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The role of lexical representations and phonological overlap in rhyme judgments of beginning, intermediate and advanced readers

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ABSTRACT

Studies have shown that prereaders find globally similar non-rhyming pairs (i.e., bell–ball) difficult to judge. Although this effect has been explained as a result of ill-defined lexical representations, others have suggested that it is part of an innate tendency to respond to phonological overlap. In the present study we examined this effect over time. Beginning, intermediate and advanced readers were presented with a rhyme judgment task containing rhyming, phonologically similar, and unrelated non-rhyming pairs. To examine the role of lexical representations, participants were presented with both words and pseudowords. Outcomes showed that pseudoword processing was difficult for children but not for adults. The global similarity effect was present in both children and adults. The findings imply that holistic representations cannot explain the incapacity to ignore similarity relations during rhyming. Instead, the data provide more evidence for the idea that global similarity processing is part of a more fundamental innate phonological processing capacity.

1. Introduction

Rhyme awareness is one of the earliest forms of phonological awareness to develop (e.g., Vloedgraven & Verhoeven, 2007). Generally, children are around the age of three or four when they start to realize that two words, say *ball* and *wall* rhyme. Since phonological awareness is considered to be an important predictor of later reading skills (Blachmann, 2000; Hulme, Snowling, Caravolas, & Carroll, 2005; Lundberg, 2009; Perfetti, Bell, & Hughes, 1987) and early intervention studies have shown that reading achievement improves with phonological awareness training (Ehri et al., 2001; Snow, Burns, & Griffin, 1998), rhyme awareness assessments are often used in both research and practice for the early detection and prevention of reading problems. However, after more than thirty years of research, it still remains unclear whether these early stages of phonological awareness are indeed predictive of later reading skills (Bryant, MacLean, Bradley, & Crossland, 1990; Goswami, 1999; Hulme et al., 2002; Macmillan, 2002). In a review of this ongoing debate, Stuart described the current situation as 'a temporary truce' (Stuart, 2005, page 43). In order to come to a consensus on the specific role of rhyme awareness in reading acquisition, it is important that the nature of rhyme processing is fully understood.

Most present rhyme awareness assessments make use of fairly simple paradigms. Children are presented with rhyming and non-rhyming pairs without distracter conditions. And, if distracters are presented, it is mostly in the form of a semantically related condition (i.e., what rhymes with *cat*; *dog* or *hat*?). The simple nature of rhyme awareness assessments may be one cause of the debated predictive value of rhyming skills for later reading abilities. Evidence for this idea comes from studies that have shown that preliterate children have more difficulties with more demanding rhyme tasks that included phonological distracters (i.e., what rhymes with *ball*; *bell* or *wall*?) (Cardoso-Martins, 1994; Carroll & Snowling, 2001; Wagensveld et al., in press). So far, it is unclear if this so-called *global similarity effect* in rhyme judgments is a developmental effect which can only be observed in children or whether the effect is the result of a more fundamental process that remains present in more advanced readers. The present semi-longitudinal study attempts to shed light on this issue by examining the role of global phonological similarity in rhyme processing in one group of children at two early stages of reading education and in advanced adult readers. By measuring response times in addition to accuracy and by presenting children with pseudowords in

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addition to words, we attempt to provide more detailed information on the processes that underlie rhyme awareness.

1.1. The global similarity effect in rhyming

Even when words do not share common phonemes, children can still perceive them as alike due to certain similarities in their phonological features. This global similarity effect can be illustrated by a study of Carroll and Snowling (2001) in which they presented preschool children with the word *dish* and asked them to pick an alliterating word from the alternatives *beach* and *duck*. The preschool children found it difficult to ignore the phonological similarity between *dish* and *beach* and made more errors when they were presented with this type of globally similar distracters than with semantically (e.g., *sheep*: *shoes* or *pig*) or unrelated distracters (e.g., *bell*: *boat* or *dog*).

Studies in various domains of developmental language research have shown that children are sensitive to global phonological similarities in words. This sensitivity influences performance in classification experiments (Carroll & Myers, 2010; Snowling, Hulme, Smith, & Thomas, 1994; Treiman & Baron, 1981; Treiman & Breaux, 1982), verbal short-term memory (Henry, 1991; Jarrold, Cocksey, & Dockerill, 2008), letter-sound learning (de Jong, 2007) and rhyming skills (Cardoso-Martins, 1994; Carroll & Snowling, 2001; Wagensveld et al., in press), all showing that global similarity tends to influence a child's performance.

