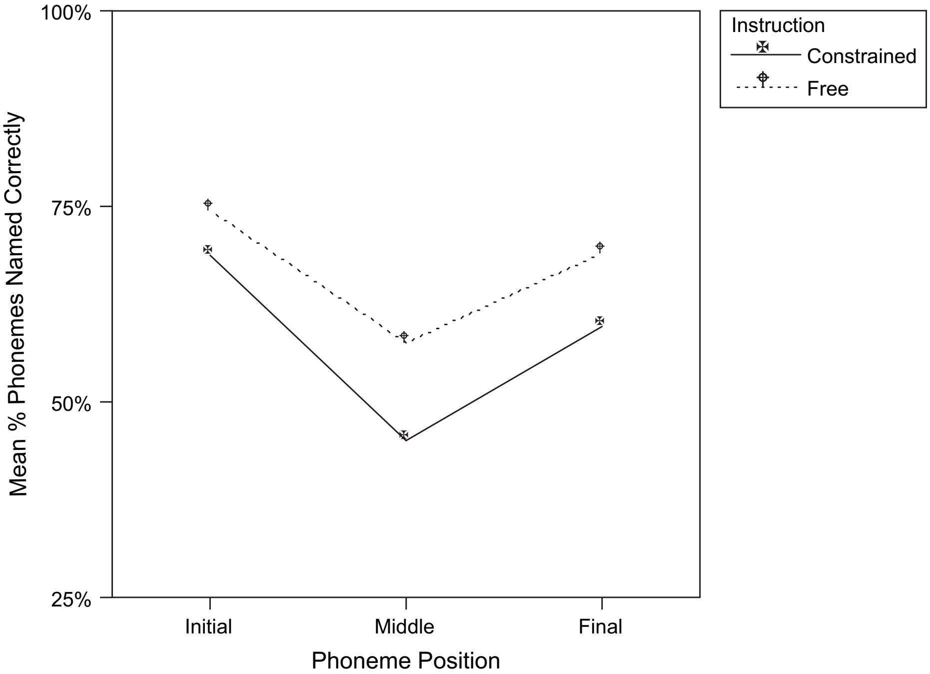

Fig. 1. Mean percentage of correctly named phonemes on free-isolation and constrained-isolation tasks for each phoneme position.

difficult; they were more often named incorrectly than phonemes in initial positions (as can be seen above), and they were more often named incorrectly than phonemes in final positions. Specifically, for free instruction: middle vs. final position, $t(199) = -6.57$, $p < 0.001$, Cohen's $d = 0.32$; for constrained instruction: middle vs. final position, $t(199) = -6.28$, $p < 0.001$, Cohen's $d = 0.38$.

4.2. Effects of instruction, phoneme position, and phoneme class

To test effects of phoneme class on task performance, the next analysis was conducted on a subset of comparable items of the initial-sound and the final-sound-isolation task and on a subset of initial and final position phonemes of items on the free-isolation task. To equate the number of phonemes belonging to a specific class for the initial-sound and the final-sound-isolation task, two measures were taken. First, words with phonemes that did not appear in final positions were removed from the initial-sound-isolation task. Second, filler items in the final-sound-isolation task that previously served to obtain lists with an equal number of items were randomly removed. As a result, both item lists contained three plosives (/p/, /t/, and /k/), three fricatives (/s/, /f/, and /g/), two nasals (/m/ and /n/), and two liquids (/l/ and /r/). For the free-isolation task, a similar procedure was used: phonemes that did not occur in the final position were not used and filler phonemes were randomly removed. This led to exactly the same subset of phonemes in both isolation tasks: three plosives (/p/, /t/, and /k/), three fricatives (/s/, /f/, and /g/), two nasals (/m/ and /n/), and two liquids (/l/ and /r/) in initial and final positions.

Again, raw scores of correctly named phonemes were transformed into percentages of the maximum possible number of phonemes that could be named correctly (10 phonemes for the initial and final position each). Means and standard deviations for each level are shown in Table 1.

