Pretend Play, Divergent Thinking, and Math Achievement in Girls: A Longitudinal Study

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The present study examined longitudinal relationships among early pretend play, divergent thinking, and academic achievement in school-age girls. Theoretically, processes in pretend play should relate to divergent thinking and academic achievement. The aim of the present study was to establish longitudinal correlates of pretend play in school-age girls. It was hypothesized that early measures of pretend play would predict divergent thinking and academic achievement, controlling for verbal intelligence, at a 4-year follow-up. Thirty-one girls in the fourth through eighth grades participated in the study. Four years before the present study, these children received the Affect in Play Scale and a divergent thinking task. Children in the present study were administered a divergent thinking task (Alternate Uses Task). In addition, AIMSweb scores of academic achievement in reading and math were collected from school records. As hypothesized, early pretend play predicted later divergent thinking. Children whose pretend play was more imaginative and organized generated more alternate uses for common objects. Positive affect in play predicted originality of responses. In addition, both pretend play and divergent thinking predicted girls’ mathematics achievement longitudinally. Divergent thinking and play combined accounted for 31% of the variance in math achievement over time. All results remained significant when verbal intelligence was controlled. The present study provides important longitudinal evidence for the predictive power of pretend play in children’s development and adaptive functioning, particularly as it relates to divergent thinking and math achievement in girls.

Keywords: achievement, creativity, divergent thinking, pretend play

Pretend Play and Divergent Thinking

Fein (1987) conceptualized pretend play as a natural form of creativity. Further, Russ (1993) theorized that pretend play is important in fostering creativity, as many of the cognitive and affective processes involved in creativity occur in pretend play. Cognitive processes such as insight ability, flexibility, and divergent thinking, and affective processes such as the experience of emotion and incorporation of affect themes from memory or imagination, are important in both creativity and pretend play (See Russ, 2004, 2014 for reviews). The present study focused on divergent thinking, which is the ability to generate a variety of ideas. Pretend play can be considered practice for divergent thinking, as children are mentally transforming toys into a variety of objects and role-playing different scenarios (Singer & Singer, 1990).

Empirical research supports the theoretical link between pretend play and divergent thinking. Although divergent thinking has recently been criticized as a measure of creative ability, there is longitudinal evidence for the predictive validity of the Torrance Test of Creative Thinking, a divergent thinking measure (Kim, 2008). It has predicted creative achievement in adults over periods of 40 years (Cramond, Mathews-Morgan, Bandalos, & Zuo, 2005) and 50 years (Runco, Millar, Acar, & Cramong, 2010). In school-age children, divergent thinking has related to pretend play in a number of different studies across research laboratories (Fisher, 1992; Hoffmann & Russ, 2012; Kaugars & Russ, 2009; Singer & Singer, 1990; See Dansky, 1999; Russ, 2004, 2014 for reviews). Hoffmann and Russ (2012) found positive correlations between the cognitive and affective domains of pretend play and children’s divergent thinking abilities, independent of verbal intelligence. In addition, children who expressed a greater variety of affect categories in their play were better divergent thinkers. A study of preschool children showed that children who demonstrated more pretend play and whose play contained a greater frequency and variety of emotions were able to provide more responses on a divergent thinking task (Kaugars & Russ, 2009). Other studies have found similar relations between both positive and negative affect in play and divergent thinking (Lieberman, 1977; Russ & Grossman-McKee, 1990; Russ & Schafer, 2006).

Further, some experimental studies have shown that play facilitates the development of divergent thinking skills (Dansky, 1980; Dansky & Silverman, 1973). Dansky and Silverman (1973) found that children who were allowed to play with objects gave signifi-
icantly more uses for those objects than did a control group. Further, Dansky (1980) extended the previous study to include a second set of objects that were novel for both the play and control groups. He found that play had a generalized effect, such that children in the play group supplied more uses for both sets of objects than the control group. He also found that free play facilitated divergent thinking only for children who engaged in pretend play with the objects. Children’s use of make-believe and fantasy mediated the relationship between play and divergent thinking. There is mixed evidence in this area of research, and some researchers have proposed the existence of some third variable that accounts for the relation between play and divergent thinking or the presence of experimenter bias to account for positive results (Lillard et al., 2013). However, there is enough promising research in this area to merit further investigation using masked experimenters and new study designs (Russ & Wallace, 2013).

