Phonological awareness, executive functioning, and theory of mind

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A R T I C L E   I N F O

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A B S T R A C T

Language plays a critical role in theory of mind (ToM) development, particularly the understanding of false beliefs (FB). Further, there is some evidence that the development of FB is important for metalinguistic development, such as the understanding of homonyms and synonyms. However, there is debate regarding the nature of this relationship. This study explored the role of ToM, including FB, understanding and executive function in another aspect of metalinguistic development involving phonological awareness, specifically rhyming. Of interest was the relative role of ToM and executive function, particularly inhibitory control, in children's ability to identify rhymes. Two studies of 4-year-olds demonstrated that ToM understanding was primarily associated with rhyming ability, whereas inhibitory control was not independently related. Results are discussed in terms of children's ability to flexibly shift between different perspectives, by bracketing one perspective and focusing on the other, in both metalinguistic and ToM tasks.

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An extensive body of research now shows that language and theory of mind (ToM), usually assessed by false belief (FB) understanding, are closely connected in early childhood (Milligan, Dack, & Astington, 2005). The majority of this research has focused on the facilitative role of language in the development of ToM (de Villiers & Pyers, 2002; Slade & Ruffman, 2005). However, there is some limited research that indicates that an understanding of ToM may also contribute to language development, particularly metalinguistic ability. Yet there is debate regarding the nature of this relationship. The present study explores the role of both ToM and executive functioning (EF) in preschool children's development of phonological awareness with a specific focus on rhyming as a metalinguistic ability. We were particularly interested in EF assessments of inhibitory control. We use the term ToM to refer to tasks that require understanding conflicting representations, including FB, representational change, and appearance–reality distinctions.

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1. Theory of mind development

During the preschool years children make rapid progress in the understanding of mental states of themselves and others. This understanding has its origins in infancy as children view others as intentional agents (Tomasello, 1995). An important accomplishment in ToM development occurs by 5-years of age when children develop an understanding of FBs. This reflects an understanding that two people can have different or conflicting beliefs about the same event. For instance, in the standard unexpected content task, children are shown a closed band-aid box and asked what they think is inside it. Following the child’s typical response of band-aids, the box is opened to reveal that it contains paper clips instead. After closing the box, the child is asked what someone who has never seen the box will think is inside of it. A child who understands FB will reply “band-aids,” while a child who does not will respond “paper-clips.” To pass this task requires recognition that there can be two distinct ways of representing the situation. Similar achievements occur in children’s understanding of appearance vs. reality, in which the child can understand that the underlying reality (e.g., identity of an object) can be different than its appearance (e.g., a sponge that looks like a rock).

2. Theory of mind and language

Language development serves a critical role in the development of ToM, particularly in tasks involving FB (Astoning & Baird, 2005). There has been considerable controversy, however, regarding whether particular dimensions of language are more important than others in its development. Studies have shown that both vocabulary (Farrar & Maag, 2002; Milligan et al., 2005) and grammatical development (Jenkins & Astoning, 1996; Slade & Ruffman, 2005) are linked to FB understanding.

Is there any evidence that FB understanding is necessary for later language development? The majority of longitudinal studies have shown that language development plays a role in FB reasoning but the reverse is not typically found (Astoning & Jenkins, 1999; de Villiers & Pyers, 2002). However, Slade and Ruffman (2005) found that the relation between language and FB was bidirectional once the tasks were equated using the same range for scores, rather than using different scales. Similarly, Lockl and Schneider (2007) found that FB understanding predicted later language ability, although the size of the relation was modest and only existed for the later time points.

One aspect of language that may be dependent on FB understanding is metalinguistic development. Metalinguistic skills involve knowledge of language and/or the ability to manipulate linguistic forms (Bialystok, 1993). They include such skills such as phonological awareness, semantic judgments and grammaticality judgments. Doherty and his colleagues (Doherty, 2000; Doherty & Perner, 1998) have shown that the ability to understand both synonyms and homonyms is linked to FB. In their homonym task, 3- and 4-year-olds were asked to judge whether a puppet selected the correct homonym to a word previously identified. A child was shown four pictures and then asked, for example, to point to a picture of a bat (e.g., living kind); a puppet then selected an object labeled by the homonym (e.g., baseball bat). The child’s task was to determine whether the puppet made the right selection. According to Doherty (2000), in order to understand homonyms the child has to attend to the form of the words (both are bats) and ignore the differences in meaning. Children’s ability to do so was correlated with their FB understanding even after age and general language ability were controlled. Similar relations between FB and synonyms have been reported (Doherty & Perner, 1998). To correctly detect synonyms, children have to attend to similarities in meaning and make sure that the forms are different.

