Inspiring a Generation to Create:

Critical Components of Creativity in Children

Bay Area Discovery Museum

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Inspiring a Generation to Create:

Critical Components of Creativity in Children

a Bay Area Discovery Museum white paper

Helen Hadani, Ph.D. – *Author*

Garrett Jaeger – *Co-author and Research Fellow*

Erica Fortescue and Elizabeth Rood – *Contributors and Editors*

Mark Runco, Ph.D. – *Academic Advisor*

Fumiko Hoeft, M.D., Ph.D. – *UCSF brainLENS, Neuroscience Lab Director*

Chelsea Myers and Smadar Patael, Ph.D. – *UCSF brainLENS, Contributors*

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7 introduction

Childhood is a magical time when cardboard boxes can turn into castles or spaceships, and teddy bears can request extra sugar in their tea. Creativity may be a hallmark of childhood, but it is not just child's play. In fact, research suggests that identifying and nurturing creative potential in the early years of childhood is crucial for raising the next generation of innovators whose mindset and problem solving skills will solve today's (and tomorrow's) greatest challenges (Cramond, Matthews-Morgan, Bandalos, & Zuo, 2005; Root-Bernstein & Root-Bernstein, 2006; Runco, Millar, Acar, & Cramond, 2010).

Children have unlimited creative potential: they are curious, playful, imaginative, and open to new experiences. They express their creativity through play, paintings, problem solving, and the mismatched outfits they wear to school. Parents and teachers do not need to teach children to be creative. All children have creative potential if you know where to look (Runco, 1996). Creativity is not a fixed quantity, but rather a renewable resource that can be improved and nurtured by optimizing the environment that allows an individual's creative potential to blossom. Children need time to immerse themselves in creative activities, a place that feels safe to express ideas that are unconventional, and encouragement to explore the unknown so they can discover what they enjoy and unlock a universe of possibilities.

Parents and educators are hearing a strong message from opinion leaders in industry and politics that we must promote creativity in this current generation, and the evidence is convincing. According to a major survey conducted in 2010 by IBM of more than 1,500 Chief Executive Officers from 60 countries and 33 industries worldwide, business leaders believe that—more than rigor, management, discipline, integrity, or even vision—successfully navigating an increasingly complex world will require creativity (IBM, 2010). President Barack Obama took time in his 2011 State of the Union address to declare:

> The first step in winning the future is encouraging American innovation. None of us can predict with certainty what the next big industry will be or where the new jobs will come from. Thirty years ago, we couldn't know that something called the Internet would lead to an economic revolution. What we can do—what America does better than anyone else—is spark the creativity and imagination of our people. (State of the Union Address, 2011)

In the public media and in business environments, the terms "creativity" and "creative thinking" have many commonly accepted uses and meanings (e.g., originality, imagination, inventiveness, ingenuity). In the academic world, one standard definition is that an idea is creative if it is both original and useful (Runco & Jaeger, 2012). Others (Simonton, 2012) add a third criteria for creativity—surprise—based on the evaluation standards of the United States Patent and Trademark

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Office (USPTO). A more recently proposed definition (Kharkhurin, 2014) provides cultural perspective through two additional criteria of aesthetics (truth of nature) and authenticity (expression of one's inner self).

In this paper, we address two important questions from a developmental perspective: (1) What are the processes or skills that are developing in children that contribute to their creativity? and, (2) What environments, opportunities and types of adult and peer interaction foster the development of these skills? A phenomenon observed across several studies describes a reduction in original thinking in children ages 9–10 years compared with younger and older children—the "fourth grade slump." The social pressures on young adolescents toward being part of the crowd often lead children to lose their capacity to think "out of the box." Torrance (1967, 1968) was the first theorist to describe this decline in original thinking, and the fourth grade slump has been supported and documented by several of the leading researchers in creativity (Gardner, 1982; Runco, 2011). Specifically, when children reach middle childhood, they are far more inclined to seek out what is conventional and to inhibit the ideas and behaviors that make them stand out as different. Runco theorized that the pressure to fit in and follow social norms is extremely high during this stage of development and special attention needs to be paid to protecting children's creative potential during this time.

Another key theme that emerges from surveying the body of research on the development of creativity in children is that creativity during the ages of 6–14 years is impacted by a broad group of developmental skills—including communication, motivation, and physical activity—which are often overlooked in a narrow definition of creativity. Furthermore, illustrating the separate components of creativity helps to show that creativity is strongly influenced by environmental factors such as explicit instructions, positive process-oriented feedback from important adults (e.g., teachers and parents), and active involvement in novel experiences. This contradicts the widely held notion that creativity is an inborn and elusive talent.

Researchers from many different fields including psychology, education, neuroscience, business, computer science, and the visual arts have contributed to advancing our understanding of creativity in children and adults. As such, a rich and diverse body of research has emerged; however, further work is needed to integrate the research findings generated by the diverse fields and provide a clear and consistent perspective of how to best support and foster creative thinking in children. Research on the brain science of creativity is a fascinating and emerging field that has the potential to transform our understanding of how creativity develops and provide a framework to guide the diverse range of scientists and theorists studying the creative mind. To this end, we introduce some of the most current research on the neuroscience of creativity related to a range of developmental skills.

In this paper we will explore the developmental characteristics of creativity in children ages 6–14 years and examine the environments and opportunities that facilitate creativity and what interferes with it. We conducted an extensive literature review to find the most current and high caliber developmental and neuro-scientific research on creativity, which required us to survey literature

from many different fields including cognitive and developmental psychology, neuroscience, education, and business management. With this review, our intention is to provide an in-depth and accessible summary of the factors influencing creativity in children, and to group the information into components that are aligned with how the fields and bodies of research are organized in the academic literature. We propose and discuss seven key components of creativity organized by three developmental domains:

Cognitive

- Imagination and Originality
- Flexibility
- Decision Making

Social and Emotional

- Communication and Self-Expression
- Motivation
- Collaboration

Physical

- Action and Movement

Developing programming and learning experiences that nurture these skills will support young people to blossom into adults capable of realizing their creative potential. Toward that goal, we offer practical applications of the research on how to best promote creativity through the development of these skills for youth in out-of-school programs. Educators and parents crave practical suggestions for how to foster creative thinking in children and research-based practices offer the most promise for boosting the creative potential in all children.

Fig 1

The neuroscience of jazz improv: The art of letting go

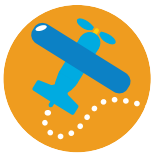
Soulful improvisation is at the heart of the treasured history of jazz music. Neuroscience researchers Charles Limb and Allen Braun felt this vivacious musical style would be a great proxy for studying the elusive act of spontaneous artistic creativity. They enlisted the help of highly skilled jazz pianists to perform two pieces—one rehearsed and one improvised—while undergoing functional magnetic resonance imaging (fMRI).

During spontaneous improvisation, the musicians' medial prefrontal cortex—a region associated with story telling and self-expression—was highly active, compared to when they were playing a memorized piece.

At the same time, the musicians' dorsolateral prefrontal and lateral orbital regions—parts of our brain connected to self-monitoring and attention—were less active during improv. This suggests that part of letting go enough to jam requires us to turn off our inner critic and give ourselves permission to be unplanned and defocused.

Contributed by UCSF brainLENS

Limb, C. J., & Braun, A. R. (2008). Neural substrates of spontaneous musical performance: An fMRI study of jazz improvisation. *PLoS One, 3*(2), e1679.

Components	Description
 **Imagination & Originality** Imagine and explore original ideas	Creativity involves producing original ideas that are unusual or novel, and it sometimes involves combining two or more different concepts to create a new, synthesized idea. Children express their imagination and original ideas through pretend play and the creation of imaginary companions and make-believe worlds.
 **Flexibility** Maintain openness to unique and novel experiences	The interaction of intelligence and creativity often begins with the flexible combination and modification of prior concepts or strategies to produce new representations. Children can experience flexibility by seeing from different perspectives, remaining open to new and challenging experiences, or (especially as they become older) gaining awareness of how only seeing from a single perspective can limit their creativity.
 **Decision Making** Make thoughtful choices that support creative efforts	Discretion, judgment, and decision making play an important role in the development and expression of creativity for children. Decision-making skills require convergent thinking, which is critical to creativity because it allows individuals to refine ideas and to select the best possible answer from the ideas generated to solve a problem.
 **Communication & Self-Expression** Communicate ideas and true self with confidence	Communicating one's unique perspective plays a vital role in creativity by allowing individuals to express their feelings, ideas, and desires through language, art, and physical movement. A sense of confidence and connection to authentic feelings allows children to express their unique insights and thoughts with others.
 **Motivation** Demonstrate internal motivation to achieve a meaningful goal	Motivation is at the core of the developmental experience and inspires children to explore and satisfy their curiosity. When individuals are internally motivated, acting without the promise of a reward, they are more creative.
 **Collaboration** Develop social skills that foster creative teamwork	Collaboration allows for the exchange of ideas among children as they work to find a solution for a problem or project. Working together towards a shared goal fosters perspective-taking and provides a chance for children to explain and expand their thinking in new ways.
 **Action & Movement** Boost creative potential through physical activity	Exercise and physical activity are associated with better focus, enhanced memory, and greater ability to learn. Action and movement stimulate the building blocks of learning in the brain, and regular exercise can act as a cognitive enhancer to promote creativity.

Cognitive

imagination & originality

When people describe creativity, the words "imagination" and "originality" are common responses—these two elements are at the heart of creativity. Children often express their imagination and original ideas through pretend play and the creation of imaginary companions and make-believe worlds (Cohen & MacKeith, 1991; Root-Bernstein, 2014; Singer & Singer, 1990; Taylor, 1999).

Many theorists have studied the relationship between pretend play and creativity and have proposed that pretend play is a way for children to practice original thinking—one of the main cognitive processes in creativity (Singer & Singer, 1990, 2005).

Pretend play and creativity Imaginative play emerges in children toward the end of the second year and continues to be a prominent style of play throughout the preschool years and into early grade school. It is important to note that "play" in the context of imagination and creativity is typically child-directed and open-ended—making "soup" from rocks and grass versus putting together a puzzle. A recent study by Elizabeth Bonawitz and her colleagues demonstrated that adult-directed play can constrain children's exploration and discovery of a novel toy (Bonawitz, Shafto, Gweon, Goodman, Spelke, & Schulz, 2011). Bonawitz et al. examined how adults introducing a new toy influenced preschoolers' exploration and interest in the toy. When adults communicated that they knew how to use the toy and were going to teach the child about it—as opposed to pretending they had just discovered a new toy and were inviting the child to figure it out with them—children played with the toy for significantly less time and performed fewer kinds of different actions on the toy. Children who

> "The trick is to find a good balance, to avoid giving up the imaginative capacity completely, continue to play, at least cognitively, throughout life, not just in childhood, and have ready but mindful access to pretense, as well as counterfactual, hypothetical, and imaginary ideas and worlds."
>
> *(Runco & Piña, 2013, p. 385)*

were introduced to the toy by a "naïve" adult (e.g., "I just found this! I wonder how it works!") showed more interest and explored far longer. These findings provide important insights for teachers and parents on how important it is to balance direct instruction with open-ended exploration in the context of play. Where there is no "right" answer—as was the case in this study and is the case in creative endeavors—the freedom to self-direct and explore leads to higher engagement.

A rich body of research linking childhood imagination and later creativity is the work of Sandra Russ and her colleagues on pretend play in early childhood (Russ, 1993; Russ & Cooperberg, 2003; Russ & Fiorelli, 2010; Russ, Robins, & Christiano, 1999). In a series of longitudinal studies using the Affective Play Scale (APS) developed by Russ (1993), Russ and colleagues provide evidence that pretend play is predictive of divergent (i.e., generating creative ideas by exploring many possible solutions) and original thinking over time. Russ, Robins and Christiano (1999) found that the quality of imagination and fantasy in early pretend play predicted divergent thinking over a 4-year period (from grades 1 and 2 to grades 5 and 6), a relationship that was independent of IQ. Most notably, Russ and Cooperberg (2003) followed some of the children (29 out of the original 121) into high school, and again found that the quality of fantasy and imagination in the early grade school years was positively related to divergent thinking ability in high school—an effect that spanned over 10 years.

Imaginary playmates Popular children's books, comics, and cartoons including *Where the Wild Things Are, Calvin and Hobbes, and Caillou* tell the story of a child's adventures with imaginary playmates. How common are imaginary playmates in childhood? Contrary to what many people think is a rare phenomenon, developmental researchers have found that imaginary playmates are a staple of early childhood and persist well into the school years (Taylor, Carlson, Maring, Gerow, & Charley, 2004). Dorothy and Jerome Singer—two of the leading experts on childhood imaginative play—asked preschool children and their parents about children's imaginary playmates and found that 65% of children answered "yes" when asked whether they had some form of make-believe friend (1990). Relatedly, Marjorie Taylor, author of *Imaginary Companions and the Children Who Create Them* (1999) found that 63% of children had make-believe friends when she interviewed children and parents about the children's imaginary companions.

Given that a large percentage of children have imaginary playmates, it is important to investigate whether imaginary companions are associated with creativity. In a study with elementary students, Eve Hoff (2005) examined whether there is a relationship between imaginary companions and creative potential in fourth graders. Hoff presented fourth graders in three Swedish schools with an activity questionnaire that measured the involvement in creative activities and hobbies (e.g., drawing, writing stories), whether they remember their dreams, and whether children had an imaginary companion. To measure children's

creative potential, Hoff presented the participants with three tasks including The Unusual Uses Test (UUT; Guilford, 1967), which measures the fluency of ideas (i.e., number of ideas). In the UUT, participants make up as many alternative uses as possible for a well-known object that commonly has a single use (e.g., a newspaper or paperclip). Hoff adapted the task for children in her study and used an empty milk carton as the well-known object. Hoff found that children with imaginary companions were more creative on two of three estimates of creativity; these findings support the theory proposed by other scholars that imaginary companions are precursors to creativity (Myers, 1979; Singer & Singer, 1990). Furthermore, Somers and Yawkey (1984) proposed that imaginary companions promote originality of ideas by allowing children to discover opportunities, explore materials, and use them in new ways. As such, imaginary playmates may be more common than adults realize and research suggests that they are positively associated with creativity, so adults should be mindful not to discourage children from making friends that not everyone can see.

Imaginary worlds or paracosms Stephen MacKeith (1982; Cohen & MacKeith, 1991) proposed another kind of imaginary play—"paracosms" or "world play" (coined by Michele and Robert Root-Bernstein, 2006)—involving the creation of full imaginary worlds. This kind of imaginary play is less common and typically starts at later ages (peaks around age 9 and then fades in the late teenage years) than imaginary playmates (Cohen & MacKeith, 1991). When children create imaginary worlds they sometimes invent special people, countries, and languages, and these worlds can be described in elaborate detail through stories, pictures and maps.