On these items, a $2 \times 2 \times 4$ MANOVA was conducted with instruction (free vs. constrained), phoneme position (initial vs. final) and phoneme class (plosive, fricative, nasal, liquid) as within subjects factor. All main effects were significant: task instruction, Pillai's trace = 0.08, $F(1,199) = 17.60$, $p < 0.01$, partial $\eta^2 = 0.08$; phoneme position, Pillai's trace = 0.31, $F(1, 199) = 88.42$, $p < 0.01$, partial $\eta^2 = 0.31$; phoneme class, Pillai's trace = 0.1, $F(3, 197) = 6.98$, $p < 0.01$, partial $\eta^2 = 0.10$. Of the three two-way interaction effects, the Instruction × Position effect was nonsignificant. The interactions between Instruction and Class, Pillai's trace = 0.04, $F(3, 197) = 2.76$, $p < 0.05$, partial $\eta^2 = 0.04$, and Position and Class, Pillai's trace = 0.21, $F(3, 197) = 17.69$, $p < 0.01$, partial

Table 1
Mean percentages (and standard deviations) of correctly named phonemes as a function of phoneme class, phoneme position, and task instruction

Phoneme class	Instruction			
	Constrained		Free	
	Initial	Final	Initial	Final
	M (SD)	*M* (SD)	*M* (SD)	*M* (SD)
Plosive	70.8 (40.7)	63.0 (41.2)	80.7 (36.2)	71.3 (39.3)
Fricative	80.5 (35.6)	63.7 (41.4)	83.3 (32.9)	70.0 (37.1)
Nasal	77.0 (39.1)	58.0 (44.4)	82.0 (36.2)	66.5 (43.2)
Liquid	81.0 (36.0)	52.8 (43.2)	81.0 (36.0)	63.8 (41.9)

$\eta^2 = 0.22$, were significant. The three-way interaction Instruction × Position × Class was also significant, Pillai's trace = 0.05, $F(3, 197) = 3.18$, $p < 0.05$, partial $\eta^2 = 0.05$ (see Fig. 2).

The three-way interaction effect was further examined by conducting paired samples *t*-tests for each of the two instruction types separately, with Bonferroni adjustment of the alpha level set at 0.05/6 = 0.008. Difference scores between initial and final phoneme positions were calculated for each phoneme class and then all classes were compared per instruction type. For the constrained instruction, results showed all but one significant difference. Initial minus final position: plosives vs. fricatives, $t(199) = -5.49$, $p < 0.001$, Cohen's $d = 0.26$; plosives vs. nasals, $t(199) = -4.26$, $p < 0.001$, Cohen's $d = 0.30$; plosives vs. liquids, $t(199) = -6.78$, $p < 0.001$, Cohen's $d = 0.52$; fricatives vs. nasals, $t(199) = -0.86$, ns, Cohen's $d = 0.06$; fricatives vs. liquids, $t(199) = -4.31$, $p < 0.001$, Cohen's $d = 0.30$; nasals vs. liquids, $t(199) = -3.21$, $p = 0.002$, Cohen's $d = 0.23$. These results show that the effect of phoneme position was weakest for plosives and strongest for liquids. The same analyses were conducted for the free-isolation task which resulted in one significant difference, namely initial minus final position: plosives vs. liquids, $t(199) = -2.99$, $p = 0.003$, Cohen's $d = 0.21$. Again, the position effect seemed to be weakest for plosives. However, for the free-isolation condition, five out of six comparisons were not significant, meaning fewer differences in the effect of phoneme position on correct naming of phonemes of a particular class than in the constrained condition.