What accounts for this relation between FB and understanding of synonyms and homonyms? Initially, Doherty and Perner (1998) developed a “representational understanding of mind” (RUM) explanation, according to which children’s understanding of mental states as representations is applied to non-mental representations. In the case of homonyms, the homonym task requires children to make a distinction between what is represented and how it is represented, just as FB requires understanding two different representations (beliefs) of a situation. To understand synonyms, children have to recognize that there can be two different names for the same object.

An alternative explanation is that children’s difficulty with understanding synonyms resides with their assumption that an object can only have one name or label, similar to the mutual exclusivity
(ME) hypothesis. As Perner, Stummer, Sprung and Doherty (2002) observe, however, it is not clear why overcoming mutual exclusivity bias would be related to FB. Perner et al. (2002) reinterpreted the ME interpretation of relationship between FB and synonyms as reflecting advances in the Piagetian notion of representing perspectives. Specifically, they argued that both the FB task and the synonym task require the ability to shift flexibly between different perspectives and to bracket one perspective while focusing on the other. In the case of FB, passing requires shifting from one’s own belief and focusing on the belief of someone else.

Kloo and Perner (2005) argued that at the center of young children’s ability to pass these tasks is their understanding that one “entity . . . can be described differently from different perspectives” (p. 54; see also Kloo, Perner, Aichorn & Schmidhuber, 2010). Thus, on this interpretation, it would be expected that the understanding of metalinguistic tasks is linked to FB because both require an understanding of different perspectives of a particular word or situation and both require the ability to shift flexibly between perspectives and to bracket one while focusing on the other. It could be further predicted that metalinguistic tasks would be related to other ToM measures reflecting shifting perspectives, such as appearance–reality tasks (Flavell, Flavell & Green, 1983).

A third possible explanation of the relation between FB and synonyms/homonyms is that children’s difficulty resides in executive function, and in particular inhibitory control ability, and does not require a representational understanding as proposed in the RUM explanation (Garnham & Garnham, 2002; Garnham, Brooks, Garnham & Ostenfeld, 2000). Garnham et al. (2000) had found that FB was related to their homonym task but not their synonym task after removing the effects of age. Further, they found no association between children’s performance on the synonym and homonym tasks. The authors interpreted these findings indicating that FB and homonyms reflect a common ability not shared with the synonym task. Thus, they suggested that the RUM hypothesis was not supported. Instead they proposed that the link between homonyms and FB was due to a shared need for inhibitory control (IC). That is, to pass both a FB task and a homonym task, children must inhibit a dominant response, e.g., inhibit a meaning of a word in favor of another. In contrast, the synonym task does not require any inhibitory response. Doherty (2002) suggested that the Garnham et al. synonym task did not require children to distinguish between representations and thus did not disprove the RUM hypothesis. Garnham and colleagues did not provide a direct test of the IC interpretation. The Perner et al. (2002) study examining the link between FB and synonyms, however, included a control task that required inhibitory control. For example, if a puppet named the color of an object, the child had to say the name of the object or vice versa. Thus, the child had to inhibit repeating the color name the puppet used. Performance on this task was much higher than performance on either the FB task or synonym task, indicating that an IC explanation cannot account for the relationship between FB and synonym task performance. In addition, performance on this task was not related to FB performance. The direct role of performance of the control task on children’s ability to produce synonyms was not examined, perhaps because children’s performance was near ceiling on the control task. In summary, metalinguistic development has been shown to be related to FB. While there is some suggestion that inhibitory control may be linked to metalinguistic development, there has been little empirical investigation or support of this link.

3. Theory of mind and phonological awareness

In the present series of studies, we further explore the nature of the relation between ToM, EF, and metalinguistic development by examining a different type of metalinguistic task—phonological awareness (Anthony & Francis, 2005; Blachman, 2000). According to Doherty and Perner (1998) FB should be associated with any metalinguistic awareness tasks “that require an understanding of the interrelation between the formal aspects of language and meaning” (p. 298). Adopting a broader view of FB, we would extend this claim and predict that other ToM tasks, such as appearance–reality, would also be related to metalinguistic development.

Phonological awareness (PA) is the ability to understand and manipulate the sounds of language. It emerges during the preschool years and includes abilities such as rhyming and phoneme and syllable deletion (Anthony & Francis, 2005; Goswami & East, 2000). PA is important because it plays a predictive
role in later reading ability (Bryant, Maclean & Bradley, 1990). Rhyming ability, which emerges around the same time as ToM, is one of the first PA abilities to develop.

