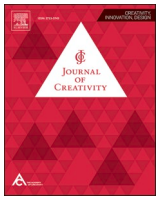
Journal of Creativity 34 (2024) 100090

Contents lists available at ScienceDirect

Journal of Creativity

journal homepage: www.elsevier.com/locate/yjoc



Exploring the creativity-curiosity link in early childhood

Julie Vaisarova, Lezxandra Saguid, Anne S. Kupfer, Helena S. Goldbaum, Kelsey Lucca *

Department of Psychology, Arizona State University, 950 S. McAllister Ave, Tempe, AZ 85287, USA

ARTICLE INFO

Keywords:
Creativity
Curiosity
Early childhood
Measurement
Child development
Cognitive development

ABSTRACT

Childhood is a pinnacle of both creativity and curiosity, and although these constructs theoretically overlap, few studies have probed whether they are directly related in childhood or driven by similar cognitive and emotional processes. Across two online Zoom sessions, 36 3- to 6 year-olds completed six tasks measuring diverse manifestations of curiosity and creativity, as well as tasks assessing vocabulary, self-esteem, and executive function. Caregivers also completed questionnaires regarding their children's curiosity. Only two significant, positive correlations were found between indices of creativity and curiosity: between originality of ideas (creativity) and breadth of exploration (curiosity), and between creativity on a production-based task and parent-reported breadth of exploration (curiosity). Further, the two constructs were predicted by different child characteristics. Age was the main predictor of creativity; originality of children's ideas in two divergent thinking tasks decreased with age, while fluency and holistic ratings of production-based tasks increased. Self-esteem, in turn, was the strongest predictor of curiosity, correlating positively with several subtypes of parent-reported curiosity. The results of this exploratory study suggest creativity and curiosity may not be as closely linked in childhood as some have proposed, and that pinpointing their relations will require careful attention to the individual components and expressions of each construct.

Introduction

Creativity and curiosity are often mentioned in the same breath. Both are critical for the ability to learn and innovate, and there is a popular perception that both peak in childhood and fade with age and education (though empirical evidence for this decline is inconclusive; Barbot et al., 2016; Claxton et al., 2005; Engel, 2011). As such, there is a clear need to understand the processes underlying both creativity and curiosity in early childhood. However, little work has mapped the trajectory of these skills before the age of 5 and even less has examined the extent to which they rely on shared or distinct cognitive and socioemotional processes. Understanding the overlap between creativity and curiosity early in life can not only help advance the field's understanding of their basic nature, but also better equip caregivers and educators to support children's creativity and curiosity. Pinpointing the mechanisms giving rise to these behaviors can help us understand whether similar practices can promote both creativity and curiosity (as is sometimes assumed; e.g., Scott-Barrett et al., 2023) or whether distinct approaches are needed.

Curiosity is broadly defined as an intrinsic desire to acquire new information and fill knowledge gaps (Berlyne, 1966; Kidd & Hayden, 2015; Loewenstein, 1994) while creativity is the generation of novel and useful ideas (Rhodes, 1961; Runco & Jaeger, 2012). Both curiosity and creativity rely on diverse cognitive and emotional processes and can be expressed in diverse ways (Amabile, 2012; Jirout & Klahr, 2012; Lubart et al., 2013). The ability to generate a creative idea, for instance, relies on the ability to identify problems, fluently generate and connect ideas, willingness to take risks, and motivation to engage in the creative endeavor (Albert & Runco, 1988; Guilford, 1959; Lubart et al., 2013; Wilson et al., 1954). Creative ideas can be expressed in diverse domains–including art, narrative, and problem-solving–with slightly different processes contributing to different expressions (Hong & Milgram, 2010; Lubart et al., 2013). Curiosity, too, is expressed in diverse ways and motivated by varied affective and cognitive states. Researchers have identified two broad categories of motivation for curiosity: seeking information because one derives joy from discovering new things (interest-type curiosity), or seeking to alleviate the discomfort associated with a gap in knowledge (deprivation-type curiosity) (Litman, 2008). Others have broken down curiosity further based on its specific focus and manifestation. For example, social curiosity (a drive to learn about others' thoughts and actions) appears to be a distinct dimension of curiosity in both children and adults (Kashdan et al., 2018; Lee et al., 2023). These various motivations, in turn, can be expressed through a

* Corresponding author.
E-mail address: klucca@asu.edu (K. Lucca).

https://doi.org/10.1016/j.yjoc.2024.100090
Received 20 March 2024; Received in revised form 16 August 2024; Accepted 7 September 2024
Available online 8 September 2024

variety of information-seeking behaviors, including exploration (interacting with the environment to find out more about it), requesting information from others, and persisting in these behaviors until curiosity is satisfied. Research suggests many of these diverse expressions of curiosity and creativity can be observed as early as infancy (Hoicka et al., 2016; Lee et al., 2023) and childhood (Russ, 2014; Vries & Lubart, 2019).

Despite having arguably distinct motivations (Singh & Murayama, 2024), curiosity and creativity have been proposed to operate in tandem. They have been linked to a common set of personality traits, including tolerance for ambiguity and openness to experience, suggesting a similar mindset sets the stage for both phenomena (Hardy et al., 2017; Kenett et al., 2023; Puryear et al., 2017). Both constructs also involve engaging with novel ideas or information, and a sensitivity to and motivation to seek novelty has been proposed as a shared underlying mechanism (Ivancovsky et al., 2024). On a neural level, similar networks–including hippocampal networks related to memory–are implicated in both (Kenett et al., 2023). Finally, curiosity and creativity involve a similar interplay of bottom-up and top-down processes. Researchers have drawn a parallel between broad, interest-driven manifestations of curiosity (desire to acquire knowledge broadly) and the divergent element of creativity (generating ideas); parallels have also been drawn between "exploitative" or deprivation-driven curiosity (striving to fill a specific knowledge gap) and convergent aspects of creativity (finding a solution for a specific problem) (Ivancovsky et al., 2024; Kenett et al., 2023). Beyond relying on similar mechanisms, creativity and curiosity might also operate sequentially with one giving rise to the other. A curiosity-driven search for information might trigger creativity by leading individuals to consider new ideas, problems, and solutions (Carr et al., 2016; Hagtvedt et al., 2019; Mumford & McIntosh, 2017). Conversely, creativity might spark curiosity because creative endeavors can lead individuals to notice knowledge gaps and generate feelings of uncertainty–a known trigger of curiosity (Baer & Kidd, 2022; Harrison, 2016; Jirout & Klahr, 2012).

While there are theoretical parallels, the link between creativity and curiosity has rarely been empirically investigated and findings are inconclusive. A recent meta-analysis of this association (Schutte & Malouff, 2020) only identified ten studies, eight focused on adults and two on middle- and high-school students. Curiosity and creativity were moderately, positively correlated across studies (mean effect size of $r = .41$), but the strength of the relation depended on the measures and the dimension(s) of creativity and curiosity assessed. The correlation was relatively strong ($r = .52$) when both constructs were measured using surveys, in which participants self-reported how well various manifestations of curiosity (e.g., seeking new experiences) and creativity (e.g., being insightful) described their behavior (Hunter et al., 2016; Schutte & Malouff, 2020). However, the link was weaker when curiosity was self-reported while creativity was measured using observer ratings of products generated by the participant. The exploration dimension of curiosity (drive to learn things broadly) was also more strongly associated with creativity than the deprivation dimension (striving to fill a specific knowledge gap). Since publication of this meta-analysis, another study has expanded this literature by examining links between adults' creativity and curiosity using behavioral measures of both constructs (Koutstaal et al., 2022). In this study, behaviors reflective of curiosity (question-asking and information-seeking) tended to be positively associated with both divergent and convergent creative thinking. However, curiosity regarding specific knowledge gaps was most strongly associated with *convergent* thinking, suggesting a specific link between deprivation-type curiosity and convergent creative processes. Collectively, this body of work highlights two important lessons for research on the creativity-curiosity link: it is essential to consider how these constructs are measured, and to consider the components of each construct.