Pairwise comparisons of each phoneme class were also applied within the constrained-isolation task for initial and final positions, again with Bonferroni adjustment of the alpha level set at 0.05/6 = 0.008. With respect to the initial position, this resulted in three significant differences, all showing plosives to be named correctly less often than the other phoneme classes. Specifically, for initial position: plosive vs. fricative, $t(199) = -5.49$, $p < 0.001$, Cohen's $d = 0.25$; plosive vs. nasal, $t(199) = -3.27$, $p < 0.001$, Cohen's $d = 0.15$; plosive vs. liquid, $t(199) = -5.05$,

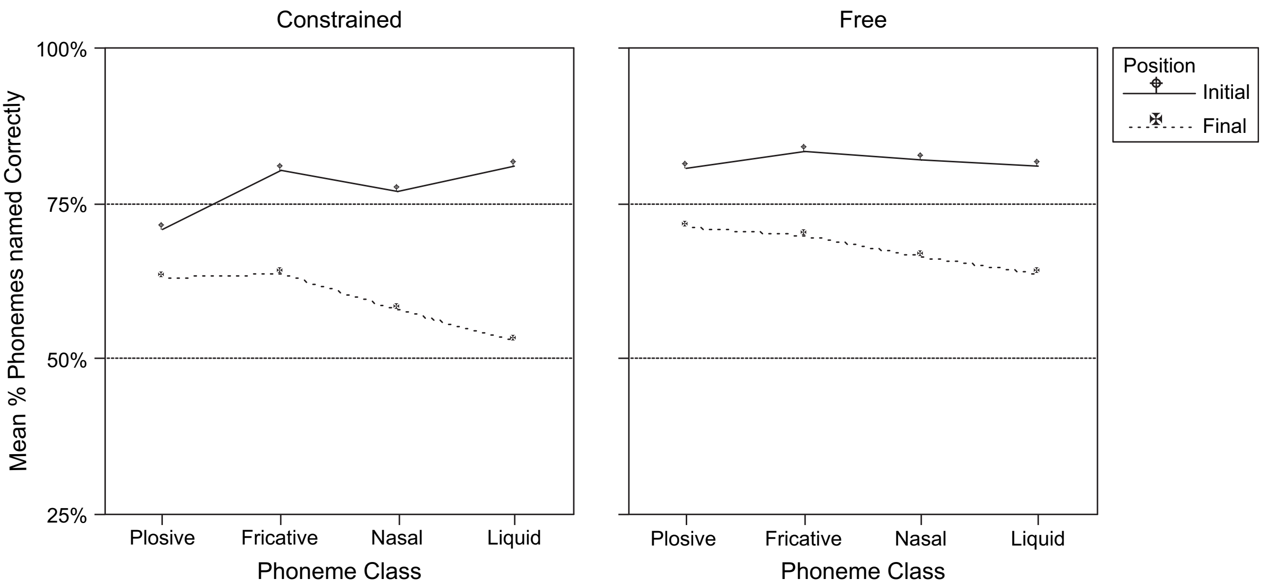

Fig. 2. Mean percentage of correctly named phonemes as a function of task-instruction type, phoneme position, and phoneme class.

$p < 0.001$, Cohen's $d = 0.27$. Comparisons of each phoneme class within final position resulted in a different pattern. For final position: plosive vs. liquid, $t(199) = 5.00$, $p < 0.001$, Cohen's $d = 0.24$; fricative vs. nasal, $t(199) = 2.92$, $p = 0.004$, Cohen's $d = 0.13$; fricative vs. liquid, $t(199) = 4.98$, $p < 0.001$, Cohen's $d = 0.26$.

Comparisons of initial vs. final position in the *constrained-isolation tasks* within each phoneme class resulted in significantly more correctly named phonemes in the initial-isolation task for all four phoneme classes, with Bonferroni adjustment of the alpha level set at 0.05/4 = 0.012. Specifically, for initial vs. final position: plosive, $t(199) = 2.79$, $p = 0.006$, Cohen's $d = 0.19$; fricative, $t(199) = 6.61$, $p < 0.001$, Cohen's $d = 0.44$; nasal, $t(199) = 6.77$, $p < 0.001$, Cohen's $d = 0.45$; liquid, $t(199) = 9.56$, $p < 0.001$, Cohen's $d = 0.71$.