Although considerable research has focused on the relation of PA, including rhyming, to later reading skills, there has been considerably less research examining the factors that contribute to its emergence. Farrar, Ashwell and Maag (2005) argued that both PA and ToM require cognitive flexibility—that is the ability to handle different representations of the same situation. They argued that in the case of rhyming ability, children have to be able to consider the sounds of words and not their meanings. This requires a different perspective than the typical one in a language-based task where meaning is always considered. This argument is similar to the perspective-taking argument (Kloo & Perner, 2005) because children have to consider two different perspectives on the relation between words—a phonological one and a semantic one. Farrar et al. (2005) gave children a rhyming oddity task in which they are shown three pictures, the labels were provided, and the child’s task was to select the two pictures that rhyme. For instance, shown pictures of log–dog–chair, the child would have to select dog and log and set aside any semantic connection between the pictures. They reported that ToM understanding in 4-year-olds was strongly related to the rhyming task, even after controlling for age and general language ability (Farrar et al., 2005). This rhyming oddity task, similar to other metalinguistic tasks, requires the ability to shift flexibly between different perspectives. Children are required to explicitly consider the sound relation between words and bracket their meaning association which they would otherwise do in a language based task where meaning is typically always considered (Nguyen, 2007). That is, in order to rhyme, children have to recognize that words can be related because of similar sounds rather than similar meanings. Children tend to automatically focus on meaning, so to rhyme an explicit or metalinguistic awareness of the sound similarity is required—that is, shifting to a different perspective.

As with the synonyms and homonyms task, however, there exist several alternative possibilities with respect to the relation between ToM and rhyming. It is possible that EF, particularly, inhibitory control, accounts for the relation between ToM and rhyming ability. To rhyme children have to inhibit their tendency to attend to the meaning of words and respond on the basis of sound. Thus, the association between ToM and rhyming may reflect IC ability which has also been linked to ToM (Carlson & Moses, 2001). Thus, in the present studies, children were given a series of EF tasks, including IC and working memory, as well as ToM and vocabulary tests, to determine which variable(s) correlated with children’s ability to identify rhymes.

In addition, to more clearly examine children’s ability to handle both semantic and phonological perspectives, we created two different rhyming tasks. In the rhyming task used by Farrar et al. (2005), the semantic association between items was not systematically manipulated. For example, in the triad goat–boat–shorts there was no semantic association between any of the words that children would have to explicitly bracket to attend to the rhyming association of goat–boat. For the present study we created two rhyming tasks, a semantic rhyming task and a non-semantic task. In the semantic rhyming task, there was an explicit semantic association between two of the items and a rhyming association between two of the items, e.g., truck–train–duck. Thus, the child had to set aside a tendency to attend to semantic associations (Nguyen, 2007) and shift to the rhyming association. In the non-semantic rhyming task, there is no competing semantic association between the items to directly conflict with the rhyming association. Children may still have to bracket the meanings of words to identify the rhymes, but since the semantic association is not as strong, the relation to ToM may be weaker.

Study 1 examined the relation of ToM and EF to rhyming ability for both the semantic and non-semantic tasks. It was expected that each of the variables would be related to rhyming, with ToM playing the largest role. These relations were expected to be the strongest for the semantic rhyming task where there is an explicit contrast between the rhyming items and the semantically related items.

4. Study 1

4.1. Method

4.1.1. Participants

Thirty-nine 4-year-olds (M = 4.5 years; range 4–0 to 5–1 years) participated (20 females). All children were native speakers of English and were recruited from local preschools. While children’s family
SES was not formally assessed, the children were enrolled in preschools associated with a University community.

4.1.2. Measures

Semantic rhyming task: Two rhyming tasks were constructed and administered similarly. The tasks differed in terms of the association between the pictures. In the semantic task two of the pictures represented words that rhymed but had no semantic association with each other. The third picture was semantically linked to one of these items, based on the norms of Frankel and Rollins (1985), but did not rhyme with it. For example, of the triad of truck–car–duck, car and truck are highly semantically related, whereas duck and truck rhyme but have no semantic association. Children were shown 10 such sets of three pictures each. Each picture was labeled twice and the child was then asked to select the two pictures that rhymed or sounded alike. Children were given four practice trials with feedback before being presented with the 10 experimental sets. Scores could range from 0 to 10.

Non-semantic rhyming task: The non-semantic rhyming task was constructed and administered similarly to the semantic rhyming task. Two of the pictures represented words that rhymed; the third picture was not semantically linked and did not rhyme with the other word. As in the semantic rhyming task, children were shown 10 sets of three pictures and given practice trials. Table 1 presents the stimuli used for both rhyming tasks.

Peabody picture vocabulary test: Children’s receptive single word vocabulary was assessed using the Peabody Picture Vocabulary Test – Third Edition (PPVT–III; Dunn & Dunn, 1997). This assesses general receptive vocabulary and is commonly used in ToM studies.

Theory of mind: Children were administered several ToM tasks designed to assess their understanding of conflicting mental representations. These included unexpected location, unexpected content and appearance–reality tasks.