Creativity and curiosity in childhood

Research on the creativity-curiosity link in children is even more limited than in adults. The self-report measures commonly used in adult studies can be difficult to implement with young children, whose ability to understand the questions and reflect on their own cognitive processes is limited. Notably, none of the studies in Schutte and Malouff's (2020) meta-analysis of the creativity-curiosity link included children younger than ten. This leaves open critical questions about the relation between creativity and curiosity early in development, when the foundational skills underlying both constructs are first emerging (Gross et al., 2020).

From a young age, children avidly explore their environment, and do so more persistently when there is more information to be gained–suggesting their exploration is motivated by curiosity (Perez & Feigenson, 2022; Schulz, 2015; Sim & Xu, 2017). Recent work has also found a multi-dimensional structure in children's parent-reported curiosity, similar to adults' self-reported curiosity, further suggesting curiosity comprises a coordinated set of information-seeking behaviors early in life (Kashdan et al., 2018; Lee et al., 2023). Children as young as preschool also engage in creativity-related behaviors, such as trying multiple solutions for a problem and mentally transforming objects' identities (Russ, 2014). While they may not yet have the knowledge and opportunity to generate creative products that are novel and useful to others, they have the capacity and motivation to engage in creative transformations relevant to themselves and their own learning (sometimes referred to as *mini-c* creativity; Kaufman & Beghetto, 2009). All of this evidence suggests curiosity and creativity are already present early in life, and have similar behavioral manifestations as in adulthood. However, whether creativity and curiosity engage the same processes in children and adults remains unclear. It is possible that creativity and curiosity tap into distinct sets of processes earlier in development, but become increasingly unified over time. Conversely, similar to other higher-order cognitive processes (e.g., executive function; Wiebe et al., 2011), curiosity and creativity might start out as a more foundational, unified set of skills that gradually differentiates with development.

A recent study by Evans and Jirout (2023) set out to fill this gap by examining associations between self-report and behavioral measures of curiosity and creativity in elementary-school-aged children. The researchers found moderate, positive correlations between creativity and curiosity when both constructs were assessed using self-report—asking children to indicate on a 5-point scale how well a series of curious and creative qualities (e.g., "I am excited to learn new things") describe them. However, these correlations did not hold when curiosity and creativity were assessed using behavioral measures. Evans and Jirout suggest this null association may be due to limited variability on the curiosity task and a limited range of tasks (one per construct). To assess creativity, the authors used a divergent thinking task that asked children to generate different possibilities. While this is a well-validated approach to estimating creative potential (Runco & Acar, 2012), verbal divergent thinking tasks may not tap into nonverbal aspects of creativity (Bijvoet-van den Berg & Hoicka, 2014); because they seek to isolate a particular set of processes contributing to creativity (divergent thinking), they also may not provide the full picture of children's creative abilities (Lubart et al., 2013; Runco, 2008). Similarly, there are alternate ways of assessing curiosity. Evans and Jirout (2023) assessed curiosity as a tendency to continue seeking factual information–a task that maps well onto the standard definition of curiosity as a desire for new information. However, there are additional dimensions and ways of expressing curiosity–such as a preference for uncertainty, or a tendency to prioritize exploring new things over taking advantage of familiar ones (Jirout & Klahr, 2012; Kidd & Hayden, 2015)–that could be assessed to provide a more complete picture of curiosity. In sum, it is possible there is a link between children's behavioral expressions of creativity and curiosity but existing research has not detected it.

Beyond using a wider variety of behavioral measures, understanding how creativity and curiosity relate could be bolstered by including

measures of other processes that might play a role in one or both of these constructs–including self-esteem, executive function, and vocabulary. If children's curiosity and creativity rely on similar underlying processes, examining their relations to external measures could help reveal what these processes are. If children's curiosity and creativity are more distinct, examining these associations could help illuminate how they differ. Self-esteem may support children's comfort and confidence in expressing their curiosity and creative ideas (Markey & Loewenstein, 2014; Pretz & Nelson, 2017). Executive function, in turn, may facilitate their ability to reflect on, evaluate, and modify their search for ideas or information. Although the authors are not aware of any studies that have investigated the link between curiosity and executive function in early childhood, Vaisarova and Carlson (2023) found evidence that executive function supports 5- to 6-year-old children's ability to strategically modify their creative idea-generation. Additionally, executive processes are thought to be a shared cognitive mechanism underlying adults' creativity and curiosity, suggesting they are also important to examine in children (Ivancovsky et al., 2024). Finally, vocabulary may help children articulate their curiosity and creative ideas - especially in early childhood, when verbal skills are rapidly developing. Several studies have found positive relations between vocabulary and creative task performance (e.g., Booton et al., 2021; Vaisarova & Carlson, 2021), though associations with curiosity have not been tested in this age group. While vocabulary is arguably less integral to creativity and curiosity per se, and more so to their expression, it is nevertheless critical to consider when examining correlations between them.

The current study

This exploratory study sets out to enrich the field's understanding of the link between curiosity and creativity in young children (ages 3 to 6). The study expands on prior research in several key ways. First, an exceptionally broad range of measures was used, tapping into diverse expressions of creativity and curiosity. To measure creativity, two verbal divergent thinking tasks were used in addition to two production-based measures (which are less reliant on verbal skills and might capture creativity more holistically; Lubart et al., 2013; Mottweiler & Taylor, 2014). To measure curiosity, two tasks were used to examine children's motivation to explore new spaces and learn new information. A newly developed parent-report measure of children's everyday curiosity was also included. While this method is likely prone to some of the same limitations as self-report, it has the advantage that caregivers can answer more specific, elaborate questions about children's behavior than children could answer themselves. Additionally, these measures have been shown to tap into multiple distinct dimensions of curiosity, allowing for more nuanced analyses (Lee et al., 2023; Piotrowski et al., 2014). Assessing curiosity and creativity in many different ways may help clarify whether the pattern of associations observed by Evans and Jirout (2023) truly suggests a lack of relation between curiosity and creativity in early childhood or whether the link was simply not revealed by the behavioral measures used.

The current study also includes measures of several cognitive and socioemotional processes that may be linked to both curiosity and creativity. Including these variables in studies exploring the connection between creativity and curiosity can help clarify the meaning of any null findings. For instance, while a lack of association between creativity and curiosity could suggest curiosity and creativity involve distinct cognitive and socioemotional processes, it is also possible that these traits are context-dependent, relying on task-specific combinations of cognitive and socioemotional factors (Lubart et al., 2013). Examining whether creativity and curiosity are systematically associated with distinct cognitive and socioemotional variables could help parse these explanations. For example, if curiosity and creativity are not associated with each other, but are systematically associated with different cognitive processes, this might indicate that certain aspects of curiosity and creativity are truly construct-specific. This exploratory study aims to lay a foundation for future research by providing an initial description of associations between curiosity, creativity, and three other relevant processes (vocabulary, executive function, and self-esteem) in the same sample of young children.

Method

Procedure

Data for the current study are drawn from a larger, two-part investigation of cognitive development. 157 children completed an initial Zoom session (50-70 min, with breaks), during which they played an online exploration game to assess their curiosity, participated in a parent-child book reading activity, and completed an executive function task (Vaisarova et al., 2024). A subset of these children ($N = 36$) then participated in a second session, scheduled on average 3.5 weeks after the first ($SD = 2.5$ weeks, range = 0.6 to 11.4 weeks). During this second session (65-100 min, with breaks), children completed measures of creativity, vocabulary, and self-esteem in a counterbalanced order. Approximately half of the children completed the vocabulary task first, and half completed the creativity tasks first[1]; all children completed the self-esteem task between the creativity and vocabulary tasks. Caregivers were asked not to interact with children during the research tasks, and both sessions were video recorded to assist with later coding. Between the sessions, caregivers completed a series of questionnaires reporting on their family demographics and their child's curiosity. For a schematic of all variables and measures, see Fig. 1. For readers interested in more detail about individual measures and their psychometric properties, citations can be found in Table 1. Families received a $10 gift card as an incentive for each session. The study was approved by the Institutional Review Board at Arizona State University. Parent/guardian consent and child assent was obtained at the beginning of each session.