The role of global similarity processing in rhyming has first been explored by Cardoso-Martins (1994). She presented Brazilian pre-school, kindergarten and first grade children with two rhyme categorization experiments. During the first experiment the children were presented with word triads that consisted of a target word (e.g., sala, 'living room') and two test words. One test word rhymed with the target (e.g., bala, 'bullet') and the other test word was unrelated to the target (e.g., fogo, 'fire'). Children who were able to perform well in this simple rhyme categorization experiment, were then presented with a second experiment with again a target (e.g., massa, 'block') and a rhyming test word (e.g., passa, 'raisin'). The other test word, which was a semantic distracter in the first experiment, was replaced by a distracter that was phonologically related to but did not rhyme with the target word (e.g., laca, 'lacquer'). The outcomes of this second experiment showed that especially the pre-literate children were confused by the phonological distracter. The kindergartners answered only 73% of the items correctly. The pre-school children had even fewer correct responses, only 45%. On the other hand, the literate children showed very little difficulty in this task (91% correct).

The observation that the global similarity effect becomes less prominent in older, reading participants was also found in early classification studies by Treiman and colleagues (Treiman & Baron, 1981; Treiman & Breaux, 1982). These studies showed that whereas children were more likely to categorize syllables on the basis of global similarities between test items, adults tended to classify syllables on the bases of common phoneme relations. A more recent study by Carroll and Myers (2010) also showed that the use of phonemic information in word classification becomes more common with age. The first goal of the present study relates to this change in strategy in word classification that becomes more available with age and reading experience. To gain insight into the specific and perhaps changing role of global similarity in maturation, we contrasted performance of beginning, intermediate and advanced readers on a rhyme judgment task with globally similar distracters.

1.2. The role of lexical representations

The afore-mentioned studies have made clear that rhyme processing in pre-literate children may depend on a global comparison of phonological structures and that a more analytical judgment of the rime constituents of words develops as a function of reading experience and age. So far, the cause of this effect has been sought in the developmental state of the mental lexicon. Theories on lexical development state that the lexical representations of young children are rather holistic in nature (Metsala & Walley, 1998; Walley, 1993; Walley, Metsala, & Garlock, 2003). Following this, Carroll and Snowling (2001) have argued that it is these ill-defined phonological representations which make rhyme judgments with phonological distracters more difficult for preschoolers.

In a recent study (Wagensveld et al., in press), we tested this hypothesis by presenting Dutch kindergartners with a word and pseudoword version of a rhyme judgment task containing three phonological conditions; rhyming (e.g., *gek–bek*, '*strange–beak*'), overlapping (e.g., *bak–bek*, '*tray–beak*') or unrelated (e.g., *sop–bek*, '*lather–beak*'). By examining pseudowords in addition to words, we were able to examine the role of the mental lexicon since pseudowords consist of phonologically legal combinations but are not represented as holistic units in the mental lexicon.

The outcomes showed that although the preschool children found the pseudoword version more difficult than the word version, a comparable global similarity effect was present in both lexical conditions. This finding led to the hypothesis that global similarity processing is an automatic, innate process that dominates phonological processing in young children that do not have well-developed segmentation skills (yet). It was suggested that global similarity may become less prominent when children start their reading education during which segmentation abilities will be trained intensively. An indication of this hypothesis was the finding that the amount grapheme knowledge children had showed a negative correlation with the size of their global similarity effect.

Lexical representations may play a more prominent role in the rhyme judgments made by literate individuals. It has been argued by Ziegler and Goswami (2005) that the explicit availability of onset-rime representations forms a separate stage between the initially holistic and later fully segmental representations that are described in the lexical restructuring theory. Following this idea, it would mean that at some point during development children will have access to a specified rime structure enabling them to make more analytical comparisons during rhyme judgments. In this case, a child who is presented with two words (i.e., *bell* and *ball*) can now base a decision on a comparison of the isolated rimes (i.e., *-ell* and *-all*). Even though this means that the rime representation is still holistic in itself (and not fully specified in separate phonemes), the global similarity between the two rimes is smaller than between the two words since the overlapping onset phoneme is no longer part of the equation. As a result, the global similarity effect should become smaller. The judgment of pseudoword rhyming provides an important control for examining this proposal. When the representations become more segmental and rime-structures become available, it will be easier to process pseudowords, that is when they encompass a rime structure that is also present in an actual word that is known by the child (e.g., the rime of the pseudoword *nall*, i.e. *-all*, is also present in the common words *ball* and *wall*).

Ziegler and Goswami (2005) based their assumption that onset-rime awareness forms a separate stage in the development of segmental representations on studies that provided evidence for explicit onset-rime awareness in various languages including observations in Dutch children (de Jong & van der Leij, 2003). However, this claim is not without controversy for the Dutch language. Geudens and Sandra (2003) could not obtain evidence for an onset-rime structure in the explicit phonological awareness of Dutch preliterates and first graders. Based on the results of a follow-up study in which they examined implicit phonological awareness skills in preliterates, they concluded that the sensitivity of Dutch children to rimes is based on a sensitivity to global similarity rather than an explicit awareness

of rime as a separate structure (Geudens, Sandra, & Martensen, 2005). Therefore, the second goal of this study was to further investigate the role of global similarity in rhyme processing with both lexical and non-lexical items at different stages of reading development in Dutch readers.