Pretend play has predicted divergent thinking in two longitudinal studies. In a 4-year follow-up study of children, early pretend play measured by the Affect in Play Scale (APS) related to divergent thinking fluency (number of different uses generated for an object) and self-reported coping ability in 5th- and 6th-grade children, independent of verbal intelligence (Russ, Robins, & Christiano, 1999). Mullineaux and Dilalla (2009) reported that realistic role-play at age 5 predicted early adolescents’ performance on a divergent thinking task at ages 10–15. They concluded that pretend play observed in preschoolers represents early creativity, which carries through to creativity development measured in early adolescence.

Gender differences in the correlations between pretend play and divergent thinking have not been systematically investigated. The small sample sizes of previous studies did not provide enough power for meaningful comparisons of sizes of correlations for boys and girls. In general, there are no mean differences in imagination or amount of affect expression in the play of girls and boys, with the exception of affect content. Boys consistently express more aggression in pretend play than girls (e.g., Fehr & Russ, 2013). It is important to investigate whether the association between play and divergent thinking remains stable over time for girls and if positive and negative affect are differentially predictive.

Pretend Play and Academic Achievement

The relation between pretend play and academic achievement has theoretical foundations in Lev Vygotsky’s conceptualization of play as the “leading edge of development” (Vygotsky, 1978). According to Vygotsky, one function of children’s play is to develop a symbol system to accompany and enrich their emerging language learning. Recent research supports the link between play and language development (Bergen & Mauer, 2000; Christie & Enz, 1992). Children tend to demonstrate their most advanced language during play, which is strongly related to early literacy (Christie & Roskos, 2006). Greater frequency of pretend play is also linked to better literacy skills (Pellegrini & Galda, 1993; Roskos & Christie, 2001).

If children’s pretend play relates to emerging literacy, might it also play a role in the development of reading ability? The majority of studies in this area focus on preschool age children and conclude that play can provide a context for early literacy learning that leads to reading, such as providing children with exposure to literacy materials in play environments (Roskos & Christie, 2001). One theory states that symbolism in pretend play is used in conjunction with language to convey meaning (Pellegrini, Galda, Dresden, & Cox, 1991). In play, children must use language to explain their transformations, thus practicing using language as an integral part of the representational process. Pellegrini and colleagues (1991) longitudinal study showed that preschool children’s use of linguistic verbs in pretend play related to early reading skills. Specifically, children who used more linguistic verbs in their play were more likely to use the text on a storybook page to guide their storytelling efforts, rather than relying on the pictures. Further, greater use of symbolic transformations in pretend play predicted children’s emergent writing status. Literature linking pretend play to later reading achievement, separate from language development and early literacy, is scarce at present.

Research points to links between pretend play and math achievement. Seo and Ginsburg (2003) found a relation between play and mathematical skills, observing that 4- and 5-year old children build knowledge of foundational mathematics concepts through free play. It may be that the principle of symbolic representation, cited by Vygotsky as linking pretend play and language development, may also apply to development of early mathematics skills. A study of preschool children showed that symbolic substitution in pretend play was the strongest predictor of both reading and math skills (Hanline, Milton, & Phelps, 2008). Specific math skills tested included number comparison, mastery of number facts, calculation skills, and understanding concepts. Children who used more advanced symbolic substitution, such as pretending to play with an object that was not physically present, had higher scores on reading and math tests. The authors concluded that the use of transformations and representations in pretend play may facilitate the shift from concrete to symbolic thinking that is necessary to understand written symbols in reading and mathematics.

Other researchers have asserted that the link between play and academic achievement is mediated by factors such as improved focus/concentration (Pellegrini & Bohn, 2005) or development of socially appropriate behavior that facilitates school adjustment (Golinkoff, Hirsh-Pasek, & Singer, 2006). Although this research is based more in free play and physical play, research on pretend play also supports its connection to academic achievement. Singer and Rummo (1973) found that children whose play contained more imaginative elements performed better in school, suggesting that cognitive components of pretend play may translate into the academic setting. This may again reflect symbolic representations used in both play and reading and math.