Participants

Participants were recruited for the first study session online, through social media and ChildrenHelpingScience.com. Families who completed the first session after July 1, 2021 ($N = 123$) were also invited to sign up for the second session. Analyses for the current study include thirty-six 3- to 6-year-old children from the United States ($M_{age} = 58.1$ months, $SD = 10.5$) who completed both study sessions. Five additional children who participated in the second session were excluded from the sample because they did not fully complete any of the second session tasks. Nineteen of the participating children were described by their caregiver as female (52.8 %), 16 as male (44.4 %), and 1 as non-binary (2.8 %); 52.8 % of participants were identified by their caregiver as White, 19.4 % as Latinx/Hispanic/Latin American, 19.4 % as Asian/Asian American, 2.8 % as Middle Eastern/Middle Eastern American, and 5.6 % as multiracial. Caregivers tended to be highly educated: 47.2 % had completed a graduate degree, 33.3 % had a 4-year college degree, and the remaining 19.4 % had completed some college.

Missing data

Participants were included in the analytic sample if they had valid data for at least one behavioral measure from the second session. However, some were missing data on one or more measures due to child refusal, experimenter error, or technological issues (0 to 22.2 % of values missing per measure). These participants were excluded from individual analyses that included measures for which they were missing data. Sample sizes by measure are indicated in Table 1.

[1] Because there were no statistically significant effects of task order on any measures of child behavior, data were collapsed across orders.

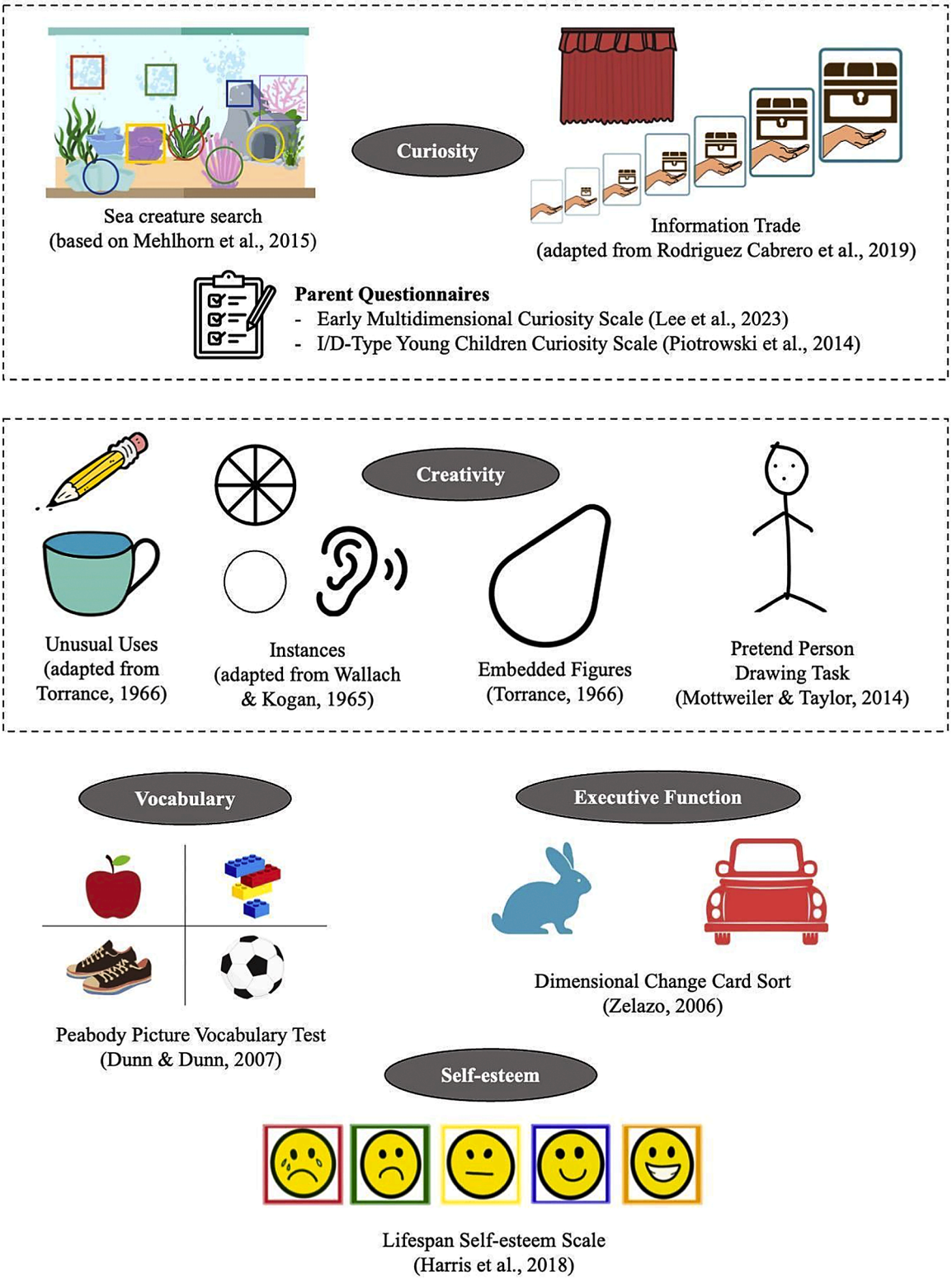


Fig. 1. Schematic of all variables and measures

Table 1
Summary of measures

Task Name	Construct	Measure Type	*N*	Citation
Sea Creature Exploration	Curiosity	Child Behavior	32	Mehlhorn et al. (2015)
Information Trade	Curiosity	Child Behavior	31	Rodriguez Cabrero et al. (2019)
Early Multidimensional Curiosity Scale	Curiosity	Caregiver Report	36	Lee et al. (2023)
I/D-Type Young Children Curiosity Scale	Curiosity	Caregiver Report	36	Piotrowski et al. (2014)
Divergent thinking: Instances	Creativity	Child Behavior	33	Wallach & Kogan (1965)
Divergent thinking: Unusual Uses	Creativity	Child Behavior	32	Torrance (1966)
Embedded Figures Task	Creativity	Child Behavior	32	Torrance (1966)
Pretend Person Drawing Task	Creativity	Child Behavior	31	Mottweiler & Taylor (2014)
Lifespan Self-Esteem Scale	Self-esteem	Child Behavior	34	Harris et al. (2018)
Peabody Picture Vocabulary Test (PPVT)	Vocabulary	Child Behavior	34	Dunn & Dunn (2007)
Dimensional Change Card Sort (DCCS)	Executive Function	Child Behavior	28	Zelazo (2006)

Measures

Curiosity

Curiosity-driven Exploration. Children's desire to explore new environments was assessed using an online search task[2]. Children were introduced to a virtual aquarium with five fish tanks, and told they would have 15 minutes to search the tanks for sea creatures. On each search attempt, they could choose to either search another of the eight hiding spots in the current tank or move on to a new tank, with the caveat that once they left a tank they could not return. The time limit made an exhaustive search of all tanks impossible, and children had to choose whether to prioritize fully searching fewer tanks or sampling all five of them. For additional details of the task protocol, see Vaisarova et al. (2024). This task drew inspiration from patch foraging paradigms, used to study decisions about the trade-off between exploiting one's current environment versus moving on to explore new, unknown environments (Mehlhorn et al., 2015). The number of tanks children explored in the 15-minute time limit was used as an index of curiosity-driven exploration, as this value reflected the extent to which children prioritized exploring tanks they had not yet seen over continuing to search in the current tank.