The same pairwise comparisons, with Bonferroni adjustment of the alpha level set at 05/4 = 0.012, were made for the *free-isolation task*. There were no significant differences between the phoneme classes for phonemes in the initial position. Comparisons of each phoneme class for phonemes in final position revealed two significant differences: plosive vs. liquid, $t(199) = 3.34$, $p < 0.001$, Cohen's $d = 0.19$; fricative vs. liquid, $t(199) = 2.71$, $p = 0.007$, Cohen's $d = 0.16$. Comparisons of phonemes in the initial vs. final position within each phoneme class resulted just as in the constrained-instruction tasks in significantly more correctly named phonemes in the initial position for all four phoneme classes: plosive, $t(199) = 3.89$, $p < 0.001$, Cohen's $d = 0.25$; fricative, $t(199) = 6.74$, $p < 0.001$, Cohen's $d = 0.38$; nasal, $t(199) = 6.22$, $p < 0.001$, Cohen's $d = 0.39$; liquid, $t(199) = 6.01$, $p < 0.001$, Cohen's $d = 0.44$.

To summarize, for both task instructions and all phoneme classes, phonemes in the initial position were more often named correctly than in the final position. The pattern of correctly named phonemes of a particular phoneme class in the constrained-isolation tasks, however, was different from that in the free-isolation task and was dependent on the phoneme position. This effect seemed to disappear in the free-isolation task: an equal number of phonemes were named correctly for each phoneme class in the initial position. For the final position, both plosives and fricatives were named correctly more often than liquids.

To address the diverging results of the position effect on the naming of phonemes of a particular class between task-instruction types, a comparison was made between position difference scores (initial minus final) of both task-instruction types for each phoneme class. This resulted in four, paired samples *t*-tests with Bonferroni adjustment of the alpha level set at 0.05/4 = 0.012. One significant difference was found for the liquid phonemes in initial minus final position: liquids constrained vs. liquids free, $t(199) = 2.94$, $p < 0.01$, Cohen's $d = 0.27$. The effect of position was larger for the liquid phonemes in the constrained-isolation tasks than the liquid phonemes in the free-isolation task.

Finally, in order to directly compare how task performance was affected by task-instruction type, comparisons of free vs. constrained task instruction were carried out per position and for each phoneme class. For the initial position there was just one significant difference, plosives in the free instruction were more often named correctly than in the constrained instruction, $t(199) = 4.66$, $p < 0.001$, Cohen's $d = 0.26$. For the final position there were three phoneme classes which were more often named correctly in the free-instruction task: plosive, $t(199) = 2.85$, $p < 0.01$, Cohen's $d = 0.21$, nasal, $t(199) = 2.77$, $p < 0.01$, Cohen's $d = 0.19$, and liquid, $t(199) = 3.68$, $p < 0.01$, Cohen's $d = 0.26$.

4.3. Occurrence of response sequences

The analyses above concerned comparisons of correctly named phonemes per task instruction, phoneme position, and phoneme class. Also of interest was which sequences of phonemes were generated by the children in the free-isolation task, which could shed light on the strategies used by the children. The occurrence of response sequences was calculated with respect to the phoneme position in the target word. The frequency of occurrence of a sequence was expressed as a percentage of the total number of sequences uttered by a participant. Sequences of three correctly named phonemes comprised 16.3% of all responses and sequences of two correctly named phonemes represented 54.3% of all responses. Results showed that for the sequences of three correctly named phonemes the order initial – middle – final occurred most often ($M = 70.7\%$, SD = 44.7). Other response sequences above 1.0% of the total number of sequences were initial – final – middle ($M = 2.2\%$, SD = 12.9) and middle – final – initial ($M = 1.3\%$, SD = 1.4). For the sequences of two correctly named phonemes, we also report response sequences which occurred at least in 1.0% of the cases were the following (an X means that the phoneme in the sequence of the child's utterance was either omitted or named incorrectly): initial – middle – X ($M = 25.5\%$, SD = 17.7), initial – X – final ($M = 26.1\%$, SD = 17.9), final – initial – X ($M = 2.0\%$, SD = 10.3), initial – final – X ($M = 7.9\%$, SD = 20.9), X – middle – final ($M = 22.1\%$, SD = 15.6).