In her new book *Inventing Imaginary Worlds*, Michele Root-Bernstein (2014) describes her daughter's make-believe world and highlights how it differs from imaginary companions:

> I had heard of children making up imaginary companions, of course. But this was different; this was a whole world, a parallel place or *paracosm*, mapped out bit by bit, day after day. Meredith's tenacious memory for every aspect of the game surprised me, as did the sheer joy and exuberance with which she generated a variety of play materials. (p. 4)

Research with highly creative individuals, such as MacArthur Fellows and Nobel Prize winners, demonstrates a bridge between children who invent imaginary worlds and adult innovation and

Fig 2

The unusual uses test

Participants are asked to make a list of as many possible uses for a common object (paperclip, broom, carrot, yard stick).

Directions: This is not a test. There are no incorrect responses, and no grades will be assigned. Please *list as many unusual uses as you can for a* ***broom***. Any response could be possible.

Part of the *Runco Creativity Assessment Battery* (rCAB)© 2011

invention (Root-Bernstein, 2013; Root-Bernstein & Root-Bernstein, 2006). Robert and Michele Root-Bernstein conducted the *World Play Project* with MacArthur Fellows and a control group of students from Michigan State University (MSU) to investigate the relationship between imaginary world invention and creativity (Root-Bernstein, 2013; Root-Bernstein & Root-Bernstein, 2006). In contrast to earlier research suggesting that inventing imaginary worlds was rare and indicated an affinity with the arts, the Root-Bernsteins found that paracosm play was "noticeably common"—approximately one-quarter of the MacArthur Fellows invented imaginary worlds as children. Furthermore, these individuals worked as adults in a diverse range of disciplines across the arts, social sciences, and sciences. Most interestingly, many of the individuals that shared their intricate imaginary worlds could articulate how the invention of those worlds in childhood nurtured and trained their creativity capacities in adulthood.

Original thinking and creative expression

Research on children's imaginary playmates and make-believe worlds highlights a fascinating—and often misunderstood—aspect of children's creative expression. While not given as much attention in the popular press, originality occurs frequently throughout the lives of children. Children do not always reserve original ideas, approaches, and perspectives for times they spend with imaginary playmates or make-believe worlds. Since original thinking does occur so often for children, an important research question to address is how it relates to creative potential and expression. Hong, Milgram, and Gorsky (1995) investigated the link between children's original thinking and creative performance in second graders. The researchers measured "original thinking" by examining children's ideational fluency—the ability to generate a large number of solutions to a problem. One of the measures used to evaluate children's original thinking consisted of two problem-solving tasks. In one of those tasks, The Chair Task, participants were told, "You want to join your classmates sitting at the table drawing. But the only chair left is broken and has only three legs [examiner shows child three-legged chair]. What can you do with the chair so that you can also sit at the table?" Then the participants were shown a number of items that could be used to solve the problem (e.g., a waste basket, a stake, a large vase filled with heavy dirt, long poles, and oranges).

In addition to measuring children's original thinking, Hong et al. examined the creative performance of second graders with a self-report scale of out-of-school creative activities. The scale consisted of items indicating creative accomplishments

and activities in domains including music, sports, and drama. For example, creative activities in specific domains included participating in a music competition (music), receiving a prize in a race (sport), and performing in a dramatic presentation (drama). Hong and her colleagues (1995) found that original thinking was significantly related to creative performance in second graders. This finding indicates that original thinking in young children predicts real-life creative performance and suggests that ideational fluency measures are a feasible indicator of creative abilities in young children.

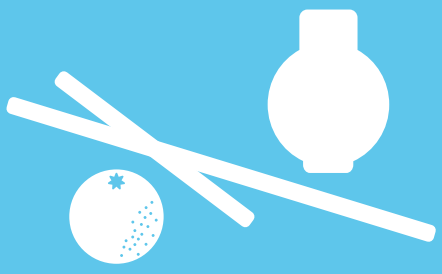
In a more recent investigation of children's original thinking, Christophe Mouchiroud and Todd Lubart (2001) conducted a series of three studies to examine the originality of elementary school children (1st–5th graders). The researchers emphasized the importance of exploring a variety of measures for assessing children's originality

Fig 3

Chair task

1. Participants are told "You want to join your classmates sitting at the table drawing. But the only chair left is broken and has only three legs (experimenter shows child three-legged chair)."

2. "What can you do with the chair so that you can also sit at the table?"



3. Then the participants were shown a number of items that could be used to solve the problem (e.g., waste basket, a large vase filled with heavy dirt, long poles, and oranges).

Implication: Problem solving has been shown to be indicative of creativity. The Chair Task provides an age-appropriate and realistic scenario that highlights how creativity can be expressed through presenting problems.

given that most divergent thinking tasks such as the *Torrance Tests of Creative Thinking* (Torrance, 1974, 1990) skew towards more abstract scenarios. For example, in one of Mouchiroud and Lubart's studies, first, third, and fifth graders were presented with divergent tasks concerning age-appropriate social situations. In the Peers Task, participants proposed solutions to gain permission to participate in a new game with their friends during recess. In the Parents Task, children were asked to propose ways to convince their parents that they could watch television later than usual. In addition, these studies support the work of Shawn Okuda and colleagues by emphasizing the importance of presenting children with tasks that are more relevant to their everyday lives and focus on real-world problems to measure creative potential (Okuda, Runco, & Berger, 1991). Mouchiroud and Lubart's studies reinforced how divergent thinking (DT) tasks are a part of the creative process and do not equate to creativity per se (See also: Runco, 2008); and furthermore, highlight the usefulness of various measures for understanding children's thinking.

Synthesis One way to produce original ideas is to combine two or more existing ideas—focusing on finding their similarities is one way to synthesize creativity. In his seminal book *The Act of Creation*, Arthur Koestler (1964), discussed the importance of bisociation, or the processes for connecting seemingly dissimilar ideas. More recently, Robert and Michele Root-Bernstein included Synthesis as one of their 13 thinking tools in their book *Sparks of Genius* (1999). Relatedly, Finke and Slayton (1988) conducted an innovative study in which they asked undergraduate students to identify geometric shapes, numbers, and letters that were used to construct recognizable objects. Some of the participants in the study were shown examples of the visible combinations, while others were not, and their creative productions varied accordingly. More specifically, across two experiments, Finke and Slayton demonstrated that subjects can often discover recognizable patterns in imagery—many of these patterns judged to be "strikingly creative"—when the parts are randomly chosen and provided without instructions for how they should be assembled. *(For examples, see Figure 3 on p. 254)*

In sum, a large and growing body of research has examined children's imagination and originality and links to creativity in adulthood. Correlational, descriptive, and longitudinal studies have documented the strong relationship between pretend play in early childhood and the creation of imaginary playmates and make-believe worlds with later creativity (Root-Bernstein, 2014; Root-Bernstein & Root-Bernstein, 2006; Russ, Robins, & Christiano, 1999). Furthermore, researchers have explored various methods of measuring children's original thinking that differ from the traditional measures proposed by Torrance (1974) and found that original thinking in young children predicts real-life creative performance (also see Guilford, 1968). These important links emphasize the importance of providing environments that spark children's imagination and encourage them to express their original ideas.

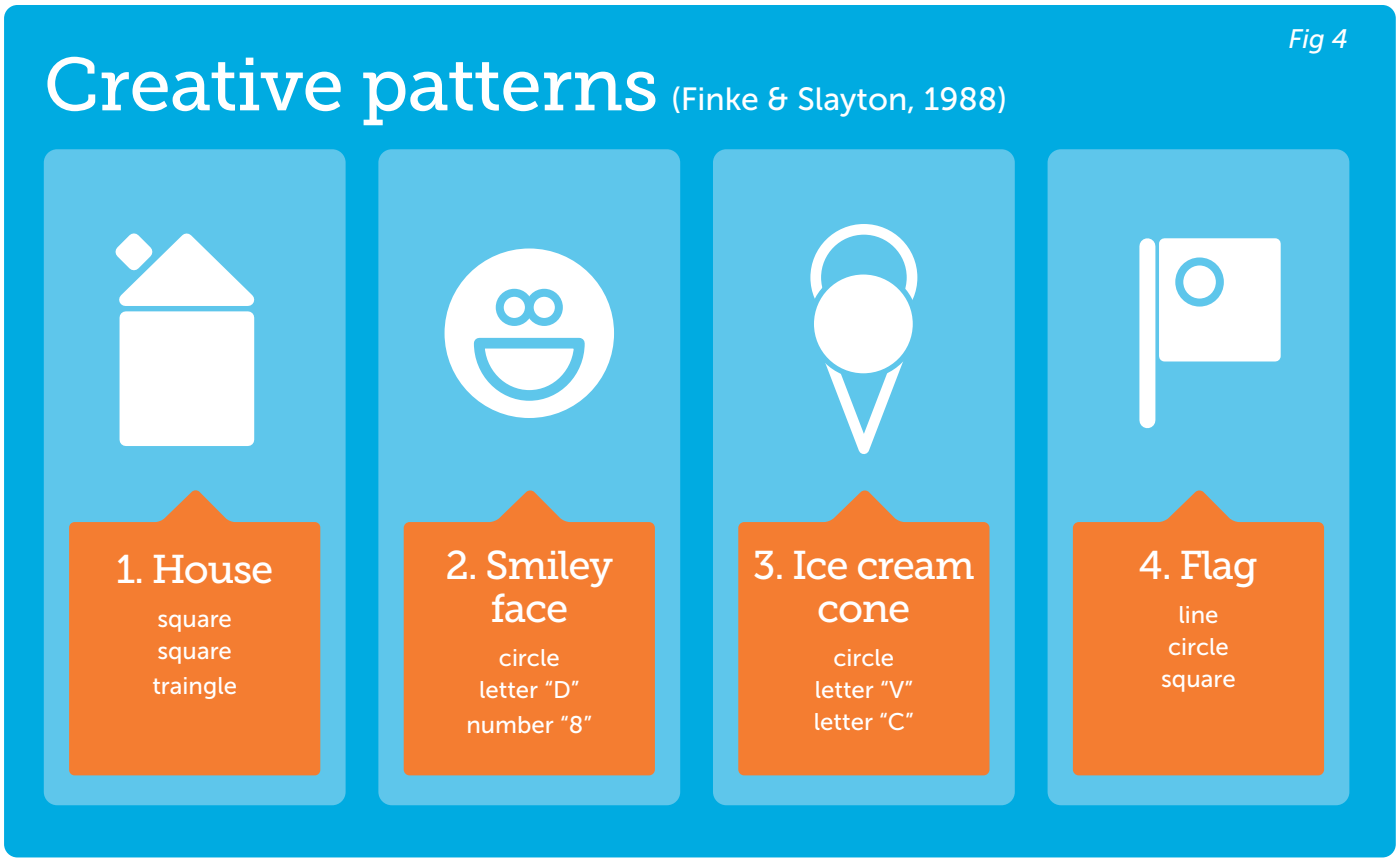
Research-supported strategies to promote imagination and originality in children

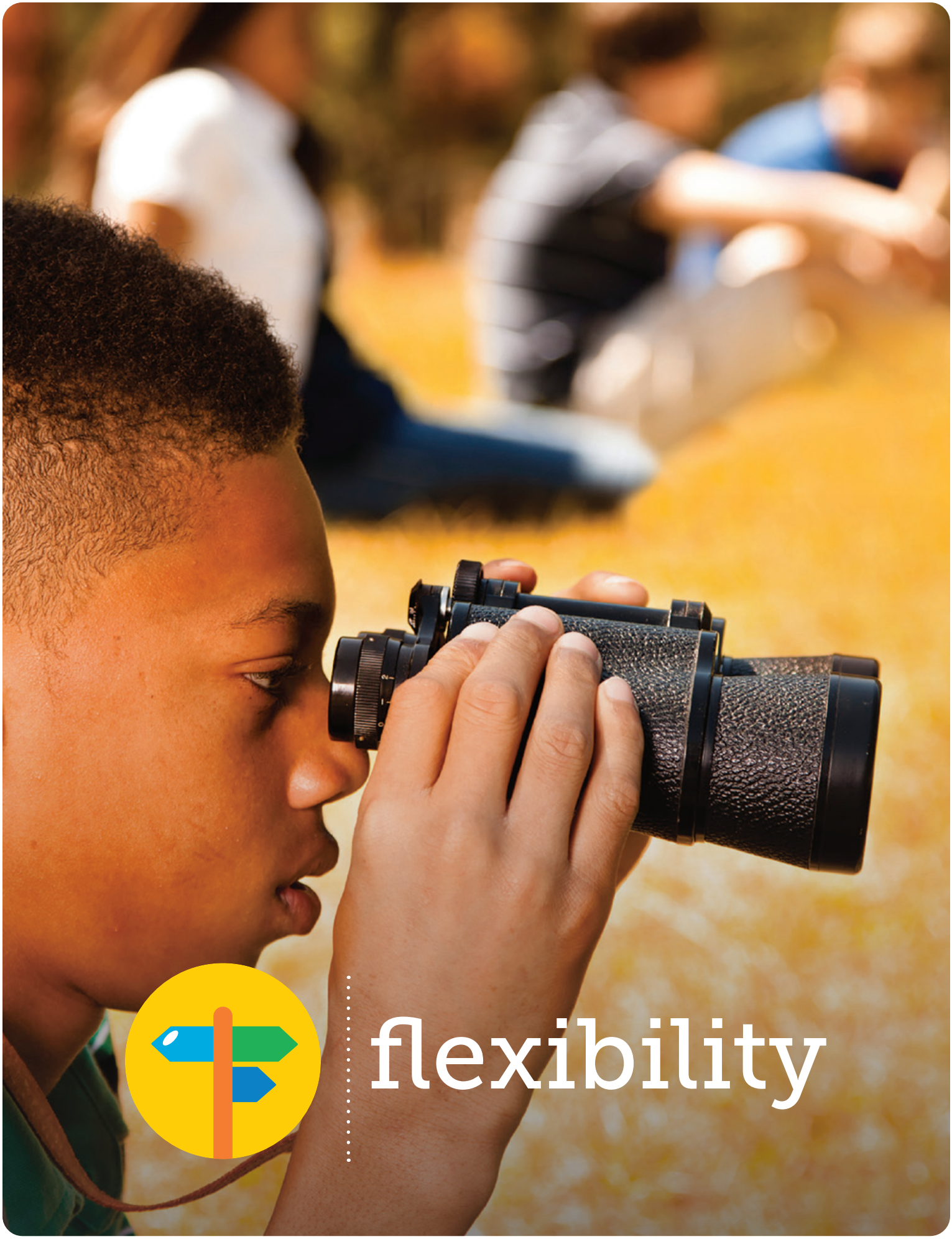
- Provide ample time for extended imaginary play in a safe and supporting environment. This includes protecting time for play and unstructured exploration during the middle childhood years, when many children experience highly-structured and adult-led activities.
- Provide activities that encourage generating lots of ideas, which often lead to the production of a larger number of original ideas.
- Prompt children to use synthesis to generate creative ideas by giving them practice in combining separate influences and ideas and building upon prior ideas.
- Celebrate curiosity and encourage children to express novel and unique ideas. This can be done by asking open-ended questions such as "What would you do in that situation?" for which there is not only one right answer.
- Foster a community in which naysayers become the outliers and children are encouraged to build on one another's ideas with a "yes...and" approach rather than a "yes...but" approach.