Information Trade. Following the search game, children's desire to learn new information was assessed using an information trade task: they were given the option to trade some of the sea creatures they had found during the search game (their "collection") to find out what was hiding behind a curtain. Children were asked whether they wanted to trade "a little or a lot," and then selected how much of their collection they wanted to trade on a 7-point scale marked with visual cues (very small to large treasure chests). A Likert-type scale was used, rather than having children trade a specific number of creatures, to account for the fact that different children found different numbers of creatures during the game.

Early Multidimensional Curiosity Scale. To assess children's tendency to express curiosity in everyday settings, caregivers completed the Early Multidimensional Curiosity Scale (EMCS; Lee et al., 2023). Caregivers read a series of statements about their child's behavior (e.g., "How often does your child ask questions or talk about things that are new to them?") and indicated the frequency of each behavior on a 5-point scale from "Never" to "Always." The current study used data from 11 EMCS items that have been found to cluster in four factors indicative of different dimensions of curiosity: social curiosity (desire to learn about other people), broad exploration (desire to explore many different features of the environment), persistence (motivation to work hard to figure out difficult tasks and problems), and information seeking (desire to seek information about a specific object or experience - e.g., a novel toy) (Lee et al., 2023). Items in each subscale were averaged to form a composite score.

I/D-Type Young Children Curiosity Scale. Caregivers completed the I/D-Type Young Children Curiosity Scale (I/D-YC) to assess two subtypes of children's curiosity: Interest-type (driven by the intrinsic joy of learning new things) and Deprivation-type (driven by the discomfort of experiencing a knowledge gap) (Piotrowski et al., 2014). Caregivers read a series of statements (e.g., "My child shows visible enjoyment when discovering something new") and rated how well each statement described their child's behavior on a 4-point scale from "almost never" to "almost always." Items within each subscale (I- and D-Type) were averaged to form a composite score.

Creativity

Divergent Thinking. Children completed two verbal divergent thinking measures–the Instances task (adapted from Wallach & Kogan, 1965) and the Unusual Uses task (adapted from Torrance, 1966). In each task, children were asked to generate multiple answers to an open-ended question. If children stopped responding for 30 seconds, or indicated they were stuck, they were reminded of the task prompt. The task continued until children had received two reminders of the prompt (see Supplementary Materials for full procedure).

Instances. Children were asked to give examples of a category with the instruction "Tell me all of the things you can think of that are _____." They completed three trials: things that are round, make noise, and move on wheels. Because the task was administered over Zoom in the child's home, and each child had different objects in their visual field, the researcher specifically asked the child to name things that were not in their room.

Unusual Uses. Children were asked to list unusual but possible uses for two objects: a pencil and a cup. When introducing each object, the researcher first prompted the child to respond with a usual use (e.g., "What do you use a pencil for?") and then prompted them to come up with unusual uses (e.g., "So we use a pencil for drawing, now tell me all the silly things you can do with a pencil that isn't drawing."). The term "unusual" was changed to "silly" because younger children during pilot testing had trouble understanding the term "unusual."

Coding. Responses from both divergent thinking tasks were transcribed from session recordings; responses that did not adhere to task instructions, were unintelligible (e.g., a single word unrelated to the task), or repeated a previous idea were transcribed but excluded from scoring. Remaining ideas were coded for fluency (number of intelligible ideas that adhered to task instructions) and originality (proportion of ideas not suggested by any other child in the sample). The divergent thinking tasks were coded by the second author, and another researcher coded fluency for approximately 20 % of the sample to assess reliability. Reliability was excellent, $ICC = .986$ and .974 for Instances and Unusual Uses, respectively.

Production-based Creativity Tasks. Two production-based tasks were administered, in which children were asked to create a drawing based on certain instructions: the Embedded Figures task (adapted from Torrance, 1990) and the Pretend Person drawing task (adapted from

[2] The first session of the larger study from which these data are drawn included an experimental manipulation to promote children's strategic exploration (Vaisarova et al., 2024). Approximately half of the children in the current study sample had been assigned to each condition, and there were no significant condition differences in this sample on any of the curiosity or creativity measures.

Mottweiler & Taylor, 2014). In both tasks, children were given up to 5 min to complete their drawing, with the researcher asking after 4 min whether they needed more time.

Embedded Figures. Children were shown an enclosed, pear-like shape (see Fig. 1) and asked to create a drawing that included this shape. After completing their drawing, children were asked to name it and tell the researcher a story about it. This gave children a chance to explain and elaborate on their drawing, providing additional information for coders. The Embedded Figures task was scored using a criterion-referenced approach, adapted from the TTCT manual (Torrance, 2018). Children's drawings and accompanying stories were scored for twelve creative strengths on a scale of 0 (no evidence of this strength in the child's drawing, title or story), 1 (moderate evidence), or 2 (highly prevalent). These strengths included emotional expressiveness, storytelling articulateness, internal visualization, and extending or breaking boundaries (see Torrance, 2018, for details; all strengths except Synthesis of Lines were scored in the current study). The second author scored this task for all children, and a second researcher coded approximately 15 % of the sample to assess reliability. Reliability of total Embedded Figures scores (the primary outcome analyzed in the current study) was excellent, $ICC = .936$.

Pretend Person. Children were asked to first draw a picture of a "real person" and then draw a picture of a "pretend person, a person that couldn't exist, a person that is made up." After finishing their drawings, children were asked to name and tell a story about them. The Pretend Person task was scored for two qualities: elaboration and overall creativity. Elaboration—the addition of detail to a product—is considered a key element of creativity alongside the more commonly measured elements of fluency and originality (Torrance, 1969). The elaboration scale developed for this study captured children's addition of detail to their "real" vs. "pretend" drawings, assigning a score from 0 to 7 based on the degree of difference. A rating of 4 indicated few differences between the drawings, with lower scores indicating a less elaborated pretend person (compared to the real person) and higher scores indicating a more elaborated pretend person. A score of zero indicated the child did not follow instructions and their "real" drawing did not contain any human-like features. Details of this protocol are found in the Supplementary Materials. The second author scored this task for all children, and two additional coders scored approximately 25 % of the sample to assess reliability. Agreement among the three coders was good, $ICC = .831$. Creativity was scored using the consensual assessment technique, following Mottweiler and Taylor's (2014) procedure. Three undergraduate research assistants with developmental psychology experience reviewed children's drawings and descriptions in different random orders, and rated each child's approach to the task on a scale from 1 (not at all creative) to 5 (very creative). Coders were asked to use their own definition of "creativity" and to not factor children's drawing or verbal abilities into their scores. Agreement among the three coders was good, $ICC = .801$, and ratings were averaged across coders to yield a final creativity score.

Self-esteem

To assess self-esteem, children completed an adaptation of the Lifespan Self-Esteem Scale (LSE; Harris et al., 2018). This self-report measure comprised four questions answered on a 5-point Likert scale ranging from "really sad" to "really happy," with each scale point illustrated with a picture of a face. To conduct the task via Zoom, each image had a different-colored border and children were asked to indicate their answer by telling the researcher which color matched their feelings (e.g., "Which color tells me how you feel about yourself?") A composite score was calculated by averaging children's ratings on the four items.

Vocabulary

To assess receptive vocabulary, children completed the Peabody Picture Vocabulary Test, 4th edition (PPVT; Dunn & Dunn, 2007). In this task, children are shown sets of four pictures and asked to point to the one that matches a word spoken by the researcher. To adapt the PPVT for online administration, children were taught to respond by pointing to the left or right side of the screen and telling the researcher whether the target image was on the top or bottom. A brief calibration phase was added at the start of the task, to ensure children could follow these instructions and the researcher could accurately record their pointing. To assess children's engagement in adjunctive behaviors during the PPVT (data not reported in the current paper), caregivers were asked to place the following objects within reach: one piece of paper, one dark-colored marker, a water bottle, and a favorite toy. Otherwise, the task followed standard PPVT administration and scoring.