5. Discussion

The present study showed that cognitive and linguistic factors and their interactions put constraints on children's performance on phonemic-awareness tasks. The first hypothesis concerning a cognitive constraint, namely, task instruction, was confirmed. Differences in the nature of the task due to the instructions were found to affect children's performance. That is, kindergartners performed better on a CVC sound-isolation task when the instruction was free-isolation rather than constrained. This finding applies to all phoneme positions – initial, middle, and final. However, the largest effect of task instruction was found for phonemes in the middle position.

The analysis of children's strategies showed that, in the case of three correctly isolated sounds, children predominantly used a left-to-right order isolation strategy in the free-isolation task. This suggests that this strategy might have helped them perform better on this task than on the constrained task. In the case of two correct answers, it is striking that in all but one, the order of the response sequences was in line with the same left-to-right order. Given the sequential character of speech, this suggests that children monitor their own articulation when they are performing this task. Content et al. (1986) proposed a similar reasoning to explain their findings regarding a final-phoneme-deletion task. They argued that one could perform this type of task by monitoring one's articulation and stop just before the last articulatory gesture. Treiman and Baron (1981) also suggested that children perform a phoneme-counting task by trying to say the phonemes to themselves. When children use the articulatory program, they do not need to be aware of the concept of initial, middle, and final sounds to perform the task. However, when children are faced with a task in which they have to isolate sounds with a pre-specified location, awareness of this concept is required. Thus, a higher degree of awareness is needed to perform the constrained-isolation tasks than the free-isolation task.

The second hypothesis concerned the effect of phoneme position, namely the initial, middle, or final position in a word. Hypothesis 2 was also confirmed. Comparing performance on the three phoneme positions, a picture arises that coincides with previous studies. In the free as well as in the constrained tasks, isolation of the word-middle phoneme proved to be the most demanding compared to the other positions. A comparable result has been found in studies on phonological awareness (McBride-Chang, 1995) and beginning spelling (Stage & Wagner, 1992; Treiman et al., 1993). Performance on word-initial and word-final phonemes was in accordance with findings reported in spelling studies: kindergartners made fewer errors in the initial phoneme than in the final phoneme in the free as well as in the constrained tasks. However, our results contrasted with some phonological-awareness studies in which deletion of the last phoneme proved to be easier than deletion of the initial phoneme (Content et al., 1986; McBride-Chang, 1995). There are probably more similarities between phoneme isolation and spelling (which requires isolation of phonemes) than between phoneme isolation and phoneme deletion. Moreover, deleting the final phoneme in CVC words is probably easier than the initial one, because fewer mental operations are needed to delete the final phoneme than the initial phoneme. In the constrained tasks as well as in the free-isolation task, producing the initial and the final phoneme involves the same number of mental operations. Therefore, differences in task performance associated with the initial and final position can be ascribed to factors that were already mentioned in the introduction: the underlying onset-rime structure of the syllable and articulation processes or memory primacy and recency effects.

The remainder of the analyses was used to test a research question: the possible interaction between task instruction, phoneme position, and phoneme class. Only subsets of items were involved to ensure a balanced distribution of phonemes, that is, an equal number of fricatives, plosives, liquids, and nasals across the initial and final positions. Also, only phonemes in the initial and in the final position were compared and examined. First, the same instruction effect as in the previous analyses was found: children performed better in the free than in the constrained condition. More detailed analyses revealed that in the initial position this effect could be attributed solely to superior performance on plosives in the free condition. In the final position, superior performance on plosives, nasals and liquids was responsible for the instruction effect. Second, the same position effect as in the previous analyses came to the surface: in the free as well as in the constrained tasks, phonemes in the initial position were more often correctly identified than phonemes in the final position, irrespective of the phoneme class to which the phoneme belonged. Thus, it is unlikely that the position effect was caused by an imbalanced distribution of phonemes in the analyses over all the items.