Activities to foster imagination and originality (see Appendix for instructions)

- Finding Patterns in Nature
- Finish the Drawing
- The Unusual Uses Game
- Walk the Talk

Fig 4





flexibility

To think and act flexibly is an essential element in the creative process and often begins with the combination and modification of prior concepts or strategies to produce new ideas.

Children can experience flexibility by seeing from different perspectives, remaining open to new and challenging experiences (McCrae, 1987), or through (especially as they become older) gaining awareness of how only seeing from a single perspective can limit their creativity (Guilford, 1967). Social pressures on young adolescents to "fit in," unfortunately, lead many children to lose their capacity to be spontaneous and flexible. This phenomenon, known as the "fourth grade slump," has been supported by researchers investigating divergent thinking and originality in children (Runco, 2011; Torrance, 1968).

Researchers think about cognitive flexibility in three different ways. First, "flexibility" can be measured as part of a person's basic personality. For example, the standard *Five-Factor* personality measures, namely the "openness to experience" factor has shown that people who are inclined to remain open to new experiences score higher on divergent thinking tasks (McCrae, 1987).

> "A hallmark of human intelligence is flexible cognition: adapting inference to unfamiliar or unexpected situations, creatively combining concepts, and modifying familiar knowledge and habits to produce novel representational syntheses or action sequences."
>
> *(Deák, 2003, p. 272)*

Second, researchers look at a person's ability to be flexible in their thinking, especially during tasks that require divergent thinking. More specifically, divergent thinking tasks (e.g., listing unusual uses for an ordinary object) are often scored by indices of originality (statistical infrequency), fluency (number of ideas), and flexibility (number of lexical categories). Third, flexibility relates to a person's ability to suppress easy answers in order to make more difficult connections, allowing for unique insight (for a summary from a neuropsychology perspective see: Alexander, Hillier, Smith, Tivarus, & Beversdorf, 2007).

Flexible cognition and language development

From a developmental perspective, the study of cognitive flexibility has been examined in relation to language abilities. Gedeon Deák (2003) describes flexible cognition as:

> The dynamic construction and modification of representations and responses based on information (i.e., similarities, cues, relations) selected from the linguistic and nonlinguistic environment. That is, when there is a range of plausible ways to understand and respond to a problem, flexible thinkers select patterns that limit this range. (p. 275)

In other words, flexible thinkers are able to shift their focus and attention to the most pertinent information in a particular circumstance in an ever-changing environment that poses new problems. Furthermore, Deák emphasizes that language both enhances and allows the expression of flexible cognition. The interplay between flexible thinking and language is most apparent in early childhood when children are rapidly mastering tasks in different environments (e.g., preschool, elementary

school), learning routines (motor, language, social), and acquiring conceptual knowledge about the world around them. For example, starting elementary school requires social and cognitive skills to interact with many new peers and adults whose actions and words are unpredictable.

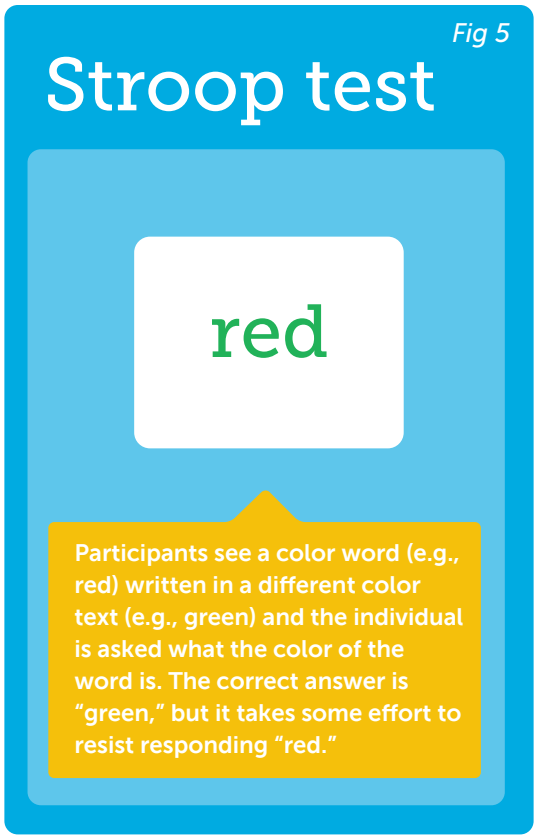
In addition to divergent thinking tasks that are scored for flexibility, researchers have developed some innovative procedures to assess flexibility in children. Stephen Ceci and Urie Bronfenbrenner (1985), for example, examined children's clock-checking rates in a cupcake-baking task. The researchers found that most 10- and 14-year-olds check the clock fairly often at the start of the session (i.e., when the cupcakes are first put in the oven), check less often as the cupcakes are baking, and then check again more frequently when the timer is about to go off. The changing clock-checking rate indicates cognitive flexibility (Deák, 2003). Traditionally, researchers have examined flexible thinking experimentally using task-switching methods in adults (Meiran, Chorev, & Sapir, 2000; Monsell & Driver, 2000). One of the most famous task-switching tasks is the *Stroop* test (see Figure 5; Stroop, 1935), in which participants see a color word (e.g., red) written in a different color text (e.g., green), and the individual is asked what the *color* of the word is. The correct answer is of course "green," but it takes some effort to resist responding "red." Flexibility is measured by changes in response time (i.e., how quickly or slowly they overcome resisting the wrong answer) in the Stroop test and other task-switching exercises.

Active participation in novel experiences

Throughout the lifespan, and especially during childhood, we have diverse experiences that require us to reconsider our prior ways of thinking in order to accommodate new information. In a recent investigation, Simone Ritter and her colleagues (2012) examined the hypothesis that active participation in unusual or unexpected events leads adults to think more flexibly and creatively.

The researchers' prediction is supported by recent research on the link between multicultural experiences and creative thinking (Cheng, Leung, & Wu, 2011; Maddux, Adam, & Galinsky, 2010; Maddux & Galinsky, 2009). In Ritter et al.'s first experiment, undergraduates were introduced to a virtual reality simulation in which laws of physics (perspective, gravity, velocity) were broken, thus violating the participants' expectations. Participants experienced unexpected events by taking 3-minute walks through a virtual replica of a university cafeteria. In one of the unusual events, participants walked towards a table with a toy car in the middle of the table and a bottle on the edge of the table. As participants walked towards the table, the toy car moved towards the bottle, but when the car hit the bottle, it did not fall to the ground. Instead, the bottle slowly moved upwards! Ritter and her colleagues found that active involvement in such novel experiences resulted in an increase in cognitive flexibility (i.e., better performance on

Fig 5



the Unusual Uses Task) greater than those where individuals were actively involved, but in normal and common situations. Importantly, Ritter and her colleagues proposed that being confronted with something unusual is not enough; *active engagement* is the key factor for an unusual event to transform into a diversifying experience that enhances flexible thinking. In other words, actively experiencing diversifying events allows us to break old cognitive patterns, and thus make novel associations between concepts.

In a second experiment, Ritter et al. (2012) presented participants with a more real-life (and culturally appropriate) experience, but one that still violated expectations in some of the conditions. More specifically, undergraduates were provided with written prompts to make a butter and chocolate chip sandwich (a popular breakfast in the Netherlands—the location of the study). Some of the participants were given directions to make the sandwich in which the usual order was changed (e.g., put chocolate chips in the dish before buttering the bread), while some of the participants were presented with a sequence of actions that follows how the sandwich is usually put together (e.g., butter bread and then put chocolate chips on top). Supporting the findings from Experiment 1, Ritter et al. found that active participation in an unexpected and unusual event increases cognitive flexibility. In the discussion of their findings, Ritter and her colleagues point out the practical implications of their findings for current policies on immigration. That is, previous research by Simonton (1997) has shown that periods of immigration have been followed by extraordinary creative achievement. Ritter et al.'s findings suggest a possible explanation by viewing the new customs and ideas that immigrants bring to the local population as "diversifying experiences" that foster creativity and innovation; this highlights the important idea of cultural diversity supporting creativity. A logical extension and practical implication for parents and teachers is providing opportunities for children to experience different cultures and actively participate in multi-cultural activities as a way to enhance creativity via cognitive flexibility.

Researchers have conceptualized cognitive flexibility as a core element of creativity and have developed innovative procedures to explore the role of flexible thinking in the creative process starting in early childhood. Research findings suggest that encouraging children to remain open to new and diverse experiences and actively participating in unexpected and unusual events can increase flexible thinking. As suggested by Ritter and her colleagues (2012), and supported by Howard Gardner's (2011) observations of eminent individuals and their travels, exposure to new environments and cultures (or professions) provide experiences with *asynchronies*, or norms that are different from prior understandings. Such experiences can push us to accommodate a new perspective and evoke creative resolutions. Flexibility, and its role in creativity, is something that we want to foster in children not only because we see great benefit for their development, but also due to its future

relevance for them in mediating challenges and obstacles and learning new concepts that change their perceptions of the world.

Research-supported strategies to promote flexible thinking in children

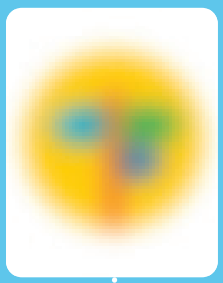
- Provide children with a rich variety of new experiences and encourage active participation in these experiences.
- Encourage children to take the perspective of others. Adults can prompt children to find people who may see a problem or situation from a different perspective than their own, and can help children to ask thoughtful questions and actively seek to understand a variety of viewpoints.
- Help children develop an understanding of their personal thinking habits by asking them to explain their thinking process when solving a problem or creating something new.
- Help children notice when they are getting stuck in their thinking or in their creative production.
- Actively teach strategies that children can use in order to get unstuck.
- Establish a safe and comfortable community so that spontaneity and the changing of routines does not disrupt children's sense of safety and belonging.
- Allow children to be comfortable with failure and tolerant of ending a project and starting over.

Activities to enhance flexible thinking (see Appendix for instructions)

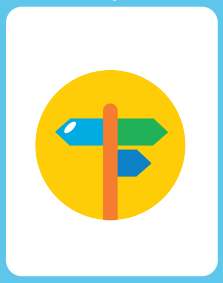
- Fairytale Flip
- How Are These Two Things Related?
- The Instances Game
- The Unusual Uses Game

Fig 6

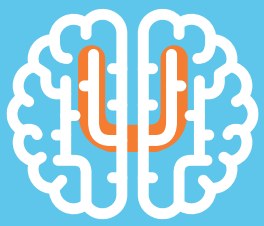
Wired for curiosity: Why learning feels so good



A recent neuroimaging study suggests there may be some truth to the phrase "curiosity killed the cat." Researchers found that when individuals see a blurred picture that stimulates their curiosity, brain regions related to an arousal or aversive state, such as the anterior cingulate cortex and the anterior insula cortex are activated.[1]



On the flip side, the same study found that when curiosity is relieved, such as when blurred pictures become clear, striatal brain regions, also involved in the receipt of reward, are activated—[1] leading us to add, "satisfaction brought it (the cat) back."



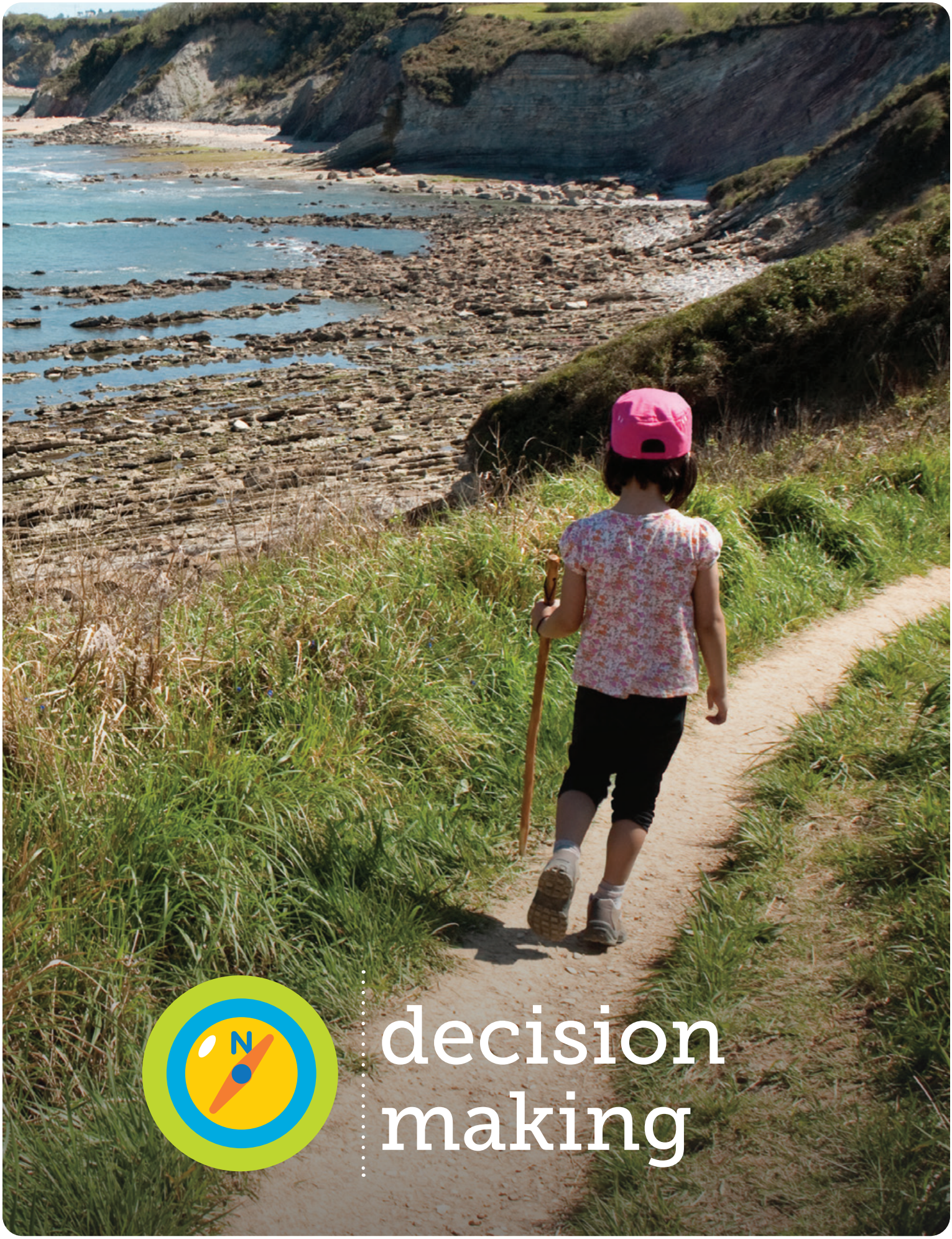
What's more, curiosity relief enhances our memory of the event, as indicated by activation of hippocampal regions.[1,2] This activation and improved memory may be strengthened by the ability to explore what piqued our interest further,[3] which is vitally useful for improvement trials in learning after error.[2]

Contributed by UCSF brainLENS

[1] Jepma, M., Verdonschot, R. G., van Steenbergen, H., Rombouts, S. A., & Nieuwenhuis, S. (2012). Neural mechanisms underlying the induction and relief of perceptual curiosity. *Frontiers in behavioral neuroscience, 6*.