Executive function

To assess executive function skills–particularly cognitive flexibility–children completed an online adaptation of the Dimensional Change Card Sort (DCCS; Zelazo, 2006). Children were shown images that differed along the dimensions of shape (truck vs. rabbit) and color (red vs. blue) and asked to sort them by pointing to two reference images (a red truck and blue rabbit) located on opposite sides of the screen. For the first six trials, children were asked to sort based on color; then, the rule was changed and children were asked to sort by shape for six trials. Children's accuracy on the six post-switch trials was recorded as their score.

Results

Preliminary analyses

Descriptive statistics for all measures are shown in Table 2. Due to the non-normal distributions of several creativity and curiosity indices, all correlations reported are Spearman's correlations. Before exploring associations between creativity and curiosity, age differences were examined. Among the creativity indices, fluency was positively associated with age ($r_S = 0.38$, $p = .031$ for Instances and $r_S = 0.43$, $p = .014$ for Unusual Uses) as were scores on the Embedded Figures task ($r_S = .52$, $p = .003$) and both Pretend Person task indices ($r_S = .63$ for elaboration and $r_S = .70$ for creativity, $ps < .001$). Originality on the Instances task, in contrast, was negatively associated with age ($r_S = -.53$, $p = .002$). Among the curiosity indices, only the Broad Exploration subscale of the EMCS was positively associated with age ($r_S = .35$, $p = .038$).

Table 2
Descriptive statistics for all measures.

Construct	Measure	Range	*M* (*SD*)	Skew
Creativity	Instances: Fluency	1-46	15.06 (11.88)	1.16
Creativity	Uses: Fluency	0-21	5.81 (5.38)	0.98
Creativity	Instances: Originality	0-1	0.44 (0.20)	0.28
Creativity	Uses: Originality	0-1	0.71 (0.35)	-1.13
Creativity	Draw a Person: Elaboration	0-7	3.29 (2.67)	0.09
Creativity	Draw a Person: Creativity	1-5	3.29 (1.20)	0.21
Creativity	Embedded Figures Total Score	0-14	6.12 (4.13)	0.45
Curiosity	Environments Explored	2-5	4.47 (0.88)	-1.29
Curiosity	Info Trade	0-6	2.74 (2.11)	0.45
Curiosity	EMCS: Social Curiosity	2-5	3.75 (0.79)	-0.27
Curiosity	EMCS: Broad Exploration	1.5-5	4.12 (0.79)	-1.09
Curiosity	EMCS: Persistence	2-4	3.25 (0.46)	0.00
Curiosity	EMCS: Info Seeking	2.7-5	3.90 (0.53)	-0.20
Curiosity	I/D-YC: Interest	2.8-4	3.71 (0.34)	-1.06
Curiosity	I/D-YC: Deprivation	2-4	2.91 (0.53)	0.28
Vocabulary	PPVT Standardized Score	76-143	113.62 (18.88)	-0.48
Self-esteem	Self-esteem Rating	2.25-5	3.94 (0.66)	-0.42
Executive Function	DCCS Level 2 Accuracy	0-1	0.77 (0.37)	-1.24

Table 3
Bivariate Spearman's correlations between creativity and curiosity indices. Gray background denotes correlations between measures of creativity and curiosity; white background denotes correlations within constructs.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Instances: Fluency	–													
2 Uses: Fluency	**.48****	–												
3 Instances: Originality	.14	-.02	–											
4 Uses: Originality	-.06	.30	.14	–										
5 Pretend Person: Elaboration	.09	.24	-.18	.11	–									
6 Pretend Person: Creativity	.20	.31	**-.53****	-.12	.35	–								
7 Embedded Figures	-.02	.30	-.28	-.04	**.45***	**.55***	–							
8 Environments Explored	.29	-.15	**.48****	.01	-.28	**-.38***	**-.37***	–						
9 Information Trade	-.07	-.08	-.11	-.06	-.18	.06	.08	-.03	–					
10 EMCS: Social Curiosity	-.06	-.03	-.31	-.01	.04	.23	-.03	-.29	.20	–				
11 EMCS: Broad Exploration	.11	.22	-.14	-.01	.24	**.42***	.20	-.11	-.03	**.44****	–			
12 EMCS: Persistence	-.01	-.25	.00	-.13	-.30	-.02	.09	.13	.12	-.02	.04	–		
13 EMCS: Info Seeking	.21	.11	.16	.04	-.03	-.04	-.04	-.05	-.04	**.33***	.23	.22	–	
14 I/D-YC: Interest	.23	-.09	-.02	-.03	-.02	-.19	-.21	.14	-.11	**.38***	.19	.11	**.50****	
15 I/D-YC: Deprivation	.06	-.06	.05	.19	.11	-.14	-.13	.29	**-.40***	**.01**	.20	.23	**.44****	**.55****

*$p < .05$, **$p < .001$

Curiosity and creativity: Bivariate associations

Bivariate associations between all curiosity and creativity measures are summarized in Table 3. Only two significant positive associations were found between the two constructs: originality on the Instances task was associated with the number of environments explored in the virtual search game ($r_S = .48$, $p = .008$) and creativity on the Pretend Person task was associated with parent-reported broad exploration ($r_S = .42$, $p = .018$). The former association, but not the latter, remained marginally significant after controlling for age ($r_S = .37$, $p = .05$). Surprisingly, Embedded Figures scores were *negatively* associated with the number of environments explored (an index of curiosity; $r_S = -.37$, $p = .049$) as were Pretend Person creativity scores ($r_S = -.38$, $p = .045$). However, after controlling for age, these associations were no longer statistically significant ($ps > 0.20$).

Predictors of creativity and curiosity

To further explore whether creativity and curiosity draw on similar cognitive and socioemotional factors, correlations with children's vocabulary, executive function, and self-esteem were examined. Results are summarized in Table 4. Overall, children's self-esteem appeared to be the best predictor of their curiosity; self-esteem correlated positively with the information-seeking subscale of the EMCS and and the two I/D-YC subscales ($ps < .05$). In contrast, as summarized above, age was the strongest predictor of creativity.

Table 4
Spearman's correlations between creativity and curiosity measures and child vocabulary, executive function, self-esteem, and age.

	Correlation with…			
Creativity or Curiosity Index	Vocabulary	Executive Function	Self-esteem	Age
Instances: Fluency	-.05	-.22	.28	.38*
Uses: Fluency	.34	.18	.16	.43*
Instances: Originality	-.07	-.18	-.02	-.53**
Uses: Originality	-.05	.09	.07	-.17
Pretend Person: Elaboration	.08	.31	.10	.63**
Pretend Person: Creativity	-.01	.36	.27	.70**
Embedded Figures	.07	.40*	.14	.52**
Environments Explored	.00	-.26	.14	-.35
Information Trade	-.33	-.43*	.07	-.14
EMCS: Social Curiosity	.01	-.19	-.13	.03
EMCS: Broad Exploration	.10	.08	-.02	.35*
EMCS: Persistence	-.16	-.07	.25	-.14
EMCS: Info Seeking	.04	.03	.36*	.00
I/D-YC: Interest	-.09	-.24	.43*	.08
I/D-YC: Deprivation	.06	-.03	.47**	-.01

*$p < .05$, **$p < .001$

Children's scores on the Embedded Figures correlated positively with their executive function scores ($r_S = .40$, $p = .045$), although this association appeared to be explained by age and dropped below the level of conventional statistical significance when age was held constant ($p = .16$). Children's willingness to trade their virtual sea creature collection for new information was negatively correlated with executive function, ($r_S = -.43$, $p = .024$), and this association remained significant with age held constant ($p = .03$). Finally, none of the creativity or curiosity indicators were significantly correlated with children's vocabulary.