Gender differences often arise in discussing academic achievement in children. This is particularly true in regards to math achievement, as boys have traditionally been perceived as excelling in this area. However, most recent research shows no consistent evidence for gender differences in mathematics ability (Hyde, 2005). In comparing boys and girls, effect sizes for aspects of math such as computation and problem solving are either small or nonsignificant (Hyde, 2005). The only areas in which boys seem to excel are mental rotation and spatial perception, which are often irrelevant to general mathematics performance (Linn & Petersen, 1985; Voyer, Voyer, & Bryden, 1995). However, both parents and teachers have been shown to hold biases against girls’ math.
abilities (Jussim & Eccles, 1992; Tiedemann, 2000). In addition, girls tend to believe that their math abilities are lower than boys do, despite equal grades (Lloyd, Walsh, & Yaliagh, 2005; Tiedemann, 2000). The present study sought to understand the longitudinal relation between girls' pretend play skills and their academic achievement in both reading and math.

Summary

The present study examined longitudinal relationships among early pretend play, divergent thinking, and academic achievement in school-age girls. Previous longitudinal studies have found a relationship between pretend play and divergent thinking, and research has also demonstrated a link between pretend play and reading and math achievement. The aim of the present study was to establish longitudinal correlates of pretend play in school-age girls. It was hypothesized that early measures of pretend play would predict scores on measures of divergent thinking and academic achievement, controlling for verbal ability, at a 4-year follow-up.

Method

Original Study

Participants of the original study were 61 students in a private school for girls in kindergarten through fourth grade (Hoffmann & Russ, 2012). The study took place during the 2008–2009 school year. Each child was administered the APS and the Alternate Uses Task in addition to other baseline measures. The Vocabulary subtest of the Wechsler Intelligence Scale for Children—Fourth Edition (WISC-IV) was administered to assess verbal ability. The WISC-IV Vocabulary scores were also used as a measure of verbal ability in the present study.

Affect in Play Scale (APS). The APS is a standardized 5-minute play task designed to measure various dimensions of children’s pretend play. Children receive two puppets and three blocks and are given the following instructions:

I'm here to learn about how children play. I have here two puppets and would like you to play with them any way you would like for five minutes. For example, you can have the puppets do something together. I also have some blocks that you can use. Be sure to have the puppets talk out loud. The video camera will be on so that I can remember what you say and do. I’ll tell you when to stop.

The child is informed when there is one minute left. If the child stops playing during the 5-min period, the prompt, “There's still time left, keep playing,” is given. The task is discontinued if the child cannot play after a 2-min period.

The child’s play is scored from the videotape using a criterion-based rating scale. There are five main scores: (a) organization, the quality of the plot and the complexity of the story, scored from 1 to 5; (b) imagination, the novelty and uniqueness of the play including the child’s ability to use fantasy elements, scored from 1 to 5; (c) comfort, a global rating of the child’s comfort engaging in play and their level of enjoyment, scored from 1 to 5; (d) frequency of affect, a total frequency count of affect units expressed within the play narrative (e.g., a child might have the puppets say “Yikes, a monster!” [fear] or “Whee! This slide is fun!” [happiness]); and (d) variety of affect, a total count of the number of affect categories out of 11 possible categories, expressed during the play. The 11 affect categories include happiness/pleasure, anger/aggression, sadness/hurt, nurturance/affection, anxiety/fear, oral, oral aggression, anal, sexual, competition, and frustration/dislike. Affect is also divided into positive and negative content categories.

A detailed scoring manual for the APS has been developed (Russ, 1993, 2004, 2014). Past studies have reported the interrater reliability of the APS to be high, consistently in the .80s and .90s. Internal consistency for the affect scores on the APS using the Spearman-Brown split-half reliability is also high (.85; Seja & Russ, 1999). The APS has a large body of validity studies demonstrating associations with theoretically relevant criteria (see Russ, 2004, 2014).

Alternate Uses Task. As one measure of creativity, divergent thinking was assessed using the Wallach and Kogan (1965) adaptation of Guilford’s Alternate Uses Task. The task asks children to think of uses for six common objects: a newspaper, a button, a key, an automobile tire, a shoe, and a knife. Two scores are calculated from the child’s responses to the six items: (a) fluency, the number of acceptable uses generated by the child, and (b) originality, the number of acceptable uses given by a child that made up only 1% or less of all the responses given for an item. The Alternate Uses Task has excellent reliability and validity, established in many studies conducted with children (Kogan, 1983; Runco, 1991).