[2] Kang, M. J., Hsu, M., Krajbich, I. M., Loewenstein, G., McClure, S. M., Wang, J. T. Y., & Camerer, C. F. (2009). The wick in the candle of learning epistemic curiosity activates reward circuitry and enhances memory. *Psychological Science, 20*(8), 963-973.

[3] Voss, J. L., Gonsalves, B. D., Federmeier, K. D., Tranel, D., & Cohen, N. J. (2011). Hippocampal brain-network coordination during volitional exploratory behavior enhances learning. *Nature neuroscience, 14*(1), 115-120.



decision making

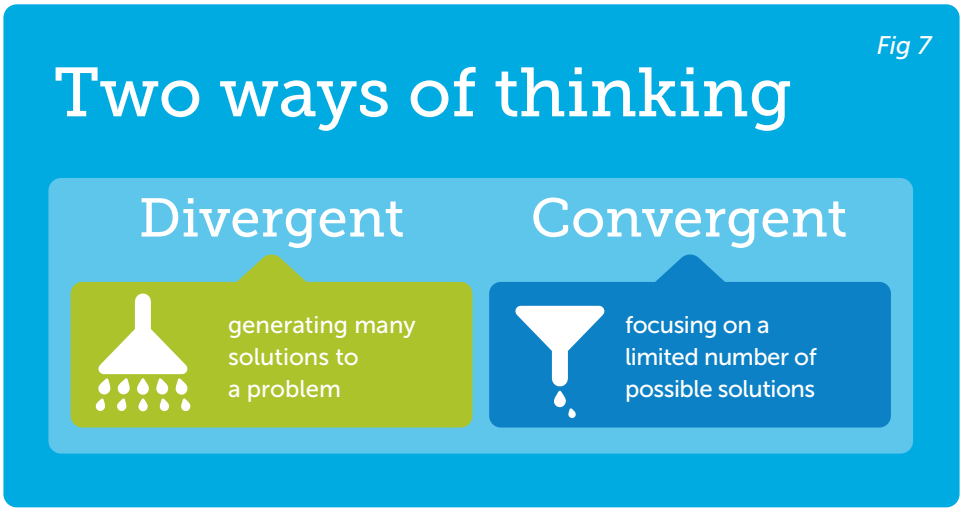
Discretion, judgment, and decision making play an important role in the development and expression of creativity. Decision-making skills require convergent thinking—focusing on a limited number of possible solutions—which is critical to creativity because it allows individuals to refine ideas and to select the best possible answer or answers from the ideas generated to solve a problem (Cropley, 2006).

By developing decision-making skills, children and early adolescents learn important conventions and even more importantly, the discretion to know when it is appropriate to exercise their originality (Runco, 2007). Sternberg (2003) viewed the development of creativity as a decision-making process and emphasized that "creativity is as much a decision about and an attitude toward life as it is a matter of ability" (p. 98). More specifically, Sternberg proposed that creativity is a decision to *be* creative, a decision of *how* to be creative, and lastly the implementation of these decisions.

Evaluating ideas Selecting the ideas that have value and are useful—the evaluation of ideas—is an important kind of decision making that plays a role in the creative process. Theorists have suggested that truly creative ideas are both original and appropriate (Runco & Charles, 1993). The process of generating creative ideas involves three components: (1) problem discovery, (2) divergent thinking, and (3) evaluation of ideas. In other words, creative ideation involves *both* divergent and convergent thinking—it is a cyclical process of generating many ideas, which helps to increase originality, and then selecting the ones that are most useful.

Children's ability to evaluate ideas has received little attention in the developmental literature. However, a few important studies suggest that children have the potential for accurate evaluations of ideas starting in early grade school. The judgments and evaluations investigated in this research are probably at least in part a reflection of decision making. Runco (1991) examined children's ability to evaluate the ideas of other children by asking fourth-, fifth-, and sixth-graders to rate ideas (generated in an earlier study) based on creativity or popularity. One group of children in Runco's study received the evaluative measures with the instructions to "rate the creativity of each idea," and another group received the measures with the instructions to "rate the popularity of each idea." Runco used the second set of instructions for two reasons: (1) popularity is inversely related to creativity (i.e., an original idea is unpopular because it is given by few individuals); and (2) rating popularity might be easier for children because it is a more concrete concept.

Fig 7



In an earlier study, Runco and Albert (1985) administered divergent thinking tests to a group of children, and the responses from those children were used for the evaluative tasks in Runco's (1991) investigation. For example, of the 240 children tested by Runco and Albert (1985), 30 responded "blocks," 19 responded "suitcases," and one gave "corn chip" as a response to the question "Name all of the things that you can think of that are square." Therefore, "blocks" was a popular and unoriginal idea, and "corn chip" was unpopular and original. The frequencies of these responses were used in Runco's (1991) study as the criteria for checking the accuracy of the ratings given by the children. The participants in Runco's (1991) study rated each idea on a one-to-ten scale. With the Creativity Instructions (e.g., "rate the creativity of each idea"), children were asked to give high ratings (10, 9, or 8) to creative ideas and low ratings (1, 2, or 3) to uncreative ideas. Similarly, they were asked to give high ratings to popular ideas and low ratings to unpopular ideas. Runco found that the most accurate evaluations were given when children were asked to estimate the number of other children who would think of each idea (i.e., estimate the popularity of ideas) rather than rate the creativity of ideas. That is, children's evaluative scores were influenced by instructions. In a more recent study, Charles and Runco (2001) investigated divergent thinking and evaluative skill in third-, fourth-, and fifth-grade students and found that the accuracy of their originality judgments and preference for appropriate ideas increased with age.

Relatedly, Runco (in press) suggested an adaptation of Kohlberg's classroom activities whereby children work in small groups to practice decision making. For Kohlberg, those were decisions about morality dilemmas, but Runco's adaptation provides children with practice making decisions specifically about solutions and ideas that might be conventional or might be creative. Lawrence Kohlberg (1968) proposed a theory of moral reasoning consisting of three stages—preconventional (up to age 9), conventional (age 9 to adolescence), and postconventional (adulthood)—that are each

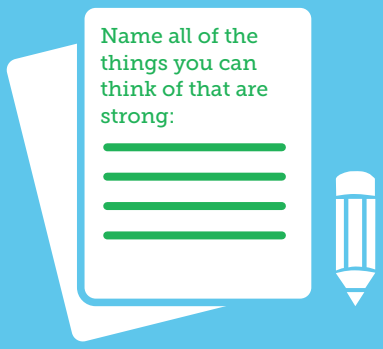
characterized by a different kind of decision making regarding what is right and wrong. Kohlberg reasoned that individuals would progress through the three stages if given the right experiences. Runco and Charles (1993) suggested that Kohlberg's theory can be applied to the understanding of children's creativity. That is, Kohlberg's three stages of conventional reasoning relate to children's art, language, social relationships, and divergent thinking. Furthermore, Runco proposed that when the fourth grade slump occurs, it is due to the child leaving the preconventional stage and not knowing what normal is, and entering the conventional stage where peer pressure and its conventional tendencies make it difficult to be original. The link between Kohlberg's moral reasoning stages and creativity is important for teachers and parents because it provides a framework for understanding why they often see a shift in children's thinking and behavior around ages 9–10 years to being less spontaneous and willing to take risks. Adults can create artificial obstacles to provoke creativity by presenting children with dilemmas where they become aware that the normal way of doing things simply will not work. For example, presenting children with the dilemma of fixing their shoe when a shoelace breaks and they have to figure out a creative solution to keep the shoe on their foot for the rest of the day.

Explicit instructions Another important part of the decision-making process related to creativity is making the choice about when to be original and when to follow conventions. Research demonstrates that decision making in children can be directed such that they choose to think in an original rather than conventional fashion. Runco (1986), for example, provided children in grades 5–8 with definitions of originality and a process for finding original ideas. After the children practiced this process several times, they provided twice as many original ideas compared to their peers who did not receive the training. Later research investigating decision making about originality found differences depending on the specific type of information given to the children (Runco & Okuda, 1991). A number of studies with both adults and children suggest that performance on divergent thinking tests can be elicited by giving explicit instructions to "be creative" (Harrington, 1975; Runco 1986; Runco, Illies, & Eisenman, 2005; Runco, Illies, & Reiter-Palmon, 2005).

Adolescents (ages 15–17 years) in Runco and Okuda's study (1991) were given three divergent

Fig 8

Instances task



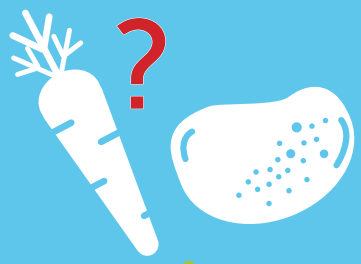
Participants are asked to think of as many possible objects that have the same property.

Directions: This is not a test. There are no incorrect responses, and no grades will be assigned. Please *list as many **things** that are strong as you can*. Any response could be possible.

Part of the *Runco Creativity Assessment Battery* (rCAB)© 2011.

Fig 9

Similarities task



Participants are asked how two objects are alike (e.g., "How are a potato and carrot alike?")

thinking tasks including an Instances Task (e.g., "Name all of the things you can think of that are strong."), an Unusual Uses Test (e.g., "Name all of the uses you can think of for a shoe."), and a Similarities Test (e.g., "How are a potato and carrot alike?"). The students received the tasks with standard instructions, explicit instructions to "be creative," and lastly, instructions written explicitly describing and encouraging flexibility ("Try to give a variety of ideas."). Lexical categories—groups of terms that can be grouped by similar attributes—help when assessing flexibility. A list of "things that are strong" that only provide the names of strong *people* is noticeably less flexible than one that gives the names of strong people, materials, smells, or language, to name a few. Runco and Okuda (1991) found that the participants' flexibility scores were enhanced with explicit instructions. Furthermore, originality scores were also enhanced with explicit instructions, and this finding confirms that explicit instructions are effective with adolescents, as well as adults (Harrington, 1975) and school-age children (Runco, 1986). These findings provide practical information for teachers because they suggest that flexibility and originality—two key elements of the creative process—can be enhanced very simply with explicit instructions. From a theoretical perspective, Runco and Okuda's results suggest that performance on divergent thinking tests requires metacognitive skills (i.e., monitoring one's own thinking), in addition to generating many ideas. That is, explicit instructions do not influence one's ability to generate ideas, but rather impact the choice of specific ideational strategies.

In summary, researchers that have investigated the development of decision-making skills in children and adolescents in relation to the creative process have found that explicit instructions can enhance children's ideational originality and flexibility (Runco, 1986; Runco & Okuda, 1991). Furthermore, research findings suggest that children can judge the popularity of ideas and they may also know when ideas are appropriate (Runco, 1991; Charles & Runco, 2001). These findings are noteworthy from a theoretical perspective because they strongly suggest that children can be *intentionally* creative. Some theorists have suggested that the creativity of children reflects a lack of skill and is more accidental than deliberate (Wolf & Larson, 1981). However, research supporting children's potential for accurate evaluations argues against the suggestion that children's creativity is more accidental than intentional.

Research-supported strategies to promote decision-making skills in children

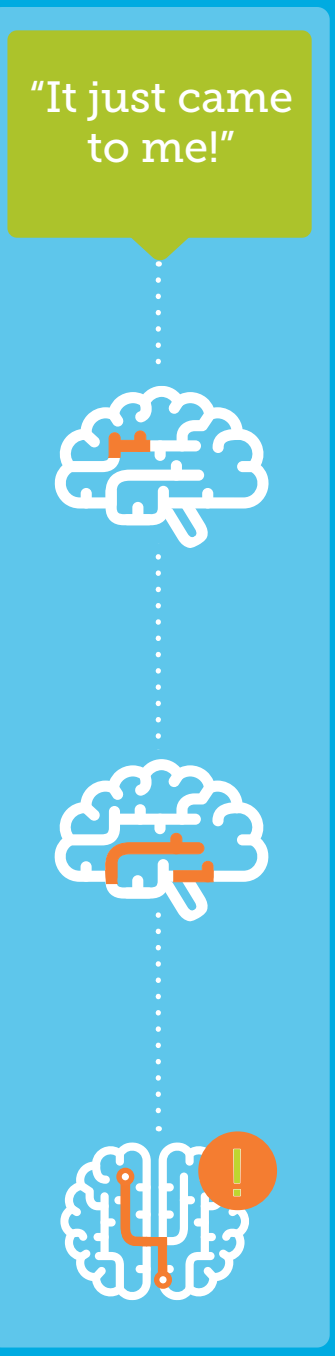
- Help children to develop discretion around when to be original and when to follow conventions by giving explicit instructions to be original when circumstances merit, and discuss situations for which conventional approaches are appropriate.
- Create ample opportunities for children to express and practice creativity and explicitly instruct children to think of as many original ideas as possible without fear of being judged.
- Consistently provide constraints (a deadline for a talent show, cost considerations) that present the need to make thoughtful choices.
- Present children with artificial obstacles or dilemmas in which the normal way of doing things will not lead to success.
- Encourage discussions about why decisions were made or not made—raising awareness of when and how they are made.
- Provide ample opportunity for review and revision of multi-step creative projects with timely feedback so that children can develop their ability to reflect on only the decisions that have been made at this stage of the project.
- Make a conscious effort to avoid either the adult or a dominant child always making decisions.

Activities to enhance decision making (see Appendix for instructions)

- A-maze-ing Design
- Select Your Words Carefully
- Sitting Down and Standing Up
- The Marshmallow Challenge

Fig 10

The evolution of a creative thought



Such a phrase, commonly uttered after a brilliant idea, is actually somewhat misleading when you get down to the neuroscience of it. In fact, research suggests our minds dance along an intricate sequence of neural processes to arrive at a bright idea.