1.3. The present study

The present study examined the influence of reading experience on two important factors of rhyme judgment abilities: lexical status and phonological similarity of test items. To address these factors we presented beginning, intermediate and advanced readers with a rhyme judgment experiment.

The present study was partly longitudinal since the early readers were first grade children who were tested again in third grade. In addition, there was a group of adult participants which were considered to be experienced readers. Participants were presented with words and pseudowords, in separate parts. In each part there were three phonological conditions: rhyme (e.g., gek–bek), overlap (e.g., bak–bek) and unrelated (e.g., sop–bek). Response times and accuracy were taken as an index of rhyme judgment skills.

There were two main hypotheses. Our first hypothesis concerned the influence of lexical status on rhyme judgment performance of readers. We expected that lexicality becomes less influential in rhyme judgments when reading experience increases, due to the more specified phonological representations that will arise as segmentation skills improve due to reading instruction. Our second hypothesis stated that with increasing reading experience rhyme processing becomes less dependent of global similarity processing, again due to the fact that with reading instruction segmentation skills will be developed resulting in a more analytical rhyme judgment approach.

2. Materials and methods

2.1. Participants

The participants consisted of 26 children (17 girls) who were all native speakers of Dutch. The children were from two schools in the center of the Netherlands and were tested two times during their literacy tuition. The first measure was taken at the end of first grade after one year of reading education. Their average age at this measurement was 7;0 years (84 months, SD 3.9 months). The second measure was taken during the second trimester of third grade; their average age at this time-point was 8;7 years (103 months, SD 4.0 months). The adult participants were 20 students (17 females) at a university in the Netherlands. Their mean age was 21;7 years old (259 months, SD 3.3).

2.2. Materials

During the rhyme judgment experiment children were presented with monosyllabic auditory word and pseudoword stimuli with a CVC structure. All words were spoken by a female speaker into a Sennheiser ME62 microphone connected to a Dell D610 latitude laptop. The stimuli were digitally recorded (44.1 kHz, stereo) using Sony Sound Forge, a sound recording program. Afterwards, the recorded stimuli were carefully edited for precise onset and offset using a speech waveform editor (Praat, version 4.5.12). Mean durations of the targets and the rhyming, overlapping and unrelated clues are presented in Table 1.

Table 1
Mean frequency and duration of stimuli used in the rhyme judgment task.

	Mean frequency	Mean duration	
	Words	Words	Pseudowords
Rhyming clues	96 (6)	498 (85)	511 (83)
Overlapping clues	96 (5)	508 (89)	515 (93)
Unrelated clues	98 (4)	477 (108)	490 (85)
Targets	97 (4)	506 (84)	492 (58)
Filler clues	97 (4)	528 (92)	506 (80)
Filler targets	97 (3)	525 (93)	478 (66)

Note. Mean frequencies are presented in percentages which are calculated using the 'Streeflijst woordenschat voor zesjarigen', an index of vocabulary knowledge of Dutch speaking six-year-old children. Mean durations are presented in milliseconds. Standard deviations of the mean are in parentheses.

2.2.1. Words

All words were selected from an index of vocabulary knowledge of 6-year-old Dutch speaking children, the so-called 'Streeflijst Woordenschat voor Zesjarigen' (Schaerlaekens, Kohnstamm, & Lejaegere, 1999). This index contains a list of all Dutch words with the percentage of Dutch and Belgian teachers who expect 6-year-old children to understand the word. All words that were used in the experiment were indexed above 80% and should therefore be familiar to the children. The average percentages of the words can be found in Table 1.

Word-stimuli consisted of 21 targets (e.g., *bek* or *hoek*) which were paired with three types of semantically unrelated clue conditions. There was only one *rhyming condition* in which the clue word shared a rhyme overlap with the target (e.g., *gek–bek* or *koek–hoek*). In addition, there were two non-rhyming conditions. In the *unrelated condition* the target was paired with a phonologically unrelated non-rhyming clue word (e.g., *sop–bek* or *nies–hoek*). In the *overlap condition* the clue word shared a phonological overlap with the target; however this was never a rhyme overlap. In this overlap condition half of all trials contained a consonant overlap (e.g., *bak–bek*) and the other half contained a vowel overlap (e.g., *poes–hoek*). Each target was only presented once per condition per participant. For the targets in the overlap condition this meant that they were paired either with a clue that overlapped in consonant or a clue that overlapped in vowel. The presentation of these clue–target pairs was counterbalanced over participants. A list of all the word stimuli and translations of the words can be found in Appendix A.