Discussion

This exploratory study investigated links between creativity and curiosity–along with the potentially related constructs of self-esteem, executive function, and vocabulary–among 3- to 6-year-old children in the United States. Across six behavioral indices of creativity, two behavioral indices of curiosity, and six parent-report indices of curiosity, very few associations were observed between these constructs. Although the small sample may have limited power to detect small associations, this pattern of results could suggest that creativity and curiosity are relatively independent in early childhood and point to a need to consider them separately in research and intervention. It might also, however, reflect their multifaceted nature. Both creativity and curiosity rely on multiple cognitive, socioemotional, and environmental factors (Amabile, 2012; Kashdan et al., 2018). Even if some of these underlying processes are shared across behavioral tasks, the specific manner in which curiosity and creativity are ultimately expressed may depend on how a particular task engages these processes (Barbot et al., 2016; Lubart et al., 2013). As suggested by Gross et al. (2020) and Evans and Jirout (2023), curiosity and creativity might be most meaningfully linked when they unfold during the same activity–for instance, when curiosity-driven exploration of materials leads to a creative solution to a problem (Evans et al., 2021).

In the current study, indices of children's creativity and curiosity also showed distinct patterns of developmental difference and association with other cognitive and socioemotional factors. Creativity, but not curiosity, differed with age; fluency and production-based creativity increased with age, while originality decreased. This study thus joins a body of research casting doubt on the popular perception that creativity fades with age, and suggesting developmental patterns depend on which aspects of creativity are examined (e.g., Charles & Runco, 2001; Kleibeuker et al., 2013). Though this was not directly examined in the

current study, the inconsistent developmental patterns might also point to the role of other cognitive skills that develop throughout early childhood–including language, task-relevant knowledge, and metacognition–in supporting children's ability to express their creativity (Vaisarova & Carlson, 2021; Vaisarova & Lucca, 2024). Further research is needed to pinpoint what these skills might be and whether they distinctly support creativity versus curiosity. It is particularly notable that the measures most reliant on fine motor skills (Embedded Figures and Pretend Person) showed the strongest positive associations with age. This pattern speaks to the challenge of parsing children's creativity from the skills needed to express it–particularly in early childhood, when many skills are rapidly developing–and raises the question of whether these skills are integral to children's creativity or a confounding factor.

In contrast to indices of creativity, parent-reported indicators of curiosity tended to be associated with higher child self-esteem. Speculatively, self-esteem might enhance children's willingness to express curiosity in everyday contexts. Children with more positive feelings about themselves may be less tentative to ask questions, meet new people, and explore new objects, and might have more positive expectations about the outcomes of these information-seeking actions (Markey & Loewenstein, 2014). Theoretically, this phenomenon might be expected to extend to everyday expressions of creativity. For example, self-esteem may expand or constrain the expression of children's creativity in social settings (e.g., due to social pressure for conformity; Hook & Tegano, 2002; Torrance, 1962). However, because creativity was only assessed in controlled behavioral tasks, this remains a question for future research.

Only one association was observed between creativity or curiosity and children's executive function skills: children with stronger executive function skills tended to trade fewer virtual "sea creatures" for new information. One possible explanation for this pattern is that children with stronger executive function were more likely to pause and reflect on the costs and benefits of their choice, and perhaps to inhibit the impulse to trade large numbers of "creatures" (as this did not actually yield additional benefit). This possibility warrants consideration, as it suggests highly curious children with strong EF skills might not consistently display their curiosity in this type of willingness-to-pay task. However, given the small sample and limited variability on the executive function measure–particularly among older children–this possibility requires further investigation using more sensitive measures of executive function.

It is also notable that children's scores were positively associated within but not across the two types of creativity tasks: divergent thinking and production-based. This pattern speaks to the multifaceted nature of creativity and the fact that different creativity tasks can draw on different sets of processes. In particular, production-based tasks that call for a single creative product are thought to involve more synthesis and convergent thinking (narrowing in on the best idea), while divergent thinking tasks that call for generating many possibilities primarily tap into associative and exploratory processes (Lubart et al., 2013). These two sets of creative thinking processes appear to be distinct by ages 7-10 (Vries & Lubart, 2019). The current study extends this research by suggesting they might be differentiated even earlier.

Finally, it is somewhat unexpected that no associations were found between vocabulary and creativity, given the verbal nature of some of the creativity tasks and past research linking certain indices of creative performance to verbal skills during middle childhood (e.g., Booton et al., 2021; Lin & Shih, 2016; Mottweiler & Taylor, 2014; Vaisarova & Carlson, 2021). It is important to note, however, that the present study assessed receptive vocabulary (understanding words) rather than expressive language skills (verbalizing ideas). Expressive language skills might be more important for children's ability to express creative ideas than the volume of words they recognize; indeed, past research suggests more consistent links between children's creative task performance and expressive language (Lin & Shih, 2016; Mottweiler & Taylor, 2014; Vaisarova & Carlson, 2021) than receptive language (Taylor et al., 2020).

Limitations and future directions

The time-intensive nature of collecting data across two virtual sessions–including nine behavioral tasks and multiple parent-report questionnaires–limited our ability to recruit and retain a large sample. While the small sample limits the study's statistical power and the generalizability of the conclusions, the richness of the data allowed for a broad exploration of associations between diverse measures of curiosity and creativity that would be impossible with fewer measures. Given the exploratory nature and small sample size of this study, we encourage readers to focus on the overall pattern of associations and their consistency (or inconsistency) across measures–rather than drawing conclusions about the statistical significance and meaning of individual pairwise correlations–and to use these as a starting point for generating hypotheses. Given the large number of ways creativity and curiosity can be expressed, these findings offer a useful starting point to help guide researchers in determining which measures to use and which dimensions to further investigate. For instance, future work might test whether the two curiosity-creativity associations observed here (production-based creativity with observed exploration and production-based creativity with parent-reported exploration) replicate in a larger sample, and if so which underlying processes might explain these specific associations.

The current conclusions are also limited by the relatively small number of behavioral curiosity measures compared to behavioral creativity measures. Behavioral measures of curiosity–in childhood and across the lifespan–have been notoriously difficult to develop (Gross et al., 2020; Jirout & Klahr, 2012). However, multiple behavioral measures of young children's preference for uncertainty (Evans et al., 2023) and other curiosity-driven behaviors (Vaisarova et al., 2023; Vaisarova & Lucca, 2024) are currently in development. Including these new measures in future research will further enrich understanding of relations between curiosity and creativity. To better elucidate whether these constructs are truly independent in childhood, or whether the present findings suggest their behavioral expressions are simply more situational than stable at a young age, future work should also develop tasks that allow for examining curiosity and creativity in the context of the same activity (Evans et al., 2021; Gross et al., 2020).

Moving forward, these findings point to the value of a nuanced, multi-method approach that combines multiple behavioral and questionnaire measures to investigate the relation between creativity and curiosity in early childhood. Continuing to probe how curiosity and creativity relate at this age, and the cognitive and socioemotional processes that support them early in development, is critical for advancing theoretical understanding of these constructs and providing educators and caregivers with tools to support children's curiosity and creativity.

CRediT authorship contribution statement

Julie Vaisarova: Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Lezxandra Saguid:** Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anne S. Kupfer:** Writing – review & editing, Conceptualization. **Helena S. Goldbaum:** Writing – original draft, Writing – review & editing. **Kelsey Lucca:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Kelsey Lucca reports financial support was provided by National Science Foundation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank the families who participated in this research and the research assistants who helped with data collection and coding (Sarah Kiefer, Nicole Johnson, Mario Alvarez, Natalia Gonzalez, Anna Hinojosa, Dylan Perazzo, Miranda Salinas, and Brooke Smith), as well as other members of the Emerging Minds Lab at Arizona State University for their feedback on this project. Acknowledgements to the website ChildrenHelpingScience.com for support with participant recruitment. This research was funded by Arizona State University and an NSF CAREER grant awarded to Kelsey Lucca ("Cultivating Curiosity to Promote Learning and Discovery," BCS 2047194). These funders did not play a role in the study design, data collection, analysis and interpretation of data, writing of the report, or the decision to submit this article for publication.

During the final review of this manuscript, the authors used Chat GPT to proofread the manuscript and ensure clarity in the writing. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.yjoc.2024.100090.