A sudden insight, or 'aha' moment, ironically takes brain preparation.[1] Prior to solving a creative problem with insight, the anterior cingulate cortex, an area of the brain involved in self-monitoring, becomes active and may in fact facilitate focus and suppress irrelevant thoughts.[2]

Next, while wrestling with the problem, there is increased activity in the superior temporal gyrus and memory regions, such as the hippocampus, which assists the integration of older knowledge with newer ideas.[1,3] What's more, we often think unconsciously about a solution before it bursts into our consciousness, hence the 'aha.'[1]

Finally, we employ the typically opposing executive (analytical) and default (emotional) networks to evaluate our ideas on whether they are both original *and* useful, the two criteria for creativity.[3]

Contributed by UCSF brainLENS

[1] Jung-Beeman, M., Bowden, E. M., Haberman, J., Frymiare, J. L, Arambel-Liu, S., Greenblatt, R., ... & Kounios, J. (2004). Neural activity when people solve verbal problems with insight. *PLoS Biology, 2*(4), e97.

[2] Kounios, J., Frymiare, J. L., Bowden, E. M., Fleck, J. I., Subramaniam, K., Parrish, T. B., & Jung-Beeman, M. (2006). The prepared mind: neural activity prior to problem presentation predicts subsequent solution by sudden insight. *Psychological Science, 17*(10), 882–890.

[3] Ellamil, M., Dobson, C., Beeman, M., & Christoff, K. (2012). Evaluative and generative modes of thought during the creative process. *Neuroimage, 59*(2), 1783–1794.

Social and Emotional

communication & self-expression

Communicating one's unique perspective plays a vital role in creativity by allowing individuals to express their feelings, ideas, and desires through language, arts, and physical movement.

Effective communicators use a variety of methods or media (language, visual, and movement) to convey meaning and effectively adapt to a variety of audiences and circumstances. Various literary devices (e.g., simile, metaphor, irony) can be used to express complex images, feelings, and comparisons through commonly experienced themes. Such devices can provide means to communicate ideas across disciplines as well. For example, a classical music piece can convey an ominous landscape or a joyful reunion with a musical phrase and crescendo. Two literary devices that have been examined in relation to creativity—metaphor and humor—allow individuals to express their unique ideas and thoughts through the written word, visual art, and theater.

Metaphor and creative expression With respect to language, researchers and theorists have studied the connection between metaphor (describing one thing in terms of another) and creativity and proposed several creative benefits of metaphor because a target problem or topic is viewed from a different perspective (see Lubart and Getz, 1997 for a theoretical perspective). More specifically, metaphors can provide comparisons that offer new perspectives, highlight or create similarities, and offer insights on how to redefine a problem—all hallmarks of flexible cognition. Furthermore, another benefit of metaphor for creative expression is that it can communicate new ideas to a wider audience by bridging the gap between the novel idea and the receiver or listener who is less familiar with a novel concept. From a developmental perspective, researchers have examined children's understanding of non-literal forms of language such as metaphor and irony and found evidence that children as young as preschool age can understand some aspects of metaphor, but the ability to comprehend more complex and subtle aspects of metaphor is not fully developed until later childhood (see Winner, 1997 for a review).

Humor and sarcasm Another form of communication that develops later in childhood is a sense of humor, and even more apparent in its onset, the elusive sarcasm. Children learn how to communicate through literal means by studying syntax and grammar in the classroom, but grasping nonliteral forms of language such as sarcasm can remain difficult to comprehend even for adults (Uchiyama et al., 2012), or across cultural differences (Katz, Blasko, & Kazmerski, 2004). O'Quin and Derks (1997) reviewed empirical literature on humor and creativity, and summarized two types of humor: incongruity resolution (solving a problem or ill-fitting situation) and nonsense, which leaves resolutions unresolved. First, resolutions of incongruities often make use of metaphor and humor to bridge social understandings of a context. For example, a basic understanding of human physiology would make us skeptical of someone whose arms were tired because they "just flew in from Las Vegas." Second, nonsense may not resolve the incongruity of being appropriate, but still fits one of the criteria for creativity—originality. For children, or Dr. Seuss fans of any age, nonsense may be the most authentic way for us to express ideas that do not always appear too coherent.

Self-efficacy and creativity A sense of confidence and connection to authentic feelings allows children to express their unique insights and thoughts with others. Self-efficacy, the belief in one's ability to achieve a goal in a particular

situation, is a central concept in psychologist Albert Bandura's social cognitive theory of how we perceive and respond to different situations. Research on this "I-think-I-can" psychological phenomenon has shown that self-efficacy plays a major role in how we view and approach challenges in all aspects of our lives (for a review, see Bandura, 1997). For students, especially during the difficult transitions from elementary to middle school and middle to high school, self-efficacy and the willingness to persist in the face of struggle are critical for academic success. As teachers often tell their students, "Whether you think you can or you can't, you're probably right."

With respect to creativity, Bandura highlighted a likely relation between self-efficacy and creativity:

> Creativity constitutes one of the highest forms of human expression. Innovativeness largely involves restructuring and synthesizing knowledge into new ways of thinking and of doing things...But above all, innovativeness requires an unshakeable sense of efficacy to persist in creative endeavors... (Bandura, 1997, p. 239)

That is, in addition to creative ability, our self-judgments about our ability to generate something novel and useful are essential for expressing creativity. Tierney & Farmer (2002) introduced the concept of *creative self-efficacy,* which is "the belief one has the ability to produce creative outcomes" (p. 1138), in a study that investigated what factors influence employees' beliefs that they can be creative in their work role. Tierney and Farmer's findings suggest that to increase creative self-efficacy in the work place, jobs should be multifaceted and require flexibility and experimentation. Furthermore, Tierney and Farmer found that creative self-efficacy can be supported by supervisors through verbal persuasion and modeling core creative activities.

Relatedly, Ronald Beghetto (2006) measured students' creative self-efficacy by asking three survey questions about their ability to generate novel and useful ideas and whether they viewed themselves as having a good imagination (e.g., "I am good at coming up with new ideas," "I have a lot of good ideas," and "I have a good imagination.").

The study participants were also given surveys on their motivational beliefs (i.e., whether the student focused on demonstrating their ability to others, tried to avoid looking incompetent in front of others, or focused on learning and improvement), classroom experience (e.g., "My teachers listen to what I have to say."), academic beliefs (i.e., extent that students believed they would do well in various academic subjects and go to college), and participation in after-school activities.

A key finding in Beghetto's study (2006) parallels that of Tierney and Farmer (2002) with respect to the assertion that efficacy beliefs are linked to ability-related feedback from authority figures. That is, Beghetto found that the strongest predictor of creative self-efficacy was positive teacher feedback. In the discussion of his findings, Beghetto points out that this suggested link between creative self-efficacy and feedback focusing on creative potential has important implications for educators and researchers that are interested in developing educational environments that enhance creativity. This finding supports the conventional wisdom that students' perceptions of how teachers relate to them has a significant impact on their experience in the classroom. Previous research supports that teachers must create a classroom environment that supports and encourages creative expression in order for students to feel confident in expressing their creativity and taking risks in the classroom (Beghetto, 2005; Nickerson, 1999). For example, providing ample time for students to take ownership of their learning, make decisions, and complete tasks at their own pace promotes creative exploration.

Beghetto also found that students with high creative self-efficacy were significantly more likely to report that they would do well in all academic subjects and were planning to attend college (2006). Furthermore, the students in the high-creative self-efficacy group were significantly more likely to report spending more time working on homework and other after school activities that focused on academic subjects including reading, writing, and science than students in the low-creative self-efficacy group. The findings from Beghetto's study are noteworthy because they strongly suggest that creative self-efficacy is positively related to several important factors that determine a student's success in an academic setting.

> "Individuals who come to believe that they can effect change are more likely to accomplish what they set out to do. Bandura calls that conviction "self-efficacy." People with self-efficacy set their sights higher, try harder, persevere longer, and show more resilience in the face of failure."
>
> *(Kelley & Kelley, 2013, p. 9-10)*

Praise and motivation In addition to a learning environment that supports expressing ideas that are "out of the box," a sense of confidence in self-expression may help children to express their unique ideas and thoughts with others. Creative ideas are by definition unique (Runco & Jaeger, 2012) and they can often be perceived as troublesome or upset the status quo. One prominent line of work has centered on the kinds of praise that children receive (Kamins & Dweck, 1999) and shown that praising the person (e.g., "You're so smart!") can decrease motivation in the face of challenges. That is, when children are given praise for their "personality" they start to avoid challenging tasks because failure would mean they are not truly "smart." In a study with kindergarten students, Kamins and Dweck found that children who received feedback focusing on personal traits and attributes (e.g., "You're really good at this.") were significantly more likely to report helplessness

than those who received praise for effort (e.g., "You must have tried really hard."). Given these findings, an effective way to build confidence in the self may be for parents and teachers to praise their child's process and effort with comments such as "I notice that your hard work has paid off."

Creativity involves communication and self-expression. Children express their creativity through play, language, music, art, and movement and research supports that children's creative self-efficacy—their beliefs about their creative potential—is linked to ability-related feedback from important adults (e.g., parents and teachers). These findings have important implications for how teachers can cultivate a classroom environment that supports students' confidence in and willingness to express their creativity. Moreover, the type of praise that parents and teachers give to children, especially when they encounter difficult tasks, plays an important role in their approach and willingness to persist in the face of challenge.

Research-supported strategies to promote communication and self-expression in children

- Model active listening with children, in which you patiently listen with exploring questions and paraphrase what they have communicated in order to check for accuracy.
- Find ways to give positive feedback to support children's creative self-efficacy.
- Promote a growth mindset by praising process, teaching children that brains grow, and by clever use of the phrase "yet" as in "you have not learned to use the saw...yet."
- Cultivate childrens' unique voices through the encouragement of risk-taking.
- Encourage children to communicate about real-world issues and provide opportunities to practice modifying communication style and medium in order to effectively reach a new kind of audience.
- Practice a variety of ways to communicate meaning–from dancing to painting, to photography and video, and open-ended projects that allow for choice and authenticity.
- Support confident proposals of ideas, followed by authentic dialogue that respects individuality and its understanding by diverse audiences.
- Give children a meaningful opportunity to showcase their creative work to a broader audience.

Activities to enhance communication and self-expression (see Appendix for instructions)

- Fairytale Flip
- One Word Stories
- The Absolutely Very Worst Possible Idea Ever
- Walk the Talk

motivation

Motivation is at the core of the developmental experience and inspires children to explore and satisfy their curiosity. When individuals are internally or intrinsically motivated, acting without the promise of reward, they are more likely to be creative.

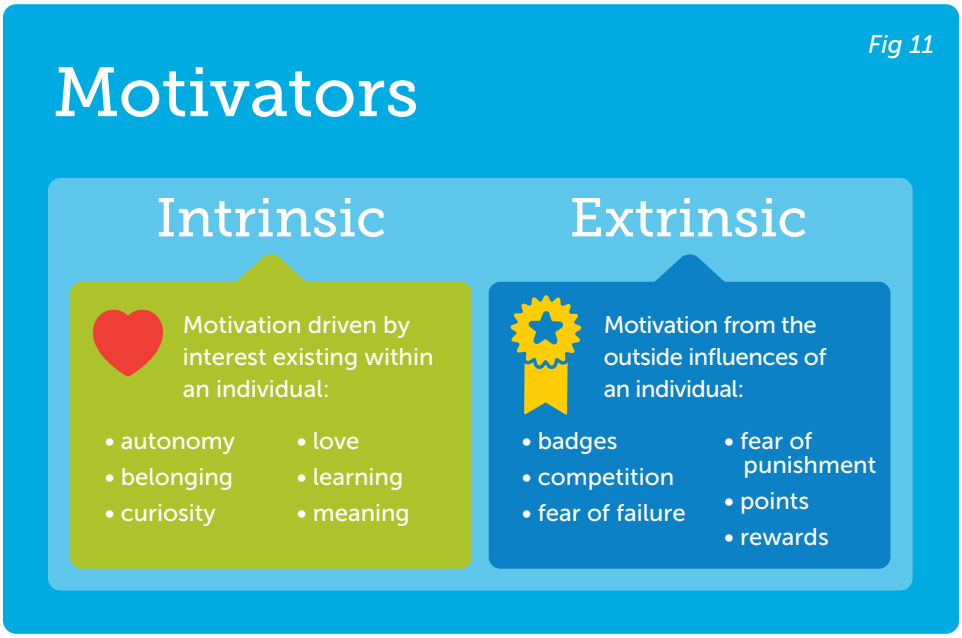
In addition to originality, creativity also requires usefulness, which includes an extrinsic motivator to discover a desired and appropriate use. When individuals are extrinsically motivated, acting for the sake of external reward, they can be less motivated to take risks and innovate. However, the push towards a goal challenges us to embrace new experiences and acquire new skills and knowledge. Children, in particular, often need an extrinsic reward to motivate them to try something new, however, once they overcome their fear they may then become more intrinsically motivated to pursue that activity. For example, imagine a child that is hesitant to ride his bike without training wheels and needs an extrinsic motivator (e.g., an ice cream cone) to push him towards riding without the security of training wheels. After the child discovers the thrill of riding on two wheels, intrinsic motivation takes over and the child wants to ride his bike because of the pure joy and satisfaction he feels cruising down the road.

Benefits of intrinsic motivation

Lepper, Greene, and Nisbett (1973) carried out a seminal study on the benefits of intrinsic motivation in a preschool classroom using a simple and age-appropriate procedure. Children's baseline tendencies to use markers were measured, and later children were either given an award or not given an award for playing with markers. The results showed that several weeks later, children who did not receive the award were more likely to continue the activity. That is, children who received a reward believed that the activity was tied to the reward, and when there was no longer any reward, children lost interest in the activity. These findings strongly suggest that intrinsic motivation can sustain children's interest in an activity, while extrinsic motivation in the form of a reward may undermine children's budding creative tendencies.

Further evidence for the positive role of intrinsic motivation in the creative process was found in Teresa Amabile's (1985) study with college students in which two groups of participants wrote poems after being primed with either intrinsic or extrinsic motivation. Intrinsic motivation suggests the drive to carry out a task out of personal fulfillments, while extrinsic motivation suggests that carrying out the task is contingent on external influences (See also: Deci & Ryan, 1985). The results of Amabile's study showed that the students in the intrinsic motivation condition wrote poems that were judged to be more creative by independent raters. This was a

Fig 11



noteworthy demonstration of Amabile's theory that creativity is best fostered by the internal drive to accomplish tasks simply for their own sake (1983b).