1. Unexpected location task: Children were told a story using Ernie and Elmo puppets, in which Ernie plays with a toy, puts it away in one location in full view of the child, then “goes outside to play.” While Ernie is away, Elmo removes the toy from its hiding place, plays with it, and then puts the toy away in a different location. Children are told that Ernie comes back to play with the toy again, and are asked the ToM question: “Where will Ernie look for the toy?” The child was awarded 1 point for answering this question correctly. Memory control questions were asked to ensure the child remembered where the character had put the object initially and its later location. In order to receive credit for the FB question, children had to answer the control question correctly. Scores on the unexpected location task were either 0 or 1 (Wimmer & Perner, 1983).

2. Unexpected contents task: Children were shown a box of crayons and asked, “What is in this box?” After the child answered that the box contained crayons (or something similar), the box was opened and emptied to show that it contained candles. The child was asked to identify the true contents. After the candles were placed back in the box, children were asked about their original belief, “When you first saw the box, all closed up like this, what did you think was in the box?” The child was
awarded 1 point for answering this ToM question correctly. Children were then told that the Cookie Monster puppet had never seen what was in the box and they were asked what Cookie Monster thought was in the box. The child was awarded 1 point for answering this FB question correctly. Children were also asked a memory control question regarding the original content of the box. To receive credit for the ToM questions, children had to answer the memory control question correctly. Scores on the unexpected content task could range from 0 to 2 (Perner, Leekam, & Wimmer, 1987).

3. **Mistaken identity task:** This was an appearance–reality task involving object identity. After first viewing a sponge painted to look like a rock, children were allowed to touch it, and then name it. The researcher then asked, “What does this look like to your eyes right now, does it look like a rock or a sponge?” They were then asked the appearance–reality question: “What is it really, is this really a rock or really a sponge?” The child was awarded 1 point for answering that it was really a sponge. Following Gopnik and Astington (1988), the researcher then asked “When you first saw this, before you touched/squeezed it, what did you think it was?” The child was awarded 1 point for answering “rock.” This was followed by a ToM question. The experimenter showed the child a cartoon cat puppet and said “Kitty has never touched this before. What does Kitty think this is, a sponge or a rock?” The child was awarded 1 point for responding “rock”. Total scores on this task ranged from 0 to 3.

Thus, total scores of the 3 ToM tasks ranged from 0 to 6. Children had to correctly answer the control questions to be given credit for the unexpected location and unexpected content questions. Eight children failed one of the control questions for one of the ToM tasks and thus they were not credited with a correct answer on that specific task.

4.2. **Executive function tasks**

*Inhibitory control:* A shortened version of the dimensional card sort task (DCCS) was presented (Frye, Zelazo, & Palfai, 1995). Children were given a rule to sort the picture cards, such as by color, and were then given a series of pictures of red and blue boats and rabbits. Children were given explicit training regarding the rule, reminders, and corrective feedback during the training to make sure they understood the rule. After sorting the cards by the color rule, the rule was switched to the other dimension, shape (or vice versa for half the children). The rule was repeated after each trial and no feedback was given. Children were given 5 chances to sort by the new rule. Inhibitory control (IC) scores were counted only after the rule had been changed and ranged from 0 to 5 correct.

*Memory for sentences:* To assess general verbal memory the Woodcock–Johnson Memory for Sentences was administered (WRMT-R; Woodcock & Johnson, 1989). Children were read sentences of increasing length and then they were required to repeat them. The sentences were scored on the basis of children’s level of imitations according to the criteria of Woodcock–Johnson Memory for Sentences Subscale.

4.3. **Procedure**

Children were presented all tasks over two sessions less than 1 week apart. Tasks from each type of measure were given in counterbalanced order during both testing sessions. Thus, during each testing session, children received a ToM task, rhyming task, and executive functioning task with the order counterbalanced across children. The PPVT was always administered during session 1.

5. **Results**

*Table 2* presents the means and standard deviations of the different cognitive and language measures. On both rhyming tasks, children were correct on about 50% of the trials. Similarly, children performed at a mean 50% level on the ToM tasks, as well as the IC task. *Table 2* also provides the mean performance on the three ToM tasks, unexpected location, content, and appearance reality. Maximum possible scores differed for each of these tests, 2, 1, and 3 points, respectively. The three ToM tasks
were significantly correlated with each other, all $r$s (37) > .41, $p$s < .05, although the unexpected content task was marginally related to appearance–reality, $r$ (37) = .32, $p$ = .057. A principle component factor analysis was performed on the ToM measures which indicated that all three measures loaded on one factor, supporting the use of a composite ToM measure in all analyses.

Of primary interest was the relation of the rhyming measures to ToM performance, as well as the executive function task of IC. These relations were examined in a series of partial correlations, controlling for age. As seen in Table 3, ToM performance and the PPVT were significantly correlated with both the semantic and non-semantic rhyming measures, after controlling for age. In contrast, the IC measure was not related to either rhyming measure. Memory for sentences was related to performance on the non-semantic rhyming task, but not the semantic rhyming task. ToM performance was related to both PPVT and IC scores.