Wechsler Intelligence Scales for Children—Fourth Edition. The Vocabulary subtest of the Wechsler Intelligence Scales for Children—Fourth Edition (WISC-IV) was administered as an estimate of children’s verbal ability. Participants were asked to define words of increasing difficulty and their answers were scored on a scale from 0 to 2, assessing verbal fluency, concept formation, and word knowledge. Of all the subtests on the WISC-IV, the Vocabulary subtest is generally the best estimate of overall intelligence. The Vocabulary subtest has been validated for children ages 6 to 16 and has demonstrated strong reliability and validity through correlations with other measures of intelligence and academic achievement (Wechsler, 2003).

Four-Year Follow-Up: The Present Study

Participants. Recruitment letters were sent to parents of the 46 girls who participated in the original study and were still enrolled at the school. A total of 31 girls returned consent forms and participated in this study, yielding a participation rate of 67%. Participants were in the 4th through 8th grades, ages 9 to 14, with a mean age of 11.1 years. There were 10 fourth graders, four fifth graders, three sixth graders, six seventh graders, and eight eighth graders. Information regarding ethnic background or socioeconomic status was not collected in this study, though the private school has a majority of Caucasian students. This was a private girls’ school. Thirty-eight percent of the students attending the school receive financial aid, and this sample was representative of that number.

A power analysis done with G*Power indicated that 31 participants would provide .53 power for a medium effect size. Because partial correlations were used to control for verbal ability, a degree of freedom was lost and power may have decreased. This power is lower than what is preferred for a fair test of all hypotheses, but the
number of original participants available at the school restricted the possible sample size.

**Procedure.** The present study was part of a larger follow-up assessment examining additional aspects of adaptive functioning such as coping, affect, and resiliency. The assessment occurred in the Fall of 2012 and the Spring of 2013, approximately 4 years following the baseline assessment. Children completed the Alternate Uses Task. Records of each consented participant’s AIMSweb standardized achievement test scores were released by the school. Two measures from the original study, the APS and the Vocabulary score from the WISC-IV, were used as predictors in the present study.

**Measures.**

**Alternate Uses Task.** As in the original study, Wallach and Kogan’s (1965) adaptation of Guilford’s (1950) Alternate Uses Task was used to measure children’s divergent thinking, although the present study used a group administration format. Wallach and Kogan’s (1965) group instructions were used, and children were given 2 min for each item. The administrator of this divergent thinking task was blind to children’s early APS play scores.

**AIMSweb achievement test scores.** AIMSweb is an assessment system designed to measure and monitor students’ academic performance in Grades K–8. A series of brief, 1–8 min tests are administered to students at various time points during the school year. All students in the present study are tested three times during the academic year, and at-risk students may be monitored more frequently. The present study used the most recent reading and math AIMSweb scores for each student. September scores were used for the longitudinal analyses conducted with all students’ scores. January scores were used in concurrent analyses for the 8th graders, as their concurrent data was collected during the spring semester.

The AIMSweb system is based on the principle of Curriculum-Based Measurement (CBM), which is used by teachers to assess student progress without readministering time consuming, statewide standardized tests (Shinn & Shinn, 2002). The use of CBM as a measure of student achievement has been supported across multiple states who report moderate to strong correlations between students’ performance on CBM and state achievement test scores (Powell-Smith, 2004; Shapiro, Keller, Lutz, Santoro, & Hintze, 2006). The present study used AIMSweb tests as measures of students’ academic achievement in reading fluency, reading comprehension, math calculation, and math problem solving. For each test, the AIMSweb Technical Manual reports reliability in terms of Alternate Form, a form of test–retest reliability. It also reports criterion validity of each test by comparing student performance to relevant portions of state achievement tests. Reliability and validity of each test is reported below.

The Reading Fluency task (Reading-CMB) measures students’ speed and accuracy in oral reading. Students are required to read a passage aloud, and their scores reflect the average number of words read per minute. Alternate form reliability ranges from correlations of .93 to .95 for students in Grades 4–8. Criterion validity has been established via correlations with state achievement tests, which range from .60 to .72.

The Reading Comprehension task (Maze) measures students’ skills in understanding the meaning of written text. Students read a passage in which every seventh word is blank, and they must select from three words to complete the sentences in context. Alternate form reliability ranges from .74 to .78.Criterion validity is supported, as correlations with state achievement tests range from .51–.59.