2.2.2. Pseudowords

The targets of the pseudowords were designed by recombining the onset of one word target with the rime of another word target. This resulted in a total of 21 monosyllabic phonologically legal Dutch pseudoword targets. These targets shared exactly the same phonemes as the targets in the word condition. The same re-association method was used to create pseudoword clues from the clue words in the three phonological conditions. This resulted in the clue target combinations; rhyming pairs (e.g., *baam–daam* or *mip–bip*), unrelated pairs (e.g., *not–daam* or *gos–bip*) and overlap pairs (e.g., *diem–daam* or *mit–bip*). A list of all the pseudoword stimuli can be found in Appendix B.

2.2.3. Fillers

Since there was only one rhyming condition as opposed to two non-rhyming conditions, it was possible that the children and adults could develop a response bias towards the non-rhyming condition. To prevent this, participants were presented with 21 filler word

Table 2
Mean phonological similarity values of word and pseudoword pairs per condition.

	Phonological similarity			
	Words		Pseudowords	
Rhyming pairs	1620	(371)	1610	(399)
Overlapping pairs	1014	(335)	1003	(309)
Unrelated pairs	33	(47)	43	(47)

Note. The phonological similarity is based on data from the Dutch diphone database. The higher the global similarity value, the more alike the pairs are. Standard deviations of the means are in parentheses.

and pseudoword pairs in addition to the previously described experimental stimuli. Responses to the filler stimuli were excluded from the analysis. A list of all the filler stimuli and translations of the filler words can be found in Appendix C.

2.2.4. Similarity factor

To control for global similarity factors in order to be able to compare the effects observed in words and pseudowords, a similarity factor (SF) was computed using the Dutch diphone database from a study by Smits, Warner, McQueen, and Cutler (2003). In this gating study adult Dutch participants were asked to identify the Dutch diphones. Responses to the diphones were used to create a confusion matrix, indicating the likelihood of a phoneme being correctly interpreted as itself or as any of the other phonemes. In the present study these values were as an indicator of phonological similarity amongst (pseudo)word pairs. A phonological similarity value was calculated for each condition which can be found in Table 2. Please not that the higher the score, the more similar a pair is.

2.3. Procedure

For the children, the experimental rhyme judgment began with a short practice interview. During the interview, the experimenter provided the child with words and encouraged the child to think of a matching rhyme word. Wrong answers were corrected and if the child could not produce a rhyme word an example was given and the child was encouraged to think of another example. Immediately after the interview the experimental test session began. Adult participants did not have a practice interview.

During the rhyme judgment session, experimental stimuli were presented binaurally using Presentation 9.70 over a Sennheiser HD 433 headphone at a comfortable listening level of 65 dB. The child or adult was instructed to judge each pair as either rhyming or non-rhyming by means of press on one of two response buttons. Response buttons for rhyme and non-rhyme were counterbalanced over participants.

Each experimental trial had a total duration of 6000 ms. A trial began with the presentation of a fixation cross in the middle of the screen for 950 ms. At 1000 ms after trial onset the clue word was presented over the headphones (not on screen) and 1200 ms after the clue onset the target word was presented in a similar fashion.

Responses to words and pseudowords were assessed on the same day in two separate parts of the same experiment with a break in between of which the duration depended on the need of the child. All children and adult participants started with the experiment containing the words. Each experiment began with a training block containing six practice items (two of each condition) to get familiar with the task, these items were not used for analysis. The practice block was followed by three experimental blocks. In the experimental blocks, the child or adult was presented with the words and pseudoword from the three experimental conditions. The stimuli were divided over the three experimental blocks such that each target item was presented once per block with one of the clue conditions (rhyming, unrelated or overlapping). The presentation order of blocks was counterbalanced across participants. There was a break between blocks of which the duration again depended on the need of the child or adult participant.

3. Results

The mean response times and percentage of incorrect responses were calculated per participant for each of the two lexical and three phonological conditions. Response latencies were calculated from the onset of the target item. Only correct responses were included and outliers, i.e. extremely early (<300 ms) or late (>4800 ms) responses, were excluded from the analyses. Table 3 represents the outcomes of the rhyme judgment task. Response latencies (panel A) and error scores (panel B) are displayed separately for each group and lexical and phonological condition.

To test our hypotheses, four GLM repeated measures analysis were performed for children and adults and for response times and accuracy measures separately.[1] The GLM's of the children had Grade (1, 3), Word Type (word, pseudoword) and Phonological Condition (rhyme, overlap, unrelated) as within subject factors. Adults GLM's had Word Type (word, pseudoword) and Phonological Condition (rhyme, overlap, unrelated) as within subject factors. The observed outcomes of the GLM's are described separately below as respectively lexical effects and phonological effects.