When children are intrinsically motivated, they try harder in the face of difficulty, which leads them to understand that effort leads to achievement. This in turn leads them to adopt an incremental view of their own ability (Dweck & Leggett, 1988; Dweck, 2000). A rich and growing body of research by Carol Dweck and her colleagues demonstrates that the type of praise that children hear has an impact on their motivation framework that they adopt, and in turn can predict behavior outcomes including how children reorient themselves after failure (Dweck, 2006; Kamins & Dweck, 1999; Mueller & Dweck 1998).

In one line of research, Dweck and her colleagues looked at the effect of different types of praise on children, mostly early adolescents (Dweck, 2006; Mueller & Dweck, 1998). First they gave each child a set of ten fairly difficult problems from a nonverbal IQ test and then praised some of the children for their *ability* ("Wow, you got eight right. That's a really good score. You must be smart at this."). They praised other children for their effort ("Wow, you got eight right. That's a really good score. You must have worked really hard."). Dweck and her colleagues found that 90 percent of the children who were praised for effort were willing to take on a challenging new task (Mueller & Dweck, 1998). In contrast, the ability-praised children rejected a challenging new task that they could learn from. Why? Because they were averse to taking risks for fear of failure. When children inevitably fail, they must reorient themselves to try harder to overcome obstacles by taking risks, and they are much more likely to take risks when their self-efficacy increases through practice and hard work (e.g., a growth mindset).

> "With the growth mindset, you are allowing yourself to be changed at all times, allowing new things to happen, and new ideas to form. It's unsafe to some but this wondering and openness is something all of us recognize as the birthplace of creativity. New things can't happen if you already know everything. You have to be curious—and take the risk of learning things you never anticipated."
>
> *(Dweck, http://nilofermerchant.com/2013/09/27/do-you-trust-in-your-ability-to-grow/)*

Role of extrinsic motivation in the creative process

Given the rich body of research supporting the many benefits of intrinsic motivation on a wide range of ages, what is the role of extrinsic motivation in the creative process? Overall, extrinsic motivation is often associated with lower creativity. In multiple studies of the workplace, Amabile found that employees who were high in extrinsic motivation (i.e., those who only carried out their tasks

because they were part of the job) took fewer risks in carrying out their duties (1983a, 1988, 1993). For example, they were less likely to actively seek ways of improving how they carried out their daily work tasks. Independently, the employees' immediate supervisors reported on the perceived creativity of the employees' work. It was found that as employees reported more extrinsic reason for carrying out their duties, they were less motivated to take risks, and, to the extent that they were less motivated to take risks, they were also judged to be less creative. Furthermore, people who are only extrinsically motivated may become depleted faster (Job, Dweck, & Walton, 2010) and focus more on being seen as smart rather than viewing challenging tasks as learning experiences (Dweck & Leggett, 1988). In a classroom environment, research suggests that extrinsic motivation may lead students to study less regularly, show less excitement about schoolwork, and use less innovative strategies to tackle difficult material (Simons, Dewitte, & Lens, 2000). Judicious use of extrinsic rewards may provide the preliminary motivation for young people learning about new interests and skills, but intrinsic drive leads to greater engagement and creative output.

Self-determination: intrinsic and extrinsic motivation When one thinks about the various students in a classroom, it is likely that some of the students will be relatively autonomous in their motivations—these students engage in activities with eagerness and volition. On the other hand, teachers and parents can find themselves frustrated with students that lack this type of motivation and drive. *Self-determination theory* (SDT) (Deci &

Fig 12

Self-determination theory: reframing intrinsic vs. extrinsic motivations

Intrinsic, Extrinsic, and Self-determined motivation

Components	Intrinsic	Extrinsic	Explanation
Child is afraid to ride a bicycle without training wheels because it seems scary. The parents use the promise of an ice cream cone to motivate the child to give it a try.			The child participates in the task with an expectation of a reward.
Child does not like all of the hard work that learning to ride a bike requires. However, once they learn to ride, they find it exciting and fun!			The activity that once seemed tedious or too difficult has become a source of intrinsic joy.
Child is scared of crashing on a bicycle without training wheels, but sees that learning to ride a bike would mean they could ride to friends' houses to play.			The child accomplishes a task in order to overcome an obstacle and achieve a specific goal (e.g., riding to a friend's house)—an example of self-determined behavior.

Ryan, 1985, 1991) is a broad motivational theory that addresses this issue and supports that self-determination (e.g., a greater sense of choice) leads to better conceptual understanding and enhanced personal growth and adjustment. Moreover, researchers have examined the role of self-determination in fostering creativity, cognitive flexibility, and self-esteem in the classroom (for a review see: Deci, Vallerand, Pelletier, & Ryan, 1991). Intrinsically motivated behaviors—those that are engaged in for the inherent pleasure and satisfaction of doing so—are the prototype of self-determination because those behaviors emanate from the self. However, recent theory and research suggest that there are different types of extrinsically motivated behaviors and these behaviors differ to the extent to which they represent self-determined responding (Deci et al., 1991). For example, a student may willingly do more work in a class because she believes it is important for continued success. This behavior is self-determined, but the motivation is extrinsic because the activity is performed to achieve the goal of improving performance in a class (rather than because it is inherently interesting).

Research on motivation and educational outcomes has found that self-determined motivation is linked to positive educational outcomes from early elementary school to college students. Vallerand and colleagues, for example, found that students who had more self-determined forms of motivation for doing schoolwork were more likely to stay in school compared to those with less self-determined motivation (Daoust, Vallerand, & Blais, 1988; Vallerand & Bissonnette, 1992). Furthermore, others have found links between autonomous motivation and positive academic performance (Grolnick, Ryan, & Deci, 1991; Pintrich & De Groot, 1990) and greater conceptual learning and better memory (Grolnick & Ryan, 1987; Grolnick, Ryan, & Deci, 1991). Overall, research on self-determined motivation substantiates that when significant adults—most notably parents and teachers—support

autonomy and maintain a high level of interpersonal involvement with students, those students are more likely to retain their intrinsic motivation for learning.

Both intrinsic and extrinsic motivation play an important role in the creative process, and it is important to recognize the effort and hard work that are involved in the process that result in a positive outcome. Furthermore, factors that support self-determination including offering choice, minimizing controls, and acknowledging feelings, facilitate conceptual understanding and flexible thinking. While these ideas may seem abstract, self-determined behaviors are often encouraged for children by parents when they, for example, push their children to take piano lessons with a hope that they may enjoy it later in life. The seemingly

tedious hours of practice that precede some level of skill may not be fun at first, yet they may in fact transform into a labor of love.

Research-supported strategies to promote motivation in children

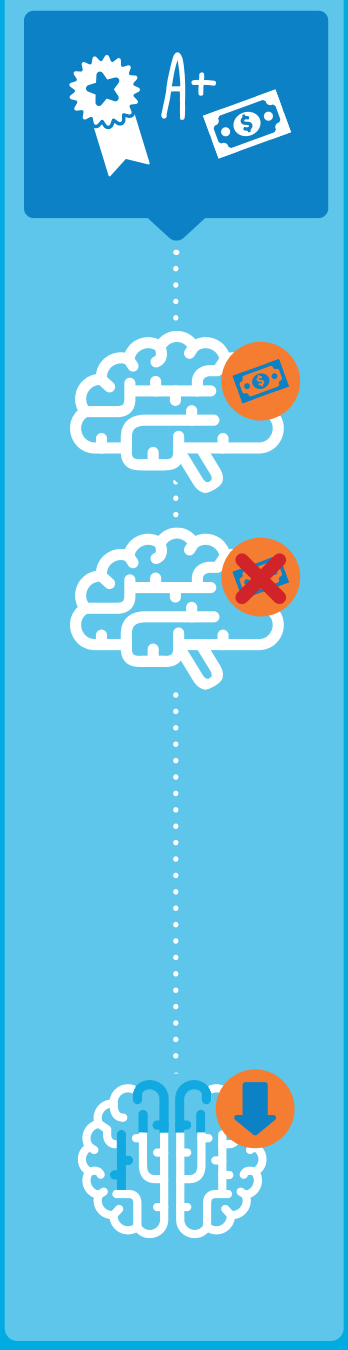
- Provide a safe environment and ample time for children to pursue their interests and make choices. When children have choice and can pursue their own curiosity and connection to the world around them they are more likely to be propelled by motivation and to persist in the face of setbacks.
- Demonstrate and model that rewards may come after lengthy delays—patience proves sustainable over the pursuit of immediate satisfaction. Adults can help children to be inspired by individuals who achieve mastery over a long period of time and present an accurate view of the many challenges and setbacks that occur in pursuit of long-term goals.
- Teach children how to identify and celebrate when something was done for the sake of doing because of internal motivation rather than external rewards.
- Discuss discretion with children so that they are aware of internal motivations and external rewards.
- Consistently shake up the status quo of a project or program, asking for suggestions to improve.

Activities to enhance motivation (see Appendix for instructions)

- Sitting Down and Standing Up
- Give children the choice from our list of activities, and allow them as many trials as they need before they either: (a) move onto another go-round with the current activity; (b) choose another activity from the list; or (c) get bored.
- Allow them to create their own rules for these activities.

Fig 13

Undermining interest: When rewards do more harm than good



Few efforts go without reward, whether it is grades in school, a biweekly paycheck, or a silver medal after taking second in the local marathon. However, research has uncovered a phenomenon commonly referred to as the *undermining effect*.

The undermining effect is when an extrinsic motivator, such as money or a grade on a test, lessens the intrinsic appeal of a task. In traditional psychology experiments demonstrating the undermining effect, there are two groups asked to perform an interesting task: a reward group and a control group. After the task, participants are given a "free choice" period where the control group tends to voluntarily participate in the interesting task more often than their reward group peers.

A neuroscience study found that this undermining effect decreased activity in the anterior striatum and prefrontal cortex—areas involved in the valuation system—when rewards that were once present are taken away. Such a decrease in evaluation or judgment allows us to produce ideas with less interest in how others view them, thus placing fewer filters upon the originality of our ideas. In sum, reward- and performance-based incentive systems may be detrimental to the pursuit of our natural interests.

Contributed by UCSF brainLENS

Murayama, K., Matsumoto, M., Izuma, K., & Matsumoto, K. (2010). Neural basis of the undermining effect of monetary reward on intrinsic motivation. *Proceedings of the National Academy of Sciences, 107*(49), 20911-20916.

collaboration

What do you picture when you think of the most famous and great creators? Many people picture an individual at work in isolation (e.g., in a lab, at a desk, or under a tree), making discoveries and creating great works without the help of others. However, this popular notion of a "lone genius" generating ideas completely on their own is in many cases inaccurate (Montuori & Purser, 1995).

In the business world, famous collaborations including Bill Hewlett and David Packard, and Steve Jobs and Steve Wozniak have resulted in the creation of companies whose inventions pioneered new industries and business models. Moreover, a closer examination of the origins of quantum physics and psychoanalysis reveals a vast network of collaborators in addition to the leading contributions of Einstein and Freud. Taken together, these famous examples provide support for the notion that collaboration can lead to creative endeavors that could not be accomplished by one individual alone.

Group creativity and imitation From a historical perspective, group creativity or collaboration was one of the four operating principles in *Synectics*, a methodology for creativity introduced by W. J. J. Gordon in the early 1960's. That is, Gordon (1961) declared that individual and group creativity can be assumed to be analogous—the processes that individuals use to invent are similar to the processes that groups use. If our own creativity allows for the connection of seemingly unrelated ideas, then collaboration can provide opportunities to share diverse ideas amongst others.

Starting in infancy, children's learning is enhanced through rich experiences provided by interactions with and imitations of others—we are social creatures that have an intense interest in people and learn from others. Young children mimic those around them as they learn more about the perspectives of other children, adults, and even animals. Meltzoff and his colleagues (2009) examined the brain mechanisms underlying social learning by simulating the role of immaturity with machine learning algorithms and found that imitation accelerates learning. In other words, even computers with all of their processing power learn more efficiently when programmed to act like children, imitating others out of curiosity. Furthermore, recent empirical findings from neuroscience on mirror neurons (i.e., neurons that are active when a person performs an action and also when that person observes another person doing that action) suggest that we are hard-wired to empathize with others in order to understand the feelings and mental states of others (for a review see Iacoboni, 2009). Empathy and the ability to take the perspective of another are central ideas for human-centered design, as highlighted by *IDEO* founders Tom and David Kelley (2013) in their recent book *Creative Confidence*. The Kelleys emphasize

> "Peer collaboration (as distinct from peer tutoring or cooperative learning) involves children working together to complete a single, unified task that represents the shared meaning and conclusions of the group as a unit."
>
> *(Fawcett & Garton, 2005, p. 158)*

the importance of empathy as a precursor to ensuring that creative products solve problems effectively as part of the design thinking process. In other words, a deep understanding of the needs and realities of the people you are designing for—walking in someone else's shoes—can lead to more appropriate and breakthrough innovations.

Collaborative learning in children While creativity is not always social, it does provide alternative perspectives and processes. Through sharing, imitation, understanding, and including others' contributions, both children and adults can brainstorm creative solutions (Paulus & Nijstad, 2003; Sawyer, 2003; 2006). Researchers have also shown that collaboration can lead to collective creations and enhanced learning that could not be accomplished by one person alone (Fawcett & Garton, 2005; Sawyer & DeZutter, 2009). Fawcett and Garton (2005) investigated the effect of collaborative learning on children's problem-solving ability using a card sorting activity. Children ages 6–7 years completed the sorting activity either individually or in same-gender pairs, and the pairs consisted of same or different ability children. The researchers found that children who collaborated collectively (in pairs) obtained a significantly higher score in the card-sorting task than children who worked individually. Interestingly, only those children of lower sorting ability who collaborated with high sorting ability partners showed a significant improvement in sorting ability from pre- to post-test scores. These findings support a growing body of research on peer collaboration showing that children working collaboratively towards a common goal achieve higher learning output compared with individual efforts (Moshman & Geil, 1998; Samaha & De Lisi, 2000; Underwood, Underwood, & Wood, 2000). Furthermore, these research findings support the common belief that collaborative work enhances children's learning through active participation and providing valuable opportunities to work cooperatively in a safe and supportive environment.

Distributed creativity More recently, Sawyer and DeZutter (2009) examined how creative products emerge from collaborative networks by

analyzing a series of five theater performances that were improvisationally developed by a teenage theater group during rehearsal. Sawyer and DeZutter use the term *distributed creativity* to refer to "collaborating groups of individuals [that] collectively generate a shared creative product" (p. 82). The researchers analyzed the interactions of the teen performers by focusing on their observable actions (e.g., talk, nonverbal gestures, and the use of objects) and identifying recurring patterns in their collective behavior. Sawyer and DeZutter identified two general features of the performances that emerged in their analysis of the theater group's rehearsals. First, the group collaboratively created narrative elements (e.g., original characters, relationships, and plot events) that went beyond what was provided by the book version of the stories they were portraying on stage. Second, after months of rehearsals, the performers had developed a set of "bits" of action and dialogue that they used to consistently to communicate essential plot points. Thus, this analysis of the interactions between theater performers over several months of rehearsals and performances supports the notion that creativity is often embedded in social groups and furthers our understanding of how creative products emerge from collaborative networks.