To further examine these relations we conducted an additional series of partial correlations. For the semantic rhyming measure, ToM remained related to rhyming performance after controlling for PPVT scores, $pr$ (36) = .47. Similarly, for the non-semantic rhyming task, ToM performance was related to rhyming performance after controlling for PPVT, $pr$ (36) = .48, $p$ < .01, and memory for sentences $pr$ (36) = .41, $p$ < .05.

Of particular interest was the relation between the two rhyming tasks and ToM, after controlling for IC. In two separate partial correlations, ToM and both rhyming tasks remained correlated after controlling for IC, all $prs$ (36) > .48, $p$s < .01. These patterns of partial correlations indicate that the relationship between rhyme and ToM is not due to the effects of IC. Further, we examined the relation

### Table 2
Means and standard deviations (SDs) for all measures in Study 1 and Study 2.

<table>
<thead>
<tr>
<th>Task</th>
<th>Study 1</th>
<th></th>
<th>Study 2</th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Means</td>
<td>(SD)</td>
<td>Means</td>
<td>(SD)</td>
</tr>
<tr>
<td>Semantic rhyming</td>
<td>5.08</td>
<td>(3.28)</td>
<td>5.67</td>
<td>(3.17)</td>
</tr>
<tr>
<td>Non-semantic rhyming</td>
<td>5.56</td>
<td>(3.01)</td>
<td>5.75</td>
<td>(3.14)</td>
</tr>
<tr>
<td>Total rhyming</td>
<td>10.50</td>
<td>(5.81)</td>
<td>11.42</td>
<td>(5.87)</td>
</tr>
<tr>
<td>Semantic relations</td>
<td>NC</td>
<td></td>
<td>6.55</td>
<td>(3.00)</td>
</tr>
<tr>
<td>Theory of mind (ToM)</td>
<td>2.96</td>
<td>(1.85)</td>
<td>2.97</td>
<td>(1.99)</td>
</tr>
<tr>
<td>Mistaken location</td>
<td>.63</td>
<td>(.72)</td>
<td>.63</td>
<td>(.58)</td>
</tr>
<tr>
<td>Mistaken content</td>
<td>1.00</td>
<td>(.86)</td>
<td>1.10</td>
<td>(.81)</td>
</tr>
<tr>
<td>Appearance–reality</td>
<td>1.32</td>
<td>(1.01)</td>
<td>1.30</td>
<td>(.91)</td>
</tr>
<tr>
<td>IC (DCCS)</td>
<td>2.74</td>
<td>(2.30)</td>
<td>3.07</td>
<td>(2.36)</td>
</tr>
<tr>
<td>Day/night</td>
<td>NC</td>
<td></td>
<td>11.37</td>
<td>(4.54)</td>
</tr>
<tr>
<td>Memory for sentences</td>
<td>46.64</td>
<td>(15.65)</td>
<td>32.65</td>
<td>(11.33)</td>
</tr>
<tr>
<td>PPVT</td>
<td>93.42</td>
<td>(14.38)</td>
<td>95.57</td>
<td>(14.78)</td>
</tr>
</tbody>
</table>

Notes: The range of scores for the each of the rhyming tasks is 0–10, making the range of scores for total rhyming composite score 0–20.
NC indicates the measure was not administered in Study 1.
The range of scores for the ToM task is 0–6 (mistaken location, 0–1, mistaken content, 0–2, and appearance–reality, 0–3).
The range for the IC task is 0–5.

Table 3
Partial correlations controlling for age in Study 1.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic rhyme</td>
<td>–</td>
<td>.81*</td>
<td>.25</td>
<td>.24</td>
<td>62*</td>
<td>.46*</td>
</tr>
<tr>
<td>Non-semantic rhyme</td>
<td>–</td>
<td>–</td>
<td>12</td>
<td>.35</td>
<td>.55*</td>
<td>.46*</td>
</tr>
<tr>
<td>IC (DCCS)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>.01</td>
<td>–</td>
<td>.42*</td>
</tr>
<tr>
<td>Sentence memory</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>52*</td>
<td>.31</td>
</tr>
<tr>
<td>PPVT</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>41*</td>
</tr>
<tr>
<td>ToM</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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</tr>
</tbody>
</table>

Note: Inhibitory control (IC) was measured using the Dimensional Card Sort Task (DCCS).

* $p$ < .05.
* * $p$ < .01.
between ToM and IC, after controlling separately for the two rhyming tasks. Controlling for semantic rhyming, the correlation did not reach significance, \( r (36) = .32, p = .064 \). In contrast, controlling for non-semantic rhyming, the correlation between ToM and IC, remained significant, \( r (36) = .38, p < .05 \). It is important to note, however, that these correlations are relatively similar. This latter set of partial correlations suggests that the link between ToM and IC is not due to shared variance with the rhyming tasks.