Table 3
Mean response latencies (panel A) and mean error score (panel B) on the rhyme judgment task.

		Rhyme	Overlap	Unrelated
A. Response time (ms)				
Words	First grade	1458 (63)	1520 (62)	1509 (70)
	Third grade	1409 (57)	1528 (57)	1450 (53)
	Adults	952 (46)	969 (40)	909 (38)
Pseudowords	First grade	1532 (54)	1640 (54)	1662 (71)
	Third grade	1597 (75)	1677 (80)	1616 (72)
	Adults	965 (53)	925 (32)	891 (37)
B. Error score (%)				
Words	First grade	5.7 (1.2)	9.3 (1.7)	4.3 (1.4)
	Third grade	4.8 (1.0)	6.8 (1.7)	2.3 (1.0)
	Adults	3.1 (0.9)	1.4 (0.5)	0.0 (0.0)
Pseudowords	First grade	16.0 (2.4)	16.9 (2.6)	12.1 (2.9)
	Third grade	9.6 (2.6)	11.2 (2.9)	5.6 (1.9)
	Adults	1.9 (0.6)	1.2 (0.6)	0.2 (0.2)

Note. Response latencies are calculated from the onset of the target and are represented in milliseconds. Error scores are display the percentage of incorrect answers. Standard errors of the mean are in parentheses.

3.1. Lexical effects

Our first hypothesis stated that lexical status has a smaller influence on rhyme judgment performance as reading experience

[1] Since the children were tested longitudinally, so in the first and third grades, we included them in one ANOVA with time as a within subject factor and we have run a separate ANOVA for the adult participants.

increases. For children, we found a main effect of Word Type in both response latency and accuracy outcomes, indicating that the lexical nature of the test items influenced both speed and accuracy. The children processed words faster and more accurately than pseudowords ($F_{rt}(1, 25) = 18.43$, $p < .001$, $\eta^2_p = .42$, $F_{error}(1, 25) = 23.26$, $p < .001$, $\eta^2_p = .48$). In addition, the accuracy outcomes of the children showed an interaction between Word Type and Grade ($F_{error}(1, 25) = 8.61$, $p < .01$, $\eta^2_p = .26$) which could not be observed in the response time data.

Although both first and third grade children found words easier to judge than pseudowords, further investigation of the interaction between Word Type and Grade accuracy scores revealed that the difference between errors made during word and pseudoword judgment was larger for the first graders (8.6%, SD 7.8) than the third graders (4.1%, SD 7.7, $t(25) = 2.97$, $p < .01$, $d = .59$), i.e. the first graders found the pseudoword condition more difficult than the third graders. There was no main effect of lexical status in either the response time or accuracy data of the adult participants.

In sum, we found that beginning and intermediate readers find words easier to process than pseudowords and that advanced readers do not show differential effects of lexical status.

3.2. Phonological effects

Our second hypothesis concerned the role of global phonological similarity processing in rhyme judgment. We expected that the global similarity effect in both word and pseudoword rhyming would diminish as reading experience increased.

The response latency data of the children provide some support for this idea. Although there was a main effect of phonological condition ($F(2,50) = 10.75$, $p < .001$, $\eta^2_p = .30$), there was no evidence of a global similarity effect.[2] The two, for the global similarity effect, critical conditions did not differ; the overlapping items were processed just as fast as the unrelated items ($t(25) = 1.56$, $p < .20$, $d = .44$). The adult participants also showed a main effect of Phonological Condition ($F(2, 38) = 5.62$, $p < .05$, $\eta^2_p = .23$). Surprisingly, a clear global similarity effect was observed in the response latency data of the adult participants; overlapping items were judged more slowly than unrelated items ($t(19) = 4.38$, $p < .001$, $d = 1.24$). So, whereas global similarity relations did not affect rhyme processing latencies in children, adults responded more slowly to globally similar items.

This discrepancy could not be observed in the accuracy data. We found that the children showed a main effect of phonological condition ($F(2, 50) = 9.93$, $p < .005$, $\eta^2_p = .28$). Paired samples t-tests revealed that overlapping items were more often judged incorrectly than unrelated items ($t(25) = 5.56$, $p < .001$, $d = 1.57$). The adult participants showed a similar main effect of phonological condition in the accuracy outcomes ($F(2, 38) = 7.92$, $p < .01$, $\eta^2_p = .29$). Like the children, this main effect was also the result of overlapping items being processed less accurately than unrelated items ($t(19) = 2.94$, $p < .01$, $d = .83$). There were no interactions between Phonological Condition and Grade or Lexical Status.

Summing up, in contradiction to our second hypothesis, the global similarity effect was not present in the response latency data of both first and third grade children but was clearly present in the accuracy outcomes of these groups. Adult participants showed the global similarity effect in both the response latency outcomes and accuracy data.