Taken together, research on the early role of imitation in learning, the importance of empathy in the human-centered design process, and the benefits of peer collaboration and distributed creativity support the conventional wisdom that *two minds are better than one*.

Working together towards a shared goal fosters perspective-taking and provides opportunities for children to synthesize alternative viewpoints, formulate explanations to others, and expand their thinking in new ways. Humans are inherently social creatures; however, collaboration is a learned skill and one that is not often taught intentionally or effectively in the classroom. Teachers that view collaboration as a skill worthy of teaching and promoting in their classroom are providing students with a valuable skill that is foundational to creativity in the classroom and beyond.

Research-supported strategies to promote collaboration in children

- Encourage children to practice sharing individual ideas with others. Adults can help children notice when a goal is achieved because of the collective efforts of the group versus an individual working on the task alone.
- Provide activities to help children build upon the ideas of another to co-create something new.
- Guide children to draw out all voices in a group and to identify and honor the many talents of each group member.
- Coach children to resolve conflicts in a healthy way, take a big picture view of relationships, and, when disagreeing, do so in a respectful manner.
- Prompt children to develop empathy and consider the perspective of others by connecting with community members and trying out new experiences.
- Provide project-based opportunities that are structured to avoid merely splitting of tasks in favor of sharing and co-creating.

Activities to foster collaboration (see Appendix for instructions)

- Fairytale Flip
- One Word Stories
- Select Your Words Carefully
- The Marshmallow Challenge

Physical action & movement

The relationship between physical fitness and academic achievement has received increasing attention as a result of the dramatic increase of children that are overweight and unfit, and the pressure on schools to meet strict academic standards (many in relation to *No Child Left Behind*).

Overall, the research examining the link between exercise and academic achievement has found a positive relationship. In particular, exercise and physical motion are associated with better focus, positive emotion, enhanced memory, and greater ability to learn (Catering & Polak, 1999; Fredrickson, 2001; Keays & Allison, 1994; McNaughten & Gabbard, 1993; Sibley & Etneir, 2003). Relatedly, an emerging body of research suggests that physical activity can boost creative potential.

Physical fitness and academic achievement

Research generally supports a positive relationship between physical fitness and academic achievement in elementary through early high school students (California Department of Education [CDE], 2001; Castelli, Hillman, Buck, & Erwin, 2007; Coe, Pivarnik, Womack, Reeves, & Malina, 2006). In a large-scale study, the California Department of Education (CDE) examined the relationship between physical fitness and academic achievement in fifth, seventh, and ninth graders (CDE, 2001). The CDE found a positive relationship between physical fitness and reading and mathematics scores from the Stanford Achievement Tests for all three grade levels. That is, higher levels of fitness were associated with higher academic achievement.

Moreover, Coe and colleagues (2006), in addition to Castelli and her colleagues (2007), supported the findings of the CDE (2001) by finding a positive relationship between physical activity and high grades in school and higher scores on standardized tests. In a study with sixth-grade students, Coe et al. (2006) investigated the effect of physical education class enrollment and physical activity on academic achievement. Participants were randomly assigned to physical education during either the first or second semester of school, and academic achievement was assessed using grades from four core academic classes (math, science, English, and world studies) and standardized test scores. Interestingly, Coe et al. found that the students' grades were similar regardless of whether they were enrolled in physical education during either semester, but students who performed or met guidelines for vigorous physical activity had significantly higher grades than students who did not perform vigorous activity in both semesters. That is, higher grades in the middle school students were associated with vigorous physical activity (as measured against the Healthy People 2010 levels proposed in the United States Surgeon General's report on physical activity and health; Centers for

Disease Control and Prevention, 1996), but no such link was found between academic achievement and enrollment in physical education. Castelli et al. (2007) also examined the relationship between physical fitness and academic achievement in third and fourth graders. The researchers found that children who had higher levels of physical fitness were more likely to have higher standardized test scores in reading and math, regardless of sociocultural variables including age and sex.

A strength of Coe et al.'s (2006) study is that students were randomly assigned to physical education either the first or second semester without bias. However, a limitation of this study was the lack of data on socioeconomic status of the participants. Coe et al. point out that the observed relationship between physical activity and academic achievement could be misinterpreted without considering the possible contribution of socioeconomic status. More specifically, it is possible that high socioeconomic status is responsible for high academic achievement, with physical activity acting as a "marker" for higher grades and not a causal factor. On a more general level, the body of research examining the link between physical activity and academic achievement needs to be interpreted carefully by keeping in mind the common phrase "correlation does not imply causation." An important addition to this body of literature is a recent study by Charles Hillman and colleagues which demonstrates a causal effect of a physical activity program on executive control (Hillman, Pontifex, Castelli, Khan, Raine, Scudder, . . . , & Kamijo, 2014). Specifically, Hillman and colleagues randomly assigned children (7–9 years) to a 9-month afterschool physical activity program or a wait-list control and found that children in the exercise group displayed significant improvements in their scores on computerized tests of executive function (resisting distractions and maintaining focus) and cognitive flexibility (multitasking).

Relatedly, in his recent book *Spark*, John Ratey (2008) described a model developed by a school district in Naperville, Illinois, that focuses on aerobic exercise and lifelong fitness. Middle school students engage in a wide variety of physical activities, including a mixture of traditional games and more novel play activities such as climbing walls and interactive video games that involve movement. In this large-scale case study, Ratey observed that as the fitness of the students improved, academic performances increased dramatically. Furthermore, a growing body of research on the many benefits of recess during the school day provides support for the conventional wisdom that physical activity has a positive impact on achievement and learning (for a review see: Ramstetter, Murray, & Garner 2010).

It is important to note that although a growing number of studies have documented a positive relationship between physical fitness and academic achievement and other cognitive performance measures (California Department of Education [CDE], 2001; Castelli et al., 2007; Coe et al., 2006; Field, Diego, & Sanders, 2001; Lindner, 2002), other studies have observed small positive relationships (Daley & Ryan, 2000) or negative relationships (Tremblay, Inman, & Williams, 2000). In particular, Tremblay, Inman, and Williams (2000) found that physical activity had a positive relationship with self-esteem

> "The neurons in the brain connect to one another through "leaves" on treelike branches, and exercise causes those branches to grow and bloom with new buds, thus enhancing brain function at a fundamental level."
>
> *(Ratey, 2008, pg. 5)*

> "The moment my legs begin to move my thoughts begin to flow—as if I had given vent to the stream at the lower end and consequently new fountains flowed into it at the upper."
>
> *(Thoreau, 1851)*

and a "trivial" negative relationship with academic achievement in 12-year-old children. The researchers point out that for some children, physical activity may be indirectly linked to improved academic achievement by improving self-esteem.

Physical activity and creativity Given the empirical support for the link between physical fitness and academic achievement, does the research literature support a similar relationship between physical activity and creativity? Conventional wisdom suggests that creative individuals sometimes engage in physical activity to help overcome mental blocks and boost their creative potential. The famous philosopher Henry David Thoreau described this phenomenon eloquently by stating that: "the moment my legs begin to move my thoughts begin to flow—as if I had given vent to the stream at the lower end and consequently new fountains flowed into it at the upper" (1851).

A limited but growing number of studies have shown that physical activity may sometimes enhance creative thinking in adults (Blanchette, Ramocki, O'Del, & Casey, 2005; Colzato, Szapora, Pannekoek, & Hommel, 2013; Gondola, 1986, 1987; Gondola & Tuckman, 1985; Oppezzo & Schwartz, 2014; Steinberg, Sykes, Moss, Lowery, LeBoutillier, & Dewey, 1997). This emerging body of literature suggests that the nature and consequences of the link depend on particular creativity tasks and the fitness of the individual. Gondola and colleagues conducted a series of studies that showed positive effects, varying substantially from one study to another, of both acute and long-term physical exercise on a variety of creativity measures including flexibility of thinking, expressions of different ideas, and original ideas (Gondola, 1986, 1987; Gondola & Tuckman, 1985).

More recently, Colzato, Szapora, Pannekoek, & Hommel (2013) investigated whether creativity in two types of creativity tests—convergent and divergent tasks—is affected by moderate and intense physical exercise in adult athletes and non-athletes. To measure divergent thinking, generating many new ideas to solve a problem that has more than one solution, the researchers used the Alternate Uses Task (also known as the Unusual Uses Test), in which participants are presented with a particular object (e.g., a pen) and asked to generate as many possible uses for the object as possible. In contrast, the Remote Associates Task (RAT; Mednick, 1968) was used to measure convergent thinking, the process of generating one solution to a particular problem. Participants in the RAT are presented with three unrelated words (e.g., blue, cake, cottage) and asked to identify one common associate (cheese). The researchers hypothesized that the same exercise that exhausts the cognitive resources of a less fit individual may have little or no impact on a skilled athlete. That is, non-athletes may show exercise-induced "costs" (e.g., do poorly on a task) in more control-demanding tasks like convergent thinking tests while athletes might either not show such costs or perhaps show exercise-induced benefits (e.g., do better on a task). Colzato et al. found that acute physical exercise had a small positive effect on convergent thinking in adult athletes (compared to non-athletes). Interestingly, exercise interfered with divergent thinking in both athletes and non-athletes.

In a related study, Oppezzo and Schwartz (2014) conducted a series of four experiments in which undergraduates walked on a treadmill or outdoors and their scores on divergent and convergent thinking tasks were compared before, during,

and after the walking exercise. In the first study, participants completed a divergent thinking task when sitting and then when walking on a treadmill. The participants also completed a convergent thinking task when sitting and walking. Oppezzo and Schwartz found that walking had a large effect on divergent thinking—the average increase in creative output was around 60%. However, participants did mildly worse on the convergent thinking task when walking than when sitting. In the second and third experiments, participants completed the divergent thinking task when seated and then walking, when walking and then seated, and when seated twice. Again, walking led to higher scores on the divergent thinking task. Lastly, Experiment 4 tested the effect of walking on creative analogy generation. Walking outside produced the most novel and highest quality analogies compared to sitting inside, walking on a treadmill, and being rolled outside in a wheelchair. Overall, the researchers found that the creativity for almost every student increased significantly when they walked (both indoors and outside). These findings support the conventional wisdom that physical movement, walking in particular, boosts creative ideation.

Creative thinking in team sports In a related body of work focusing on team sports, Daniel Memmert and his colleagues have investigated sport-related creative thinking—the extraordinary motor, perceptual, and creative abilities of athletes (Memmert, 2007, 2011; Memmert & Perl, 2009; Memmert & Roth, 2007). More specifically, "in sports games, 'creative' refers to those varying, rare, and flexible decisions that play an important role in team ball sports like football, basketball, field hockey, and handball" (Memmert, 2011, p. 94). In one of the first studies to examine the developmental trajectory of sport-related creative thinking in children, Memmert (2011) investigated the influence of attention and expertise on the development of general and sport creative thinking in children ages 7, 10, and 13 years. Children with at least two years of experience playing handball and children with no handball experience completed two divergent thinking tasks (one specific to handball and one general task) and two attention tasks (one specific to handball and

one general task). In the non-specific divergent thinking task, children were given a sheet of paper with 24 ovals and asked to draw anything that came to their mind in each of the ovals. In the specific divergent thinking task, children watched handball videos and were asked to imagine themselves as one of the players. While watching the videos, the children were asked to name all of the opportunities that might possibly lead to a goal. Children's performance on both of the divergent thinking tasks was judged using observation criteria for originality, flexibility, and fluency.

Overall, Memmert's findings suggest that general and sport-specific creativity have similar paths of development. Specifically, as children get older they are able to produce more original solutions in both sport-related and general creativity tasks. Furthermore, these findings indicate that attention processes and expertise play a role in the development of sport-related and general creative thinking. Memmert found that skilled players with high attention scores performed better than skilled players with low attention scores.

Sports are undoubtedly one of the more prominent sources of play and recreation for children, especially with organized sports being integrated into school curricula. Matthew Bowers and his colleagues (2014) looked at how organized sports have affected adulthood creativity by asking college-aged participants to report their past involvement in both organized and unstructured athletic activities, followed by a creativity assessment using the *Abbreviated Torrance Test for Adults* (ATTA; Goff & Torrance, 2002). Bowers et al.'s findings indicate that individuals who participate in more unstructured sports activities are more likely to become creative adults. More specifically, children who spend roughly two hours per week engaged in informal sports activities will show a significant increase in adulthood creativity, while those who spend a little more than three hours per week in organized sports activities show an equivalent *decrease* in adulthood creativity. Since the most creative individuals in the study tended to split their time about equally between each setting, the findings suggested that "balancing organized and informal sports is the key to increased creativity" (Bowers et al., 2014, p. 324). The results from this

study provoke interesting suggestions for parents on their children's involvement in athletics. That is, unstructured sports settings make a difference and can have a positive impact on adulthood creativity. Of course, active involvement in sports is healthy for children, but what this study suggests is that our sports programs would benefit from a less regimented approach to sports training.

Together, this emerging body of research supports Gardner's theory of bodily-kinesthetic talent as it contributes to not only intelligence, but also to creative efforts in the form of using physical movement to solve problems or develop products (1999). This proposed intelligence includes not only the direct applications of dancers and athletes, but also individuals who use body parts (e.g., hands of a sculptor or mechanic) in their craft. Furthermore, the *Torrance Tests of Creative Thinking (TTCT)* included action and movement as a key element in which we can solve problems. In maintaining the use of divergent thinking of the TTCT, the *Thinking Creatively with Action and Movement* (TCAM; Torrance, 1976) addresses how individuals produce ideas using movement. For young children, responding in action and movement (as opposed to a verbal response) may allow access to concepts that may exceed the capacities of their current state of language development. The body of research that investigates the link between physical activity and creativity is a promising endeavor for future research to reveal practical applications for both inside the classroom and out. In conclusion, research on the links between physical activity, academic achievement, and creativity supports the conventional wisdom and anecdotal evidence that movement and exercise not only strengthen our bodies, but also enhance learning and boost creative potential.

Research-supported strategies to promote action and movement that enhance creative thinking in children

- Encourage movement as a modality for learning and provide opportunities to participate in active learning environments that engage both the mind and body.
- Teach children that movement and activity breaks can foster incubation and aha! moments by emphasizing that regular exercise and physical activity increase health, reduce stress, and better equip the brain to engage in higher-order thinking.
- Provide ample time for regular, physical activities that focus on kinesthetic learning.
- Encourage participation in physical games and sports that provide perspective-taking and physical communication with an emphasis on informal and unstructured sports activities.