The Math Computation Task (M-COMP) measures skill in performing basic and complex calculations in areas such as addition, decimals, fractions, and percentages, among others. Student scores reflect the number of problems they answer correctly. Reliability ranges from .85 to .90. Criterion validity for this test was calculated by comparing M-COMP scores with scores on the Group Mathematics Assessment and Diagnostic Evaluation (G-MADE), given in third and eighth grades. Validity ranged from .73 to .76.

The Math Concepts and Applications test (M-CAP) measures problem solving and logical reasoning skills. Again, scores reflect the number of problems solved correctly in areas such as order of operations, measurement, patterns/relationships, and data. Reliability for students in Grades 4–8 ranges from .80 to .88. Validity data show correlations with state achievement tests ranging from .57 to .78.

For each subject test, raw scores were transformed into standardized Z scores based on national grade norms (means and standard deviations) separately for each grade to allow comparison of scores across grades.

**Data Considerations**

In this sample of 31 participants there were some missing data. Three participants from the original sample did not wish to be videotaped during the pretend play task, leaving 28 participants with APS scores. Two participants from the original sample did not complete a second baseline session and thus are missing baseline divergent thinking scores. A few students were absent on the days the AIMSweb achievement tests were given, so there are 29 scores for reading fluency, 30 for reading comprehension, and 30 for math concepts/applications. Therefore, each measure had a slightly different number of participants. Descriptive statistics of all variables are reported in Table 1. The data were examined for outliers. No outliers were found that would alter the correlations.

**Results**

**Data Analyses**

Data analysis examined longitudinal relationships between early play and current divergent thinking and academic achievement. Additional analyses examined the longitudinal relationship between early divergent thinking and current academic achievement.

Pearson product–moment correlations were used to test for significant longitudinal associations among the variables, controlling for verbal ability. Hierarchical multiple regression was used to determine which play variables predicted divergent thinking and achievement, controlling for verbal ability and age. Baseline divergent thinking was controlled for when investigating the relation

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1 To account for missing data, we attempted to use both the multiple imputation approach and the full information maximum likelihood (FIML) approach. Because of the small sample size, the data would not converge in the analyses and neither method was able to produce stable correlations. FIML did produce a few significant results in the multiple regressions that were consistent with our findings with the original data analyses.
between pretend play and later divergent thinking. An alpha value of .05 was used for all statistical tests. Effect sizes reported are based on Jacob Cohen’s (1992) categorization of small, medium, and large effect sizes for product-moment correlations. A small effect size corresponds to a correlation of .10; a medium effect size corresponds to $r = .30$; and a large effect size to $r = .50$. One-tailed tests were used for a priori hypotheses.

**Verbal Ability**

Scores on the Vocabulary section of the WISC-IV administered at baseline were used as an estimate of verbal ability. Verbal ability was used as a control variable. It was important to demonstrate that relationships among variables were not accounted for by verbal abilities. In the current sample, participants had a mean score of 12.29 ($SD = 2.42$, range = 8 to 17). The WISC-IV Vocabulary subtest has a standardized mean of 10 and standard deviation of 3, so the present sample’s mean score was approximately two thirds of a standard deviation above average. Verbal ability did not correlate significantly with pretend play or divergent thinking. As expected, verbal ability did correlate with achievement variables of reading fluency, $r(29) = .48$, $p = .01$, and reading comprehension, $r(30) = .48$, $p = .01$.

**Age**

In the present sample, significant relationships emerged among age and most of the other measures. Children’s age related to the three pretend play variables of organization, $r(28) = .39$, $p = .04$; imagination, $r(28) = .47$, $p = .01$; and positive affect, $r(28) = .37$, $p = .05$. Age also correlated positively with divergent thinking fluency, $r(31) = .53$, $p = .002$. Children’s age was related to the academic achievement scores for math computation, $r(31) = .54$, $p = .002$, and math concepts/applications, $r(30) = .53$, $p = .003$. No relation was found between age and verbal ability.

** Interrater Reliability**

Interrater reliability for the APS was calculated for the baseline sample using 20 randomly chosen participants. Interrater reliability was assessed using a rigorous form of intraclass correlation coefficient that measures absolute agreement rather than just consistency between raters (Shrout & Fleiss, 1979). A two-way random effects model was used, testing for absolute agreement using a 95% confidence interval. The average scores for the intraclass coefficients were .94 for organization, .96 for imagination, .95 for comfort, .96 for frequency of affect, .97 for variety of affect. .95 for positive affect and .98 for negative affect (Hoffmann & Russ, 2012).