[2] The main effect was the result of rhyming items being processed faster than unrelated items (see Section 3.3 for additional findings).

3.3. Additional findings

In addition to the observations made in order to test our hypotheses, there were some unexpected findings concerning the speed and accuracy with which rhyming items are judged in comparison to non-rhyming unrelated items. We found that whereas children processed rhyming items faster than unrelated items ($t(25) = -2.98$, $p < .01$, $d = .84$), adult participants judged the rhyming condition more slowly than the unrelated condition ($t_{rt}(19) = 2.63$, $p < .05$, $d = .74$). The accuracy data showed more similar effects. Both children and adults made more errors in rhyming items than unrelated items ($t_{children}(25) = 3.00$, $p < .01$, $d = .85$, $t_{adults}(19) = 4.16$, $p < .001$, $d = 1.18$).

4. Discussion

The present study examined the influence of lexicality and phonological similarity on rhyme judgment performance in three types of readers: beginning readers in first grade, intermediate readers in third grade and advanced adult readers.

Despite the differences in reading experience, all groups were well able to perform the task. Accuracy scores varied from 83.1% (SD 2.6) to 100% (SD 0.0) correct where the lower limit was set by the performance of the first grade children on the overlapping condition in the pseudoword version of the task and the highest score was reached by adult readers in the unrelated condition in the experiment using word stimuli.

Our first hypothesis related to the role of lexicality in rhyme judgment. It was expected that items that were present in the mental lexicon, i.e., words, would be found easier to judge than items without a lexical status such as pseudowords. In addition, we expected that this effect would diminish as a function of reading experience. The outcomes clearly showed both of these effects. The children found the pseudoword version of the task more difficult; their response times were slower and responses were less accurately when items were not represented in the lexicon. Also, we observed an interaction of this effect with grade; lexicality effects were more pronounced in first graders with little reading experience than in the more skilled third graders. Adult readers did not show sensitivity to the lexical status of test items; word pairs were judged as quickly and accurately as pseudoword pairs.

Our second hypothesis concerned the global similarity effect that has been previously observed in rhyme experiments with preliterate children (Cardoso-Martins, 1994; Carroll & Snowling, 2001; Wagensveld et al., in press). Following these studies, we expected that with increasing reading experience rhyme processing would depend less on global similarity processing. Surprisingly, the outcomes of the study could not provide evidence for this idea. The global similarity effect was clearly present in the accuracy data of all groups: first graders, third graders and adults made more errors when they were asked to judge similar sounding pairs than unrelated pairs, despite their difference in reading experience. The response latency data did show differential effects. However, these were the opposite of what we expected; not the advanced adult readers, but the younger and less experienced children responded just as quickly to globally similar as unrelated items and did therefore not show a global similarity effect. The adult participants made more errors in the overlapping condition than the unrelated condition and were thus more affected by the global similarity relations between (pseudo)word pairs.

During data analysis another unexpected observation was made. We found a discrepancy in the responses of children and adults to the rhyming as compared to the unrelated items. Whereas children judged rhyming items faster than the unrelated items, the adults showed the opposite effect; advanced readers were slower and made more when they judged rhyming items than unrelated items.

In sum, the outcomes showed that rhyme judgment skills change under the influence of reading experience. Lexicality becomes a less important factor in rhyme decisions whereas global similarity between test items remains an influential factor even in experienced readers.

The present outcomes showed that word and pseudoword rhyming were equally difficult for experienced readers, whereas early readers had more difficulty judging pseudoword than word pairs. This observation can be explained by current theories on phonological awareness development. Both the lexical restructuring theory (Walley et al., 2003) and the grain size theory of reading development (Ziegler & Goswami, 2005) state that lexical representations gradually become more specified when reading experience grows. This finally results in a state where information becomes available at the level of phonemes which enables the processing of unfamiliar (or non-existing) words. Moreover, there are also theories that claim that lexical representations are adult-like from a very early age on (White & Morgan, 2008).

Considering this latter observation, the present finding of diminishing lexical effects in adult rhyming may also be influenced by the maturation of phonological memory capacities. To judge whether two items of a pair rhyme, the first item should be kept in phonological memory until the second item is perceived. During this process, the unfamiliar pseudowords place greater demands on phonological memory than words. However, when phonological memory capacities become more developed, it will be easier to process pseudowords. As a result, adults will be less affected by lexical status than children. Also in the children's data we observed that third grade children had less difficulty judging pseudowords than first grade children. To further disentangle this issue, it may be worth considering in future research whether the global similarity effects shown in adults are similar to the phonological similarity effects shown in short-term memory tasks (e.g., Papagno & Vallar, 1992).