Finally, we explored children’s incorrect strategies in the semantic rhyming task. If children did not select the rhyming pair, they could have either incorrectly chosen the semantic pair or the unrelated pair. Analysis of these two incorrect strategies indicated that when children made errors they were significantly more likely to select the semantically related pair \( (M = 3.02) \) than the unrelated pair \( (M = 1.72), t (36) = 2.49, p < .05 \). Interestingly, this incorrect semantic strategy was negatively related to ToM, PPVT, IC, and WM, all \( r s (37) > -.35, ps < .05 \), controlling for age. The unrelated strategy was only negatively related to PPVT, \( r (36) = -.49, p < .05 \), controlling for age. Together, these negative correlations support the earlier inference that rhyming ability reflects a more sophisticated cognitive strategy associated with a more advanced ToM.

6. Discussion

The results of Study 1 demonstrate that phonological awareness, specifically rhyming, is related to ToM performance. This pattern was essentially found whether the semantic or non-semantic rhyming tasks were used, suggesting that in both tasks children have to focus on the forms (i.e., sounds of words) and bracket their meaning. Thus, even when the semantic association between words was not explicit, as in the non-semantic rhyming task, children may still need to set aside the meanings of words. Together, these results are consistent with the argument that in order to rhyme children must be able to shift perspectives to consider the phonological relation between words rather than the semantic relation (Perner et al., 2002).

If this interpretation task is correct, ToM should be related to metalinguistic tasks that require the ability to flexibly shift between perspectives, while bracketing one of them. However, for metalinguistic task in which children do not have to shift perspectives, ToM should not be related to performance. To further test this interpretation, in Study 2 children were also given a semantic relations task. In this task, children are shown a triad of pictures (similar to the semantic rhyming task) and are asked to select the two items that are semantically related. For example, given a triad of dog–cat–log and asked to select the ones that go together, children should select dog–cat and not the rhymed pair dog–log. Previous research has indicated that children tend to choose items that are semantically related either from the same taxonomic category or from the same event category (Bauer & Mandler, 1989; Nguyen, 2007). In this case of selecting semantically related items, children would never actively (i.e., metalinguistically) consider the phonological association but would only consider the semantic ones. Thus, in a semantic relations task children only have to focus on the meaning and do not need to bracket the sound because they would not explicitly and automatically process the phonological relations between words. This would only happen when children are asked to explicitly attend to the sounds in a rhyming task. Consequently, there should be no relation between performance on the semantic relations and ToM tasks.

The results from Study 1 did not support the EF hypothesis since there was no association with IC as assessed by the DCCS task. This task has several different interpretations. While it is sometimes thought to be a measure of inhibitory control (Carlson & Moses, 2001), it is also interpreted as a measure of cognitive control or even different perspectives. The interpretation provided by Zelazo and Frye (1997) is that the task requires children to coordinate two contradictory rules (e.g., sort by color vs. sort by shape) in a higher-level rule. Both interpretations have generated considerable research attempting to clarify the nature of the task, and evidence can be found for both perspectives (Diamond, Carlson & Beck, 2005; Kloo & Perner, 2005). In a recent series of studies, Kloo and colleagues (Kloo & Perner, 2005; Kloo, Perner, Aichorn & Schmidhuber, 2010) argued that the DCCS task requires cognitive flexibility—“the ability to think about one and the same object in different ways” (Kloo & Perner, 2005, p. 54). That is, it requires the ability to take different perspectives. They suggest that this flexibility might be due to either “executive control” or “conceptual change” in understanding that objects can
be represented in different ways (p. 54). Study 2 further examines the role of IC by including another IC assessment—the day-night task—accepted as a measure of inhibitory control.

Thus, the purpose of Study 2 was to examine the basis of the ToM-rhyming association by including a semantic relations task. It was expected that ToM would only be related to performance on the rhyming task and not the semantic relations task. In addition, we further examined the EF hypothesis by including an additional, perhaps more accepted, measure of inhibitory control.

7. Study 2

7.1. Participants

Forty 4- to 5-year-olds ($M = 4.5$ years; range 4–0 to 5–0) participated (21 females). All children were native speakers of English and attended area preschools. The majority of the children were Caucasian.

7.2. Measures

Children were administered the same two rhyming tasks, PPVT vocabulary test, and ToM tasks as in Study 1. In addition, children were presented the following tasks:

Semantic relations task: Children were given the same 10 triads used in the semantic rhyming task. However, in the semantic relations task, children were asked to select the items that “go together.” This task was always administered on a separate day from the rhyming task.

Day–night task: This task is an EF inhibitory control task in which children are shown a series of cards depicting either a sun or moon. Children have to say the opposite word from the depicted items. Children were shown a picture of the sun, representing “day,” but were required to say “night” or shown a picture of the moon, but required to say “day”. Children thus must inhibit the tendency to say “day” or “night”, respectively. Children were given training instructions with feedback until they were correct. They were then administered 20 trials without feedback.