**Longitudinal Results**

**Play and divergent thinking.** A major hypothesis was supported in that early pretend play significantly related to divergent thinking. All analyses involving pretend play controlled for verbal ability. The cognitive aspects of pretend play, organization and imagination, related to divergent thinking fluency (see Table 2). Organization and imagination in play positively correlated with divergent thinking fluency, $r(25) = .51$, $p = .003$, and $r(25) = .39$, $p = .02$, respectively. Children whose play was rated as better organized and containing more imaginative elements generated more responses on the divergent thinking task. The magnitudes of these correlations were medium to large effect sizes (Cohen, 1992). An examination of affect in play showed that positive affect in play related to divergent thinking originality, $r(25) = .36, p = .03$. Children who expressed greater amounts of positive affect in their play generated more original responses on the divergent thinking task. The magnitude of this correlation was a medium effect size.

When age was controlled in longitudinal analyses with pretend play, correlations remained significant between organization in play and divergent thinking fluency, $r(25) = .45, p = .01$. The relationship between divergent thinking fluency and imagination in play dropped below significance, $r(25) = .26, p = .10$, but the magnitude remained a small effect size. The same was true for the relation between divergent thinking originality and positive affect in play, $r(25) = .27, p = .09$.

In examining the longitudinal relation between pretend play and divergent thinking, it was also possible to take into account children’s initial, or baseline, divergent thinking scores. When controlling for baseline divergent thinking fluency, the relationship...
between early pretend play and current divergent thinking fluency was again significantly positively correlated. Organization in play related to divergent thinking fluency, \( r(23) = .53, p = .003 \), as did imagination in play, \( r(23) = .34, p = .046 \). Children whose early pretend play was rated as more organized and more imaginative generated more alternate uses on the divergent thinking task four years later, independent of their baseline divergent thinking skills. The magnitude of these effects was large for organization and medium for imagination.

Hierarchical multiple regression was used to determine the contribution of children’s early pretend play to current divergent thinking beyond that of age and verbal ability. Verbal ability and age were entered into Step 1, explaining 39% of the variance in divergent thinking \( F(2, 25) = 7.85, p = .002 \). Two predictors were entered into Step 2 to represent pretend play: organization and positive affect in play, which accounted for 46% of the variance in divergent thinking. These predictors were chosen based on a priori hypotheses predicting their contribution to the variance in divergent thinking as well as their observed correlations with divergent thinking. Organization in play itself accounted for 8% of the variance in divergent thinking, but its contribution did not reach significance. In the final model, age was the only significant regression coefficient, accounting for 16% of the variance in math achievement (beta = .46, \( p = .02 \)).

Divergent thinking and achievement. Longitudinal relations also emerged between divergent thinking and achievement. Children’s baseline divergent thinking scores predicted math achievement four years later. Controlling for verbal ability, divergent thinking fluency predicted math computation, \( r(22) = .62, p = .001 \). In addition, divergent thinking originality predicted both math computation, \( r(22) = .65, p < .001 \), and math concepts/applications, \( r(22) = .55, p = .047 \). Children who supplied more responses, as well as more original responses, in the divergent thinking task had higher math achievement scores 4 years later.

Play, divergent thinking, and math achievement. Pretend play and divergent thinking were combined in a hierarchical multiple regression to predict math achievement longitudinally. Positive affect in pretend play and divergent thinking fluency predicted children’s math skills (math computation), after controlling for the influence of verbal ability (WISC Vocabulary). Verbal ability was entered into Step 1, explaining 33% of the variance in math skills. After entry of positive affect in play and divergent thinking fluency at Step 2, the total variance explained by the model as a whole was 34.3%, \( F(3, 24) = 4.17, p = .02 \), \( F \) change \((2, 24) = 5.66, p = .01 \). With verbal ability controlled, 31% of the variance in math achievement was accounted for by divergent thinking and...
play. In the final model, divergent thinking fluency was the only significant regression coefficient (beta = .42, p = .04).

**Concurrent Findings**

**Divergent thinking and math achievement.** Divergent thinking related to children’s current math achievement scores. Controlling for verbal ability, divergent thinking fluency related to both math computation skills, $r(28) = .47, p = .01$, and math concepts/applications, $r(27) = .58, p = .001$. Children who generated more alternate uses scored higher on tests of math achievement.