References

Albert, R. S., & Runco, M. A. (1988). Independence and the creative potential of gifted and exceptionally gifted boys. *Journal of Youth and Adolescence, 18*(3), 221–230. https://doi.org/10.1007/BF02139037

Amabile, T. M. (2012). *Componential theory of creativity*. 10.

Baer, C., & Kidd, C. (2022). Learning with certainty in childhood. *Trends in Cognitive Sciences, 26*(10), 887–896. https://doi.org/10.1016/j.tics.2022.07.010

Barbot, B., Lubart, T. I., & Besançon, M. (2016). Peaks, Slumps, and Bumps": Individual differences in the development of creativity in children and adolescents: "Peaks, Slumps, and Bumps. *New Directions for Child and Adolescent Development, 2016*(151), 33–45. https://doi.org/10.1002/cad.20152

Berlyne, D. E. (1966). Curiosity and exploration. *Science, 153*, 25–33.

Bijvoet-van den Berg, S., & Hoicka, E (2014). Individual differences and age-related changes in divergent thinking in toddlers and preschoolers. *Developmental Psychology, 50*(6), 1629–1639. https://doi.org/10.1037/a0036131

Booton, S. A., Hoicka, E., O'Grady, A. M., Chan, H. Y. N., & Murphy, V. A. (2021). Children's divergent thinking and bilingualism. *Thinking Skills and Creativity, 41*, Article 100918. https://doi.org/10.1016/j.tsc.2021.100918

Carr, K., Kendal, R. L., & Flynn, E. G. (2016). Eureka!: What is innovation, how does it develop, and who does it? *Child Development, 87*(5), 1505–1519. https://doi.org/10.1111/cdev.12549

Charles, R. E., & Runco, M. A. (2001). Developmental trends in the evaluative and divergent thinking of children. *Creativity Research Journal, 13*(3–4), 417–437. https://doi.org/10.1207/S15326934CRJ1334_19

Claxton, A. F., Pannells, T. C., & Rhoads, P. A. (2005). Developmental trends in the creativity of school-age children. *Creativity Research Journal, 17*(4), 327–335. https://doi.org/10.1207/s15326934crj1704_4

Dunn, L. M., & Dunn, D. M. (2007). *Peabody Picture Vocabulary Test—Fourth Edition*. Pearson. http://pearsonassessments.com/HAIWEB/Cultures/en-us/Productdetail.htm?Pid=PAa30700&Mode=summary.

Engel, S. (2011). Children's need to know: Curiosity in schools. *Harvard Educational Review, 81*(4), 625–645. https://doi.org/10.17763/haer.81.4.h054131316473115

Evans, N. S., & Jirout, J. J. (2023). Investigating the relation between curiosity and creativity. *Journal of Creativity, 33*(1), Article 100038. https://doi.org/10.1016/j.yjoc.2022.100038

Evans, N. S., Matthews, S. E., & Jirout, J. J. (2023). *Investigating students' exploration when encountering differing levels of uncertainty*.

Evans, N. S., Todaro, R. D., Schlesinger, M. A., Golinkoff, R. M., & Hirsh-Pasek, K. (2021). Examining the impact of children's exploration behaviors on creativity. *Journal of Experimental Child Psychology, 207*, Article 105091. https://doi.org/10.1016/j.jecp.2021.105091

Gross, M. E., Zedelius, C. M., & Schooler, J. W. (2020). Cultivating an understanding of curiosity as a seed for creativity. *Current Opinion in Behavioral Sciences, 35*, 77–82. https://doi.org/10.1016/j.cobeha.2020.07.015

Guilford, J. P. (1959). *Three faces of intellect*. 14(8), 469–479.

Hagtvedt, L. P., Dossinger, K., Harrison, S. H., & Huang, L. (2019). Curiosity made the cat more creative: Specific curiosity as a driver of creativity. *Organizational Behavior and Human Decision Processes, 150*, 1–13. https://doi.org/10.1016/j.obhdp.2018.10.007

Hardy, J. H., Ness, A. M., & Mecca, J. (2017). Outside the box: Epistemic curiosity as a predictor of creative problem solving and creative performance. *Personality and Individual Differences, 104*, 230–237. https://doi.org/10.1016/j.paid.2016.08.004

Harris, M. A., Donnellan, M. B., & Trzesniewski, K. H. (2018). The lifespan self-esteem scale: Initial validation of a new measure of global self-esteem. *Journal of Personality Assessment, 100*(1), 84–95. https://doi.org/10.1080/00223891.2016.1278380

Harrison, S. (2016). Fueling, curating, connecting and fascinating: Why and how creativity provokes curiosity. *Capitalizing on creativity a work* (pp. 76–85). Edward Elgar Publishing.

Hoicka, E., Mowat, R., Kirkwood, J., Kerr, T., Carberry, M., & Bijvoet-van den Berg, S (2016). One-year-olds think creatively, just like their parents. *Child Development, 87*(4), 1099–1105. https://doi.org/10.1111/cdev.12531

Hong, E., & Milgram, R. M. (2010). Creative thinking ability: Domain generality and specificity. *Creativity Research Journal, 22*(3), 272–287. https://doi.org/10.1080/10400419.2010.503535

Hook, C. W., & Tegano, D. W. (2002). The relationship between creativity and conformity among preschool children. *The Journal of Creative Behavior, 36*(1), 1–16. https://doi.org/10.1002/j.2162-6057.2002.tb01053.x

Hunter, J. A., Abraham, E. H., Hunter, A. G., Goldberg, L. C., & Eastwood, J. D. (2016). Personality and boredom proneness in the prediction of creativity and curiosity. *Thinking Skills and Creativity, 22*, 48–57. https://doi.org/10.1016/j.tsc.2016.08.002

Ivancovsky, T., Baror, S., & Bar, M. (2024). A shared novelty-seeking basis for creativity and curiosity. *Behavioral and Brain Sciences, 47*, e89. https://doi.org/10.1017/S0140525X23002807

Jirout, J. J., & Klahr, D. (2012). Children's scientific curiosity: In search of an operational definition of an elusive concept. *Developmental Review, 32*(2), 125–160. https://doi.org/10.1016/j.dr.2012.04.002

Kashdan, T. B., Stiksma, M. C., Disabato, D. J., McKnight, P. E., Bekier, J., Kaji, J., & Lazarus, R. (2018). The five-dimensional curiosity scale: Capturing the bandwidth of curiosity and identifying four unique subgroups of curious people. *Journal of Research in Personality, 73*, 130–149. https://doi.org/10.1016/j.jrp.2017.11.011

Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four C Model of creativity. *Review of General Psychology, 13*(1), 1–12. https://doi.org/10.1037/a0013688

Kenett, Y. N., Humphries, S., & Chatterjee, A. (2023). A thirst for knowledge: Grounding curiosity, creativity, and aesthetics in memory and reward neural systems. *Creativity Research Journal, 35*(3), 412–426. https://doi.org/10.1080/10400419.2023.2165748

Kidd, C., & Hayden, B. Y. (2015). The psychology and neuroscience of curiosity. *Neuron, 88*(3), 449–460. https://doi.org/10.1016/j.neuron.2015.09.010

Kleibeuker, S. W., De Dreu, C. K. W., & Crone, E. A. (2013). The development of creative cognition across adolescence: Distinct trajectories for insight and divergent thinking: Creative cognition across adolescence. *Developmental Science, 16*(1), 2–12. https://doi.org/10.1111/j.1467-7687.2012.01176.x

Koutstaal, W., Kedrick, K., & Gonzalez-Brito, J. (2022). Capturing, clarifying, and consolidating the curiosity-creativity connection. *Scientific Reports, 12*(1), 15300. https://doi.org/10.1038/s41598-022-19694-4

Lee, N., Lazaro, V., Wang, J. J., Şen, H. H., & Lucca, K. (2023). Exploring individual differences in infants' looking preferences for impossible events: The early multidimensional curiosity scale. *Frontiers in Psychology, 13*, Article 1015649. https://doi.org/10.3389/fpsyg.2022.1015649

Lin, W. L., & Shih, Y. L. (2016). The developmental trends of different creative potentials in relation to children's reasoning abilities: From a cognitive theoretical perspective. *Thinking Skills and Creativity, 22*, 36–47. https://doi.org/10.1016/j.tsc.2016.08.004

Litman, J. A. (2008). Interest and deprivation factors of epistemic curiosity. *Personality and Individual Differences, 44*(7), 1585–1595. https://doi.org/10.1016/j.paid.2008.01.014

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin, 116*, 75–98.