Furthermore, the finding that the global similarity effect is present even in advanced readers challenges the idea that the holistic nature of young children's lexical representations is what causes confusion in the judgment of globally similar non-rhyming items in children. The adult mental lexicon is thought to encompass very structured and detailed information at the phonetic level. Nevertheless, the current data showed that the global similarity effect is present in adulthood. This finding indicates that, although adults are able to systematically analyze rhyme, they still automatically process the global similarity between items which causes a delay in rhyme judgments.

Whereas adults were influenced by phonological similarities in pairs, the first and third grade children did not show a global similarity effect in the response time data. Interestingly, in an earlier study we observed a clear global similarity effect in kindergartners (Wagensveld et al., in press). An explanation for this parabolic pattern may lie in the development of more explicit phonological awareness. The intensive segmentation and blending exercises that are part of the initial phase of reading education lead to more explicit phonological awareness. It has been suggested that children may make use of this capacity to solve all phonological awareness tasks, even a task like rhyme judgment which could also be performed by using only implicit knowledge (e.g., Duncan, Seymour, & Hill, 1997). It can be hypothesized that as segmentation exercises become less frequent in the classroom curriculum, the ability to quickly detect rhyme becomes less apparent. This may explain why adults are more slowly in judging the rhyming and overlapping pairs as opposed to the unrelated pairs. Possibly, the adults do not need to segment the unrelated items to judge them, but they do segment the overlapping and rhyming items leading to longer response times for these items.

The question that remains, though, is why adults tend to get confused by global similarity relations. A possible explanation for the global similarity effect in adults may be found in the observations of newly born infants who show a remarkable degree of sensitivity to the phonological patterns of language (for a review see: Kuhl, 2004). Sensitivity to rhyme has been shown in children as young as nine months old (Hayes, Slater, & Brown, 2000; Hayes, Slater, & Longmore, 2009). Therefore, it could be that the global similarity effect is based on a much more fundamental system that enables large scale similarity processing immediately after children are born to facilitate quick and associative learning. A letter-sound learning study (de Jong, 2007) has shown that letter-sound learning is facilitated when the phoneme and grapheme share phonological similarity. However, these claims must be made with great caution since much more research is necessary to establish the fundamental nature of global similarity processing. As a next step, it could be worthwhile to examine whether the global similarity effect also manifests itself when adult participants are presented with similar sounding pairs that do not share identical phonemes, e.g. *dish–beach* from the Carroll and Snowling (2001) study.

For now, it has become clear that holistic representations do not suffice to explain the global similarity effect. Nonetheless, there is one important issue to consider regarding the nature of phonological representations in adults. In speech production research, the statistical dominance of speech segments such as high frequent syllables has led to the idea of a *mental syllabary*, a mental store for highly frequent syllabic units that is accessed during speech production (Cholin, Levelt, & Schiller, 2006; Levelt, Roelofs, & Meyer, 1999; Levelt & Wheeldon, 1994). This idea is partly based on the finding that the 500 most frequent syllables in Dutch, English and German (less than 5% of all syllables available) suffice to produce around 80% of all speech material in these languages (Schiller, Meyer, Baayen, & Levelt, 1996). If a mental syllabary exists for segments that are frequently used in speech production, it might be considered that units that are frequently used during perception are also stored as a unit. Although adults are able to store fully segmented representations, it still might be useful to retain holistic representations for phoneme combinations that often occur in the same combinations (such as high frequent syllables).

Finally, as was mentioned in the introduction there is an ongoing debate on the relationship between rhyme and reading (Stuart, 2005). And, even though this relationship remains unclear at present, rhyming tasks are often included in both research and practice as a measure of early phonological awareness skills. The present study showed that global similarity effects are smaller around the first years of reading education as compared to effects we previously observed in kindergartners (Wagensveld, van Alphen, Segers, & Verhoeven, in press). As a practical implication, it can thus be suggested that including a global similarity condition in a rhyme judgment task provides a better indication of the rhyming judgments skills of children.

5. Conclusions

To conclude, the present study has shown that lexicality becomes less influential in rhyme performance with the advancement of reading experience. Phonological similarity amongst test-items remains an influential factor even into adulthood. The current findings imply that the holistic nature of lexical representations cannot explain the incapacity to ignore similarity relations during rhyme judgment. A possible explanation for the effect may lie in the idea that global similarity processing is part of more fundamental innate processing capacity. More research is necessary to shed light on the exact nature of such capacity.