**Discussion**

The major findings of the present study were that children’s early pretend play predicted divergent thinking and math achievement over a 4-year period. These longitudinal findings provide evidence for the predictive power of play. Divergent thinking also predicted math achievement longitudinally, and the stability of divergent thinking skills over time was demonstrated. Finally, concurrent relationships indicated that math achievement is linked to children’s divergent thinking skills. It should be noted that verbal ability did not significantly relate to play skills, and all significant relationships remained significant when verbal ability was controlled for.

**Play and Divergent Thinking**

A major finding of this study was that children’s pretend play predicted their divergent thinking skills over time. Specifically, children whose play was more organized and imaginative were able to generate more alternate uses for everyday objects, independent of verbal ability, 4 years later. Further, children who expressed more positive affect in their play were able to generate more original alternate uses. Although both cognitive and affective aspects of pretend play also related to divergent thinking at baseline (Hoffmann & Russ, 2012), their relation was maintained at the 4-year follow-up even when baseline divergent thinking scores were controlled. At the follow-up, children with better early play also had better divergent thinking abilities, beyond what their baseline divergent thinking scores would have predicted. This indicates that aspects of pretend play predict shifts in divergent thinking over time. This is the second study to find that early pretend play predicted later divergent thinking (Russ, Robins, & Christiano, 1999). Both studies also found divergent thinking to be relatively stable over time. Even though the task was administered individually at baseline and in a group format in the present study, children’s scores at baseline were predictive of their scores four years later. Both of these longitudinal studies used different administrators for the play and divergent thinking tasks, addressing recent critiques that significant results found in studies of play and creativity may be attributed to experimenter bias (Lillard et al., 2013).

Of the affective components of pretend play, positive affect in play predicted divergent thinking originality over a 4-year period. Girls who expressed more positive affect in their play were able to generate more original uses for everyday objects. A previous study found similar positive correlations between affect in play and divergent thinking longitudinally, but correlations did not reach significance (Russ, Robins, & Christiano, 1999). Negative affect in play did not relate to divergent thinking. In previous studies with samples that included both boys and girls, negative affect has related to divergent thinking (Russ & Schafer, 2006). Perhaps the relationship was present for the boys but not the girls. Several studies found relationships between primary process thinking on the Rorschach (largely aggressive percepts) and creativity for boys but not for girls (Russ, 1982, 1988; Russ & Grossman-McKee, 1990). It is possible that the use of negative affect in play is different in girls than in boys. This is an important area to be studied in the future.

A hierarchical multiple regression analysis was performed to determine whether pretend play contributed to the variance in divergent thinking over and above age and verbal ability. Analysis showed that age accounted for more variance in divergent thinking fluency than did pretend play. Although age appears to be a significant factor in children’s divergent thinking abilities, pretend play still emerged as an important contributor to divergent thinking and accounted for 8% of the variance in divergent thinking.

**Play and Math Achievement**

Early pretend play also predicted children’s math achievement. Imagination in play and the amount of affect in the story, in particular positive affect, predicted math achievement. Previous research has supported the relation between play and math achievement concurrently, but no known research has demonstrated a longitudinal relation between pretend play and math ability. One possible explanation for our results is the special focus on science and math in this particular academic setting. This all-girls’ school strives to stimulate interest in math and science, areas traditionally dominated by males. The school encourages experiential, hands-on learning through “tinkering stations” in the hallways and real-world engineering projects in the community. It is possible, then, that processes present in pretend play such as symbolism, organization, and experimentation transfer to math achievement in a setting where similar processes are emphasized in math instruction and where girls are encouraged to reach their full potential in math. Another theory, presented by Hanline and colleagues (2008), is that practice with symbolic substitution in play transfers to the symbolic representation skills required in mathematical reasoning. This is consistent with their findings demonstrating the association between transformations and representations in play and math skills in preschool children (Hanline et al., 2008).

Contrary to hypotheses, imagination in play was negatively related to reading fluency scores. The reading comprehension and reading fluency scores correlated very differently with play scores. Although play showed no relation to reading comprehension, better play seemed to predict lower reading fluency scores. These findings are not consistent with the play and literacy research and could be a chance finding. It is also possible that AIMSweb is not assessing the kind of reading ability that would relate to play. Specifically, the reading fluency test measures how many words a child can read correctly within a certain time frame. The reading fluency score, then, reflects solely the child’s reading speed and accuracy over one brief period. It does not capture components of verbal reasoning or unstructured language production. Although a
more comprehensive set of reading/language measures might be expected to relate to play, it is not surprising that neither imagination nor affect present in play correlated positively with these brief measures.