In the introduction, we argued that findings from studies that examined the influence of phoneme class are mixed, because compound and simple phonemic-awareness tasks were the object of analyses. The present study made clear that even task-instruction differences within the phoneme-isolation task (a simple phonemic-awareness task) bring about differential effects of phoneme class. Moreover, it appears that these differential effects also interact with the phoneme's position in the word. In the free condition, the phoneme class of the initial phoneme was not important whereas in the constrained condition it was. Plosives at the beginning of the word in the constrained condition were more difficult to isolate than fricatives, liquids, and nasals. No differences were found between the other phoneme classes. Phoneme class of the final phoneme, however, was important for both the free and constrained condition. In the free-sound-isolation task, plosives and fricatives at the end were easier than liquids. In the constrained task, plosives at the end were easier than liquids, and fricatives were easier than both nasals and liquids at the end. None of the other comparisons were significant.

Taking these results together, two patterns emerge. The first pattern concerns the finding that plosives in initial position are harder to manipulate than fricatives, nasals, and liquids in initial position, whereas plosives in final position are easier to manipulate than liquids in final position. This pattern resembles the tendency described in the introduction that in word-final position plosives are easier to manipulate, whereas in word-initial position fricatives are easier (Content et al., 1986; Yavas & Core, 2001; Yavas & Gogate, 1999). In both our study and those that we referred to, plosives were compared with phonemes higher in sonority.

The same two explanations can be put forward to explain this first pattern of effects that we have found. The first explanation is related to the larger degree of co-articulation that is found in pre-vocalic compared to post-vocalic plosives (Sussman et al., 1997). That is, plosives are characterized by a complete occlusion in the vocal tract which occurs before the burst. In a pre-vocalic position, this may strengthen the co-articulation of the C and V after the occlusion. In post-vocalic position, however, the occlusion takes place just between the vowel and the burst of the plosive, giving rise to a natural pause in the acoustic signal. The resulting reduced degree of co-articulation facilitates manipulations with word-final plosives. However, the larger co-articulation between vowels and plosives in initial position hampers manipulations. In the case of phoneme isolation, this effect may be accentuated by the fact that noncontinuant plosives in initial position cannot be pronounced in isolation while the sounds of the continuant fricatives, nasals, and liquids can be sustained. This disadvantage for plosives disappears in final position, where plosives due to the natural pause in the acoustic signal can be pronounced in isolation as well. The second explanation relates to the notion of sonority. High-sonority codas cohere, due to their larger vowel-likeness, to a greater extent to the preceding vowel than phonemes lower in sonority and are thus harder to perceive and manipulate (Geudens, 2004; Geudens & Sandra, 2003; Treiman, 1989; Yavas & Gogate, 1999).

The second pattern shows that fricatives in final position are easier to manipulate than liquids and nasals in final position. Again, the notion of sonority appears to be the most likely explanation. The sonorants, liquids, and nasals appear to cohere more strongly with their preceding vowels than fricatives do and are thus harder to manipulate (Geudens, 2004; Treiman, 1989; Yavas & Gogate, 1999).

A final finding, directly related to the explanation of more cohesion between vowels and high-sonority phonemes, is the effect of position on the isolation of phonemes from different classes. The phoneme position effect was strongest for liquids and weakest for plosives. This means that in addition to a general better performance on phoneme isolation in initial than in final position, the difference in performance on phonemes in initial position as opposed to final position is largest in the case of liquids compared to plosives. This finding can be placed against the background of a higher degree of vocalization of word-final sonorants than of word-initial sonorants in Dutch (Geudens, 2004). For example, the /l/ in non-pre-vocalic position is more vowel-like or sonorant than the word-initial /l/ (Van Reenen & Jongkind, 2000).

Two main conclusions can be drawn from this study. One, the differential effects of phoneme class, due to interactions with the nature of the task, task instruction, and with phoneme position in the present and also in previous studies, show the extent to which performance on phonemic-awareness tasks is context-sensitive (Byrne & Fielding-Barnsley, 1990; Content et al., 1986; Geudens, 2004; McBride-Chang, 1995; Stanovich et al., 1984; Treiman & Baron, 1981; Treiman et al., 1998, Yavas & Core, 2001; Yavas & Gogate, 1999). According to Van Orden, Holden, Podgornik, and Aitchison (1999), it is not possible to design tasks that produce context-free effects. They state that "Cognitive systems are causally embedded in their environments and thus always entail their environments with regard to cognitive performance" (p. 71). In their view, it is not possible to observe "true" phoneme awareness: observations remain limited to the products of the interaction between the kindergartners' phonemic awareness capabilities and the cognitive and linguistic requirements of the task.