7.3. Procedure

The same procedure for administration used in Study 1 was used in Study 2.

8. Results

Table 2 presents the means and standard deviations for all the task variables. The overall mean level of performance was comparable to Study 1. The three ToM subtests were all significantly correlated with each other, all $r_s (37) > .35, p < .05$. Children did slightly better on the semantic relations task than the rhyming tasks but not significantly so. On the day–night task of IC, performance was approximately half of the 20 items correct.
Table 5
Partial Correlations controlling for age for combined participants from Studies 1 and 2.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total rhyme</td>
<td>–</td>
<td>.33**</td>
<td>.25*</td>
<td>.43*</td>
<td>.41**</td>
</tr>
<tr>
<td>IC (DCCS)</td>
<td>–</td>
<td>–</td>
<td>.13</td>
<td>.25*</td>
<td>.27*</td>
</tr>
<tr>
<td>Sentence memory</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>.28*</td>
<td>.46**</td>
</tr>
<tr>
<td>PPVT</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>.37*</td>
</tr>
<tr>
<td>ToM</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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</tbody>
</table>

* p < .05.
** p < .01.

Table 5 presents the partial correlations among variables, controlling for age. For the rhyming measures, the pattern of partial correlations is very similar to those of Study 1. Specifically, ToM was strongly related to performance on the semantic rhyming task, even after controlling for age. However, ToM was not related to the non-semantic rhyming task. ToM was related to both rhyming tasks after controlling for PPVT, pr (37) = .41, p < .05 and, pr (37) = .36, p < .05, respectively. Sentence memory was unrelated to both rhyming tasks.

In contrast, neither of the IC measures (i.e., the DCCS or the added day–night tasks) was related to rhyming ability after controlling for age. To further explore IC, we created a composite IC measure by combining the scores on these two tasks (M = 14.83). The correlations between this new measure and both rhyming tasks also were not significant, rs (37) < .01, ps > .50. Further, as in Study 1, the link between ToM and both rhyming tasks remained significant after separately controlling for memory for sentences and the composite IC measure, all prs (37) > .33, ps < .05.

Of particular interest was whether ToM also related to performance on the semantic relations task. As seen in the partial correlations of Table 4, as hypothesized, there was no relationship found with ToM. It was also not correlated with any of the EF measures or the PPVT measure. As in Study 1, we examined children’s incorrect strategies in both the semantic rhyming task and the semantic relations task. The incorrect semantic rhyming strategies were either selecting semantically related pairs or unrelated pairs. As in Study 1, children were again more likely to select the semantic pair (M = 3.01) when making an error than the random pair (M = 1.42), t (37) = 2.89, p < .05. In contrast, incorrect strategies on the semantic relations task were selecting the rhyming pair or the random pair. There were no differences in frequencies of selection of these two strategies, Ms = 2.0 and 1.4, respectively. This finding suggests that selecting a rhyming pair is not a strategy that is typically employed on this task.

Finally, to more completely evaluate the relation of EF and ToM, as well as the other variables, to rhyming ability, the measures (age, PPVT, IC, memory for sentences, and ToM) common to both studies were combined into a composite data set, resulting in a sample size of 79 participants. A total rhyming score (SR + NSR) was used since the basic pattern of previous correlations was generally the same across both studies. As can be seen in Table 5, all the variables, including the EF measures of both IC and memory for sentences, were associated with total rhyming, after controlling for age. Of particular interest is the finding that performance on the IC measure was related to rhyming in the composite data set. The strongest correlations with rhyming were the ToM and PPVT scores.

To further explore these relations, a hierarchical regression was performed, with variables age and PPVT entered as control variables, followed by the EF measures of IC (DCCS) and memory for sentences in step 2, and ToM in step 3. As seen in Table 6, only the PPVT and ToM measures were uniquely related to rhyming ability. Of particular importance is the finding that ToM still contributed to children’s ability to rhyme even after controlling for all the other variables.

9. Discussion

The findings of Study 2 confirm and extend the pattern observed in Study 1. Specifically, ToM was again related to both the semantic rhyming task, although not the non-semantic rhyming task. While ToM was correlated with the non-semantic task in Study 1, the relation was weaker, suggesting that the metalinguistic demands may not be as high since the semantic associations are not as strong. As
before, IC, including the new IC day-night measure, was unrelated to rhyming, whereas memory for sentences was correlated with both rhyming tasks.

Of particular interest in Study 2 was whether ToM was related to the semantic relations task, as it was for the rhyming task. It was predicted that ToM would not be correlated to this task since the child did not need to bracket the sounds of words but only attend to the semantic association of the words. This hypothesis was confirmed suggesting that the relation between rhyme and ToM reflected children’s ability to shift flexibly between perspectives by bracketing the meaning of words and attending to the sound relations between words. As discussed further below, these patterns of findings were supported and qualified by a regression analysis using the composite data set. Specifically, only PPVT and ToM made unique contributions to rhyming.