Another hierarchical multiple regression showed that the combination of positive affect in play and baseline divergent thinking significantly predicted math achievement over and above verbal ability. This confirms correlational evidence that early pretend play and divergent thinking play an important role in the emergence of mathematical skills over time.

Divergent Thinking and Math Achievement

The present study found a significant relation between divergent thinking fluency and originality at baseline and math achievement scores over time. Children with better divergent thinking skills scored higher on tests of math computation and math concepts/applications 4 years later. This suggests that some aspect of divergent thinking may translate into math achievement. The tasks may share common elements such as nonverbal, fluid reasoning, or processing speed. One study examining the relation between creativity and achievement measured divergent thinking in groups of gifted boys. Higher divergent thinking scores were strongly correlated (r = .68) with membership in the “math and science gifted” group (Runcro, 1999). However, a high correlation was also found for the “high overall IQ” group. Future research should further investigate divergent thinking as a potential contributor to children’s math achievement.

Divergent thinking fluency was also positively related to math achievement concurrently. Even controlling for verbal ability and for divergent thinking at baseline, children who had higher divergent thinking scores performed better on tests of math skills. This provides additional support for the idea that similar processes are involved in generativity or problem solving and mathematics. Similar to the relation between play and mathematics achievement, math and divergent thinking may share processes such as advanced reasoning and thinking “outside the box.” This idea was supported in a recent study showing that in adults, divergent thinking ability was specifically related to fluid intelligence (Nusbaum & Silvia, 2011). Although divergent thinking is related to overall intelligence to a certain extent, separating fluid and crystallized intelligence reveals a stronger association with fluid reasoning than with fact-based knowledge. Further exploration of the processes common to play, divergent thinking, and mathematics skills may yield interesting ideas about teaching or promoting mathematics achievement in children.

Limitations

This study has a number of limitations that may have impacted both the findings and the overall generalizability of results. First, the longitudinal design restricted the possible sample size. The resulting sample of 31 children is small, which limits the available statistical power and consequently the likelihood of finding significant results. It is possible that the contribution of pretend play to divergent thinking and reading and math achievement in the multiple regressions may have reached significance with a larger sample. A small sample size also limited the analyses we were able to perform to determine the nature of the contribution of age to the variables studied. Second, the sample was made up of female, mostly Caucasian, students in a private school setting. Ethnicity, gender, and socioeconomic status were not fully represented. Thus, the generalizability of these results to other populations may be limited. Finally, the AIMSWeb scores measuring reading and math achievement may not fully represent students’ ability levels. They are not considered a gold standard measure of academic achievement, so a more thorough measure may have shifted or strengthened the findings.

Implications

The above results carry implications for how parents and educators view pretend play, creativity, and math achievement. The present study and others show that a child’s intelligence is far from the sole determinant of her creative potential or even academic achievement. A recent meta-analysis showed that divergent thinking is a much better predictor of creative achievement than IQ (Kim, 2008). It is important for parents and educators to realize that IQ does not determine a child’s creative potential, and it may even be possible to promote math achievement in a way that does not rely so heavily on IQ. Math education that capitalizes on creative problem solving and manipulation of ideas and images may help girls to use their divergent thinking skills to improve their mathematics skills. Approaching math education through the lens of creative thinking may also engage girls more effectively. A study of upper elementary school students and teachers showed that in classrooms where teachers elicited student creativity, students showed the largest gains in academic achievement (Schaeter, Thum, & Zifkin, 2006). This may be a valuable tool to allow teachers to engage students as well as further their math achievement through different means.

Future Directions

The present study opens the door for several lines of future research. Replication of results with other more diverse populations would help to clarify the stability and generalizability of the longitudinal correlates of play. A larger sample size would also help to confirm these relationships and test for possible mediation effects. Another research question that emerged is the nature of the relationship among pretend play, divergent thinking, and math achievement. Identifying similar processes involved in all three domains may lead to investigation of ways to utilize pretend play or divergent thinking in promoting math achievement. This is a promising idea for teaching girls especially, as the present study showed significant concurrent and longitudinal relationships in an all-female sample.

References