Lubart, T., Zenasni, F., & Barbot, B. (2013). *Creative Potential And Its Measurement*, 176.

Markey, A., & Loewenstein, G. (2014). Curiosity. *International handbook of emotions in education* (pp. 228–245). Routledge, 1st ed.

Mehlhorn, K., Newell, B. R., Todd, P. M., Lee, M. D., Morgan, K., Braithwaite, V. A., Hausmann, D., Fiedler, K., & Gonzalez, C. (2015). Unpacking the exploration–exploitation tradeoff: A synthesis of human and animal literatures. *Decision, 2*(3), 191–215. https://doi.org/10.1037/dec0000033

Mottweiler, C. M., & Taylor, M. (2014). Elaborated role play and creativity in preschool age children. *Psychology of Aesthetics, Creativity, and the Arts, 8*(3), 277–286. https://doi.org/10.1037/a0036083

Mumford, M. D., & McIntosh, T. (2017). Creative thinking processes: The past and the future. *The Journal of Creative Behavior, 51*(4), 317–322. https://doi.org/10.1002/jocb.197

Perez, J., & Feigenson, L. (2022). Violations of expectation trigger infants to search for explanations. *Cognition, 218*, Article 104942. https://doi.org/10.1016/j.cognition.2021.104942

Piotrowski, J. T., Litman, J. A., & Valkenburg, P. (2014). Measuring epistemic curiosity in young children: Brief report. *Infant and Child Development, 23*(5), 542–553. https://doi.org/10.1002/icd.1847

Pretz, J. E., & Nelson, D. (2017). Chapter 9: creativity is influenced by domain, creative self-efficacy, mindset, self-efficacy, and self-esteem. *The Creative Self: Effect of Beliefs, Self-Efficacy, Mindset, and Identity* (pp. 155–170). Academic Press.

Puryear, J. S., Kettler, T., & Rinn, A. N. (2017). Relationships of personality to differential conceptions of creativity: A systematic review. *Psychology of Aesthetics, Creativity, and the Arts, 11*(1), 59–68. https://doi.org/10.1037/aca0000079

Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan, 42*(7), 305–310.

Rodriguez Cabrero, J. A. M., Zhu, J. Q., & Ludvig, E. A. (2019). Costly curiosity: People pay a price to resolve an uncertain gamble early. *Behavioural Processes, 160*, 20–25. https://doi.org/10.1016/j.beproc.2018.12.015

Runco, M. A. (2008). Commentary: Divergent thinking is not synonymous with creativity. *Psychology of Aesthetics, Creativity, and the Arts, 2*(2), 93–96. https://doi.org/10.1037/1931-3896.2.2.93

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal, 24*(1), 66–75. https://doi.org/10.1080/10400419.2012.652929

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal, 24*(1), 92–96. https://doi.org/10.1080/10400419.2012.650092

Russ, S. (2014). *Pretend play in childhood: foundation of adult creativity*.

Schulz, L. (2015). Infants explore the unexpected. *Science, 348*(6230), 42–43. https://doi.org/10.1126/science.aab0582

Schutte, N. S., & Malouff, J. M. (2020). A meta-analysis of the relationship between curiosity and creativity. *The Journal of Creative Behavior, 54*(4), 940–947. https://doi.org/10.1002/jocb.421

Scott-Barrett, J., Johnston, S. K., Denton-Calabrese, T., McGrane, J. A., & Hopfenbeck, T. N. (2023). Nurturing curiosity and creativity in primary school classrooms. *Teaching and Teacher Education, 135*, Article 104356. https://doi.org/10.1016/j.tate.2023.104356

Sim, Z. L., & Xu, F. (2017). Infants preferentially approach and explore the unexpected. *British Journal of Developmental Psychology, 35*(4), 596–608. https://doi.org/10.1111/bjdp.12198

Singh, A., & Murayama, K. (2024). Creativity is motivated by novelty. Curiosity is triggered by uncertainty. *Behavioral and Brain Sciences, 47*. https://doi.org/10.1017/S0140525X23003291

Taylor, M., Mottweiler, C. M., Aguiar, N. R., Naylor, E. R., & Levernier, J. G. (2020). Paracosms: The imaginary worlds of middle childhood. *Child Development*, (1), 91. https://doi.org/10.1111/cdev.13162

Torrance, E. P. (1962). *Creative development, 20*.

Torrance, E. P. (1966). *The Torrance tests of creative thinking—Norms: Technical manual research edition—Verbal Tests, Forms A and B - Figural tests, Forms A and B*. Personnel Presss.

Torrance, E. P. (1969). Prediction of adult creative achievement among high school seniors. *Gifted Child Quarterly, 13*(4), 223–229. https://doi.org/10.1177/001698626901300401

Torrance, E. P. (1990). *The torrance tests of creative thinking norms—technical manual figural forms A & B*. Scholastic Testing Service.

Torrance, E. P. (2018). *Torrance tests of creative thinking; interpretive manual*. Scholastic Testing Service, Inc.

Vaisarova, J., & Carlson, S. M. (2021). When a spoon is not a spoon: Examining the role of executive function in young children's divergent thinking. *Trends in Neuroscience and Education, 25*, Article 100161. https://doi.org/10.1016/j.tine.2021.100161

Vaisarova, J., & Carlson, S. M. (2023). *Can young children control their creativity? The role of executive function in modifying creative processes [Talk]*. Salt Lake City, UT: Society for Research in Child Development.

Vaisarova, J., Kiefer, S. L., Şen, H., Todd, P. M., & Lucca, K. (2024). Where should I search next? Messages embedded in storybooks influence children's strategic exploration in Turkey and the United States. *Journal of Experimental Psychology: General, 153*(8), 2174–2192. https://doi.org/10.1037/xge0001619

Vaisarova, J., & Lucca, K. (2024). A developmental account of curiosity and creativity: Commentary on Ivancovsky, Baror, & Bar. *Behavioral and Brain Sciences*.

Vaisarova, J., Nandiwada-Hofer, V., Parekh, N., Saldano, M., Siddiqui, S., Lee, N., & Lucca, K. (2023, April). *Curious from day one: Examining the dimensionality of infants' curiosity [Poster]*. Salt Lake City, UT: Society for Research in Child Development.

Vries, H. B., & Lubart, T. I. (2019). Scientific creativity: divergent and convergent thinking and the impact of culture. *The Journal of Creative Behavior, 53*(2), 145–155. https://doi.org/10.1002/jocb.184

Wallach, M. A., & Kogan, N. (1965). *Modes of thinking in young children*. Holt, Rinehart and Winston, Inc.

Wiebe, S. A., Sheffield, T., Nelson, J. M., Clark, C. A. C., Chevalier, N., & Espy, K. A. (2011). The structure of executive function in 3-year-olds. *Journal of Experimental Child Psychology, 108*(3), 436–452. https://doi.org/10.1016/j.jecp.2010.08.008

Wilson, R. C., Guilford, J. P., Christensen, P. R., & Lewis, D. J. (1954). A factor-analytic study of creative-thinking abilities. *Psychometrika, 19*(4), 297–311. https://doi.org/10.1007/BF02289230

Zelazo, P. D. (2006). The dimensional change card sort (DCCS): A method of assessing executive function in children. *Nature Protocols, 1*(1), 297–301. https://doi.org/10.1038/nprot.2006.46