10. General discussion

The results of both studies demonstrate that ToM is associated with rhyming ability. Of particular relevance to the importance of ToM to rhyming is the regression analysis showing that after accounting for all the other variables (age, EF, and language), ToM still made a unique contribution to rhyming ability. These findings extend previous research that has examined links between FB specifically and metalinguistic development (e.g., homonyms and synonyms) to rhyming ability and to broader assessments of ToM including a range of tasks involving conflicting representations. According to the perspective interpretation of these findings, ToM is related to metalinguistic ability, including rhyming, because both require children to be able to shift to different perspectives on a given situation (Kloo et al., 2010; Perner et al., 2002). Our view is that the rhyming task, similar to other metalinguistic tasks, requires the ability to shift flexibly between different perspectives of words. Specifically, children are explicitly asked to consider the sound of words to select the rhyming pair. This requires that they bracket the meanings or semantic relations between the words, relations they would otherwise attend to in a language in which meaning is typically always considered (Nguyen, 2007).

Several findings from the present study support this interpretation. First, performance on the semantic relations task in Study 2 was not related to ToM. In the semantic relations task, children were asked to select words that were semantically related and there was no reason for them to explicitly consider or bracket the sound relationships. However, the rhyming task requires children to explicitly consider the sound relation and bracket the meanings. Thus, ToM was not associated with the semantic relations task, as it was with the rhyming task. Further analysis of the incorrect strategies in the semantic rhyming task showed that children were more likely to select the semantically related pair than the unrelated pair, whereas in the semantic relations task, children did not favor the rhyming pair
over the unrelated pair. This pattern supports the argument that children tend to automatically focus on meaning, and consideration of rhyme requires a more explicit metalinguistic judgment where they must bracket meaning and consider sound.

Second, in the analysis of the composite data set, IC (DCCS) task and ToM tasks both correlated with rhyming. The DCCS has recently been interpreted as requiring the ability to consider different perspectives (Kloo et al., 2010). Although the effect of the DCCS task was no longer significant in a regression, the correlations do suggest they there is a common element between these tasks, which should be explored further in future studies. It might be suggested that the rhyming task does not require the ability to shift flexibly between different perspectives in the same sense as the homonym and synonym tasks. Alternatively, it might be argued that ToM is related to rhyming because it involves understanding the relation between form and meaning and not different perspectives. In our view, these interpretations are somewhat similar. Understanding the form–meaning relation requires shifting different perspectives of either the form or meaning relation of words, particularly when asked to make a metalinguistic judgment.

Support was limited for the EF hypothesis involving inhibitory control (Garnham et al., 2000). Despite considerable speculation regarding the role of inhibitory control in understanding synonyms and homonyms, there had been no direct test of this hypothesis (although see Perner et al., 2002). We had initially used the DCCS measure as an assessment of IC, although as discussed earlier, recent research has suggested that it may be more appropriate to use as a measure for taking perspectives (Kloo et al., 2010). In Study 2 we added the day–night task. In both Studies 1 and 2, neither measure was related to rhyming. Interestingly, neither were they correlated with each other, suggesting they are assessing different skills. However, as argued earlier, the DCCS task may reflect perspective taking rather than inhibitory control. Future studies are needed to further explore the nature of this relation by including other EF measures. In addition, the role of EF in understanding homonyms and synonyms should be directly explored, as well as the relation between different metalinguistic tasks.

A limitation of the present studies is that the data were not longitudinal. This makes it difficult to tease apart the direction of influence. Conceptually one interpretation is that the ability to understand conflicting representations, as reflected in the ToM tasks, allows children to engage in rhyming. The ToM tasks reflect a basic ability to shift between different perspectives which is then applied to rhyming tasks (as well as synonyms and homonym tasks). However, it could be that this ability to shift between different perspectives is independent of any particular task and reflects a more general cognitive advancement, as suggested by Leekham, Perner, Healey, & Sewell (2008). Developmental differences in the performance on these different representational tasks, if they exist, may reflect task demands rather than any core representational differences. Longitudinal research could also further clarify the role of EF in rhyming ability. It may be, for instance, that inhibitory control plays an important role in rhyming ability, but because we were examining these relations at a single time point this relation was not be evident.

More broadly, these results contribute to an expansive literature on the relation of ToM to children’s language development. The majority of prior research has examined how language development contributes to ToM development, particularly FB (A astonington & Baird, 2005; Milligan et al., 2005). While precursors of ToM development in infancy, as reflected in joint attention, are related to later language development (Baldwin & Moses, 2001), only limited research has demonstrated a link between ToM and later language (Lockl & Schneider, 2007; Slade & Ruffman, 2005). The present studies suggest that ToM is related to the emergence of metalinguistic development because it reflects children’s ability to flexibly shift between perspectives.

References