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Appendix A. Word stimuli used in the rhyme judgment experiment. English translations of the Dutch words are in parentheses

Clues								Targets	
Rhyme		Consonant overlap		Vowel overlap		Unrelated			
gek	(*strange*)	bak	(*tray*)	pet	(*cap*)	sop	(*lather*)	bek	(*beak*)
koek	(*cookie*)	hok	(*pen*)	poes	(*cat*)	nies	(*sneeze*)	hoek	(*corner*)
bil	(*buttock*)	geel	(*yellow*)	vis	(*fish*)	sap	(*juice*)	gil	(*scream*)
lach	(*laugh*)	deeg	(*dough*)	lam	(*lamb*)	nul	(*zero*)	dag	(*day*)
zak	(*sack*)	dik	(*thick*)	lap	(*rag*)	pit	(*seed*)	dak	(*roof*)
lief	(*sweet*)	duif	(*pigeon*)	vier	(*four*)	leeg	(*empty*)	dief	(*thief*)
bus	(*bus*)	muis	(*mouse*)	juf	(*Miss*)	nek	(*neck*)	mus	(*sparrow*)
ruit	(*window*)	heet	(*hot*)	duim	(*thumb*)	deuk	(*dent*)	huid	(*skin*)
wip	(*seesaw*)	kop	(*cup*)	dit	(*this*)	bot	(*bone*)	kip	(*chicken*)
mes	(*knife*)	los	(*loose*)	hek	(*fence*)	pan	(*pan*)	les	(*lesson*)
top	(*top*)	pap	(*porridge*)	mol	(*mole*)	kam	(*comb*)	pop	(*doll*)
naam	(*name*)	riem	(*belt*)	kaas	(*cheese*)	ziek	(*sick*)	raam	(*window*)
doos	(*box*)	reus	(*giant*)	boot	(*boat*)	tijd	(*time*)	roos	(*rose*)
jaar	(*year*)	hier	(*here*)	maan	(*moon*)	doof	(*deaf*)	haar	(*hair*)
lol	(*fun*)	vel	(*sheet*)	nog	(*still*)	pech	(*unlucky*)	vol	(*full*)
zin	(*sentence*)	wijn	(*wine*)	pil	(*pill*)	kus	(*kiss*)	win	(*win*)
been	(*leg*)	gaan	(*go*)	week	(*weak*)	duur	(*expensive*)	geen	(*none*)
map	(*folder*)	hup	(*skip*)	jas	(*coat*)	kok	(*cook*)	hap	(*bite*)
koel	(*cool*)	deel	(*part*)	boer	(*farmer*)	huis	(*house*)	doel	(*goal*)
zien	(*see*)	tuin	(*garden*)	diep	(*deep*)	mis	(*miss*)	tien	(*ten*)
bos	(*forest*)	vies	(*dirty*)	zon	(*sun*)	geit	(*goat*)	vos	(*fox*)

Appendix B. Pseudoword stimuli used in the rhyme judgment experiment[3]

Primes				Targets
Rhyme	Consonant overlap	Vowel overlap	Unrelated	
zek	meek	det	pun	mek
moek	tuik	voes	nil	toek
lil	diel	bis	baf	dil
kach	hieg	pam	duk	hag
jak	reek	wap	peep	rak
bief	haaf	viep	pes	hief
tus	has	luf	kech	hus
nuit	vijt	luim	deus	vuid
mip	buip	mit	gos	bip
res	dees	kek	suig	des
wop	veep	jol	tiek	vop
baam	diem	paas	not	daam
goos	wos	hoot	hied	woos
laar	ker	paan	zas	kaar
zol	guil	bor	nijp	gol
din	lon	zig	duuk	lin
keen	ran	deek	koom	reen
bap	deup	nas	sot	dap
loel	hul	doer	mik	hoel
bien	gon	jieg	lar	gien
zos	pig	mon	keit	pos

Appendix C. Filler stimuli used in the rhyme judgment experiment. English translations of the Dutch words are in parentheses

Words	Clues						Targets	
	kat	(*cat*)	bad	(*bath*)	dat	(*that*)	nat	(*wet*)
	rood	(*red*)	noot	(*nut*)	dood	(*dead*)	poot	(*paw*)
	heer	(*lord*)	weer	(*weather*)	meer	(*lake*)	beer	(*bear*)
	krom	(*curved*)	kom	(*bowl*)	stom	(*stupid*)	dom	(*dumb*)
	vet	(*fat*)	met	(*with*)	het	(*the*)	bed	(*bed*)
	rok	(*skirt*)	blok	(*block*)	stok	(*stick*)	sok	(*sock*)
	haan	(*rooster*)	staan	(*stand*)	kraan	(*tap*)	baan	(*job*)
Pseudowords	ral		kal		nal		jal	
	poog		doog		roog		noog	
	reef		deef		keef		meef	
	zieg		vieg		nieg		dieg	
	hir		bir		gir		lir	
	nom		vom		wom		rom	
	daak		gaak		saak		paak	

[3] "Baf" and "hief" do exist in Dutch language, but are quite rare words and therefore considered pseudowords in the present study.

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