The second conclusion is more practical in nature and concerns the facilitating aspects of the free-sound-isolation task over the constrained-isolation tasks. An effect that is accentuated when one chooses plosives and fricatives to figure in final position and to omit liquids in that position. Van Bon and Van Leeuwe (2003) argue that instruments designed for the purpose of screening level of phonemic awareness at an early point, should be tasks of minimal demands. In their view, notions of the beginning and the ending of words should not be required. Also, tasks should not be complicated by additional demands such as replacing phonemes by other phonemes. Both requirements are met by the free-sound-isolation task. Future research should reveal whether the free-sound-isolation task is also useful for predictive purposes.

Finally, we would like to mention a practical implication of this study that goes beyond the purpose of measuring phonemic awareness. Because phoneme isolation is a skill that is required for spelling, the results of this study may also be useful in the design of beginning-spelling exercises. The two patterns that emerged from phoneme-class comparisons in initial and final position can be directly translated in the choice for words that should be spelled by novices. First, CVC words should not contain plosives in initial position but rather fricatives, nasals and liquids. Second, in final position preference should be given to plosives and fricatives above nasals and liquids.

Appendix A. List of task items in the isolation tasks according to the phoneme classes to which the phonemes belong

Free-sound isolation		Initial-sound isolation		Middle-sound isolation	Final-sound isolation	
heg[b,e]	(G + F)	*b*al	(P)	b*ee*n	da*g*[d,e]	(F)
was	(G + F)	*l*am[c]	(L)	r*ie*m	ma*p*[d]	(P)
muur[a,b]	(N + L)	*j*uf	(G)	v*a*l	naa*m*	(N)
fout[a,b]	(F + P)	*p*aal[c]	(P)	k*i*n	boe*f*	(F)
teen[a,b]	(P + N)	*m*ouw[c]	(N)	p*aa*r	vi*s*[d]	(F)
soep[a,b]	(F + P)	*n*eef[c]	(N)	l*o*s	ma*l*[d]	(L)
bol	(P + L)	*f*ijn[c]	(F)	z*oe*n	poo*t*	(P)
gum[a,b]	(F + N)	*r*eus[c]	(L)	b*ui*k	ne*p*	(P)
deuk[b]	(P + P)	*g*oud[c]	(F)	v*uu*r	bu*s*	(F)
pijn[a]	(P + N)	*z*aag	(F)	b*a*k	ma*n*[d]	(N)
zeef[b]	(F + F)	*h*ol	(G)	m*ei*d	lij*n*	(N)
kip[a]	(P + P)	*d*oel	(P)	z*oo*n	he*k*[d]	(P)
lief[a]	(L + F)	*t*ak[c]	(P)	z*e*s	voe*t*[d]	(P)
vuil[b]	(F + L)	*s*ok[c]	(F)	k*ou*s	boo*m*[d]	(N)
raam[a]	(L + N)	*v*ijf	(F)	l*eu*k	kui*f*[d]	(F)
noot[a]	(N + P)	*k*ar[c]	(P)	h*ee*t	kaa*l*	(L)
jas[b]	(G + F)		(G)	m*u*g	vie*r*[d]	(L)

Phoneme classes between brackets (F, fricative; P, plosive; N, nasal; L, liquid; G, glide).

[a] Words that were selected because of the first sound for the analyses conducted on a subset of items from the free-sound-isolation task.

[b] Words that were selected because of the final sound for the analyses conducted on a subset of items from the free-sound-isolation task.

[c] Words that were selected for the analyses conducted on a subset of items from the initial-sound-isolation tasks.

[d] Words that were selected for the analyses conducted on a subset of items from the final-sound-isolation tasks.

[e] The phonetic realization of the final g is x according to International Phonetic Alphabet (IPA).

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