Activities to foster action and movement that enhance creativity (see Appendix for instructions)

- A-maze-ing Design
- Walk the Talk
- All of our activities could be translated into movement-based communication (e.g., charades) so that children will find ways to represent not only the words that they could have written, but also include the actions of each phrase, item, character, or concept.

appendix

A-maze-ing Design

Purpose:
Designing your own game takes a lot of creative problem solving to make it work and provides a fun way to use everyday materials to create something original. Children will design a tabletop maze using materials from the household recycling bin. The maze will be grounds for a ping pong ball race. The movement of the ping pong balls will be powered by air blown through straws.

Getting Started:
Supplies needed:

- Drinking straws (enough for each participant to have one)
- Two ping pong balls
- Large base for your maze to be built on (i.e., a large flat piece of cardboard or foam)
- Materials to repurpose such as coffee sleeves, cardboard, cereal boxes, or paper tubes
- Paper-backed tape such as masking tape or painter's tape
- Scissors or x-acto knife
- Optional: aluminum foil or pipe cleaners

Ages: all ages starting from 6
Players: can be done individually, with a partner, or with a small team
Time needed: 15+ minutes

Instructions:

1. It's time to start planning the maze. Will you sketch it out in advance or dive right in and start adding materials to your base? That's up to you and your design team.
   - Make sure you choose a start and a finish. The start and finish must be on the base of your maze.
   - Use as many different materials as you can to create as many twists, turns, and obstacles as you can in your ping pong ball maze.
   - Be sure to make your paths wide enough for a ping pong ball to travel through.
   - There is no height limit for the paths in your maze.
2. Test the maze. Push your ball along by blowing air through a straw to make the ball move.
3. Blow your ball from start to finish.
4. Time yourself or one another as you race against the clock to move your ball from start to finish.

Fairytale Flip

Purpose:
One of the neat things about fairytales is that so many people know how the story ends. But what happens when we change the ending, or tell the ending through the eyes of a different character? Creating twists on popular versions provide new perspectives that challenge our routine understandings and force us to be flexible in what

we know about the story. Use your imagination and sense of empathy to retell a familiar fairytale from a new perspective.

Getting Started:
Supplies needed: Paper, pencil or pen, and a book of fairytales which can be a helpful resource to stimulate ideas

Ages: all ages starting from 6
Players: can be done individually or with a small team
Time needed: 15+ minutes

Instructions:

1. Choose a fairytale that you want to retell through the eyes of a character or object other than the main protagonist. Maybe a story from the seven dwarves' perspective. Or a story from the point of view of the witch in "Hansel and Gretel."
2. Not sure where to start? Here are a few perspective prompts to get you well on your way to your first fairytale flip.

- How would Cinderella's fairy godmother tell her story? Or what if Cinderella's slipper could talk? What would it say?
- Up and down, up and down, up and . . .chopped down! What could the beanstalk in "Jack and the Beanstalk" say about Jack, his mother, and the Giant if he were the storyteller?

3. Write down your flipped fairytale, including as many details as you can imagine to enrich your story.
4. Here are some ideas to continue the fun:

- Create some flipped fairytale fun with your family and friends and act out your story.
- Make the set, costumes, and props and invite an audience to enjoy your performance.
- Record your performance and send it to friends and family who live far away.

Finding Patterns in Nature

Purpose:
Frank Lloyd Wright, a famous architect once said, "Study nature, love nature, stay close to nature. It will never fail you." In this game, we will follow this advice by hunting for patterns in nature, sketching them in our notebook, and using these patters for creative inspiration.

Getting Started:
Supplies needed: an outdoor place to wander, or a collection of items that are originally from the natural world (for example this could be shells, fruits, wood, rocks, house plants, etc.), a sketchbook and a pencil or pen.
Ages: all ages starting from 6
Players: can be done individually or in teams
Time needed: 20 minutes

Instructions:

1. Set your timer for 20 minutes and challenge yourself to see how many patterns you can find and sketch from nature.
2. Look at the clouds, the leaves, the rocks, whatever you see.
3. When you find an interesting pattern, make a sketch in your notebook so that you will remember this pattern and write a note about where you found it.
4. See if you can find and sketch more than five interesting patterns.

Optional extra: Now, imagine that you are an architect designing a new house. Can you find a way to use one of the patterns that you discovered as an inspiration for a part of your house? Draw what it looks like and explain to another person how you used part of the pattern from nature to help you come up with that design.

Finish the Drawing

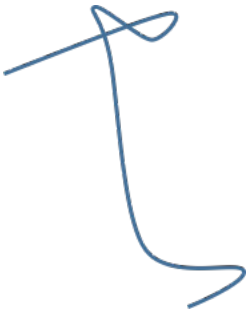
Purpose:
In this game we use our visual imagination and we practice thinking in pictures.

Getting Started:
Supplies needed: pen or pencil
Ages: all ages starting from 6
Players: can be done individually, with a partner, or with a small team
Time needed: 5 minutes

Instructions:
1. Look at this crazy shape.
2. Finish the drawing by using your imagination.
3. Share with others and tell a story about your drawing.

Crazy Shape #1:

Crazy Shape #2:



How Are These Two Things Related?

Purpose:
Creating and inventing often means making connections between distant things, which is one way of being flexible in our thinking. This fun game allows us to practice discovering surprising and unexpected connections.

Getting Started:
Supplies needed: notebook and pencil
Ages: all ages starting from 6
Players: can be done individually, with a partner, or with a small team
Time needed: 10 minutes

Instructions:
In this game, pick one word from **LIST #1** and one word from **LIST #2**.

Try to come up with three ways that these two things are similar.

Make a star next to the one that is truest and most original or unusual in your mind.

For example, how is a **cat** similar to an **iceberg**?

1. Both can be white.
2. Both can be hard to touch (the cat might run away and the iceberg might be cold or slippery).
3. Both can float in the water.

List 1: Elephant, Tree, Telephone, Fancy dress, Motorcycle, Opera music, Sandpaper

List 2: Cactus, Sandwich, Dog, Canoe, Flashlight, Restaurant, Chair, Paintbrush, Saxophone

One Word Stories

Purpose:
This is a great game for practicing creative collaboration. You have no idea what word the person might say before you so you really have to listen and respond in order to end up with a story that makes sense. Try not to think too much or

impose your idea of the story. Instead, really listen to where the group is going with the story and play your part.

Getting Started:
Supplies needed: none
Ages: all ages starting from 6
Players: 2–20 people can play
Time needed: 10 minutes

Instructions:

1. You need more than one person to play this game, and it can be played with up to 10 people. Stand up next to your partner, or, if you are in a large group make a circle in which you can hear everyone's voice.
2. One person starts by saying a word...any word.
3. Move around the circle (or back and forth when it's just two people) with each person saying one word at a time. The goal is to create one sentence that is a story.
4. A fun alternative to this game is to play "one word proverb" in which the purpose of the story is to provide a piece of wise advice with each player contributing only one word at a time. In this version, the group decides when the proverb is done by saying "yes, yes, yes" and nodding heads.

Select Your Words Carefully

Purpose:
Sometimes we are very focused on creating something, and other times we just let it happen. This group activity encourages children to be spontaneous, but also requires planning because they have to use a limited number of words to create a skit. Children are asked to present a performance in which they tell a story using only seven words and pantomime. Pantomime means using body movements to communicate. The group will have four minutes to plan and practice their skit, and two minutes to perform.

Getting Started:
Supplies needed: a piece of paper, a pencil or pen, and a deck of 49 cards. Each card has one word written on it (i.e., fork, sleep, help, chimpanzee).
Ages: all ages starting from 6
Players: 2–6 children
Time needed: 15+ minutes

Instructions:

1. The first time you play, you will direct children to create their 49 cards of words. These will become your deck of cards, and they can be used again the next time children play.
2. Each person or team chooses seven cards by drawing them from the pile at random. Each card should have only one word written on it. These are the only words that may be spoken in your performance.
3. For four minutes, plan and practice your skit. Your skit should have a beginning, middle, and end. Be sure to have at least one team member say each of the seven words you chose in your skit.
4. You have two minutes to perform your skit for an audience of one or more people.

Sitting Down and Standing Up

Purpose:
This exercise helps children practice decision making and doing what is right rather than what others want them to do. Why do we go along with the crowd when we know that what has happened is not fair to others or us? This discussion is not a game of tattletale, but rather a group sharing many solutions to a problem and collectively realizing that they should inform an adult even if it makes a peer unhappy. In the second part, children will learn when to make their own decisions, consider the

perspectives of others, and know when is a good time to apply creative solutions.

Getting Started:
Supplies needed: none
Ages: ages 9 through adolescence
Players: 2–6 children and one adult can play
Time needed: 10+ minutes

Example Topics:
Moral Dilemmas:

- You see a friend of yours cheating in class. You know that the teacher gives a reward for top scores. If your friend cheats, gets the reward, and you don't, is that fair? What do you do?
- You are walking with some friends to go see a movie. While you're walking, someone in front of you throws a bag of nasty garbage on the sidewalk in front of you. Gross. What do you do about this littering?

Creative Conundrums:

- You are in your classroom one day, and your shoelace gets caught on the chair and breaks. The broken shoelace won't work anymore, and your shoe falls off when you try walking without a lace. What do you do to fix your shoe?
- You and your family go camping for two days, but the first night a tree branch falls and tears a small hole in your tent. It is supposed to rain the second night you're there and that hole will definitely leak water. What can you do to fix the tent, keep everyone dry, and save the day?

Instructions:
Part One: Moral Dilemma

1. The adult introduces a dilemma to the group of children as a game.
2. The adult should stay in the background as much as possible, encouraging the children to explore options and navigate how to pick the best solution(s).
3. On occasion, the adult may need to step in and help clarify or keep the children interested; for example, suggesting to them that they list pros and cons may help keep things going.
4. The adult can offer what may be the right thing to do, but it is best for the group to learn for themselves what is right and wrong—encouraging development of their own thinking.

Part Two: Group Creativity

5. This game can then be adapted into a creativity exercise where the children will practice decision-making and practice discretion for knowing when to follow the group, and when to be creative.
6. Connecting moral and creative thinking becomes clear when we realize that both involve postconventional (not simply what is normal) thinking.
7. Supporting reflection on this process by talking about it afterwards will encourage children to be flexible and take perspectives of others when solving problems creatively.
8. This can become a game that children will enjoy and might even request to play often; even when adults need help with solving problems around the house!

The Absolutely Very Worst Possible Idea Ever

Purpose:
Sometimes we can come up with new ideas *and* make ourselves laugh by imagining the very WORST possible way to do something. As silly as it sounds, this can help us to break out of our regular thinking habits and can help us get ready to be creative.

Getting Started:
Supplies needed: pen or pencil
Ages: all ages starting from 6

Players: can be done individually, with a partner, or with a small team
Time needed: 10 minutes

Instructions:

1. Find a partner to do this with or use your notebook to record your ideas for later.
2. Pick any scenario from the list below:
   - walk a dog
   - get a drink of water
   - get from home to school
   - find a new pet
3. Now, try to imagine the very WORST possible way to do this.
4. Share your idea with another person and see if he or she can come up with an EVEN WORSE way to do that same thing.

The Instances Game

Purpose:
The idea is to help the child shift categories of thought from toys, to machines, to the home, to the classroom, and so on—for flexible thinking. Helping children shift to different categories changes perspective and gives them strategies to get unstuck when they run out of ideas.

Getting Started:
Supplies needed: No materials needed. Paper and writing utensils could provide visual and material opportunities.
Ages: 4 through adolescence
Players: 1–2 children
Time needed: 10+ minutes

Examples:

- Things that are square
- Things that move on wheels
- Things that are strong

Instructions:

1. Ask the child, "can you think of different things that move on wheels?"
2. After he or she gives ideas but then pauses, prompt with "Can you think of toys that move on wheels? How about machinery? How about things in your house? In your classroom?"
3. Go over their responses and discuss how these ideas are similar, and are different.

The Marshmallow Challenge

Purpose:
This is a great group challenge that can be done with children or adults and gets everyone actively building and creating. It helps to develop collaboration, flexibility, and decision making. Because the most successful teams are often the ones who start actively trying things out earlier, rather than just discussing and drawing pictures, this activity reminds us how helpful it can be to make prototypes and start testing them early in the creative process.

See www.marshmallowchallenge.com.

Getting Started:
Supplies needed: 20 sticks of spaghetti, one yard of tape, one yard of string, one fluffy marshmallow, a timer, and a yardstick or measuring tape
Ages: all ages starting from 6
Players: 4–600 people can play, all must be in teams of between 2 and 6 people
Time needed: 45 minutes

Instructions:
These are taken from www.marshmallowchallenge.com.

The task is simple: in 18 minutes, teams must build the tallest free-standing structure out of 20 sticks of spaghetti, one yard of tape, one yard of string, and one marshmallow. The entire marshmallow needs to be on top and teams can use as much or as little of the kit as they wish. Teams cannot hold onto the structure at the end of the 18 minutes. Those touching or supporting the structure at the end of the exercise will be disqualified.

The Unusual Uses Game

Purpose:
Often the best new ideas are not the first ones that we think of. This game pushes us to keep coming up with lots of ideas about how to use an everyday object, pushing us to move beyond the very first ideas we think of toward more original ideas.

Getting Started:
Supplies needed: notebook, pencil, and timer
Ages: all ages starting from 6
Players: can be done individually, with a partner, or with a small team
Time needed: 5 minutes

Instructions:

1. Set your timer for three minutes. Important note: Do not tell the children that they are being timed. This is a game and not a test and research supports that people do not produce nearly as many original ideas when they are aware of being timed.

2. Pick one item from the list below:
- Broom
- Carrot
- Yardstick
- Gallon of milk
- Beach ball

3. Start your timer and make a list of as many possible uses as you can for this object. Try to push yourself to be creative and come up with less common uses for this object.

4. Review your list once time is up. Put an *X* through any uses that, upon reflection, do not actually make sense. Circle the ones that do work and are especially unique.

5. Share your list with others. If you are playing with a group, see how many ideas you came up with that are the same as others or are different from others.

Walk the Talk

Purpose:
This movement exercise provides children with an opportunity to act silly with their body while also having an opportunity for perspective taking. Children are asked to walk across the room in as many different ways as possible. Walking like a caterpillar allows them to look up at things that they may be used to looking down upon. This exercise gives children a new way to look at the world, while using physical movement to express their creativity.

Getting Started:
Supplies needed: none
Ages: ages 5 through adolescence
Players: 2–6 children
Time needed: 10+ minutes

Examples:
- Caterpillar
- Crabs
- Giraffes

Instructions:

1. Ask the child(ren) to list three things that walk.

2. Then ask them to walk across the room in as many different ways as they can imagine.

3. Once they run out of ways to walk differently, have them revisit different styles and ask them how that particular way is different than how they normally walk.

4. Also, ask them how walking like an ant (for example) lets them look at things differently (e.g., Does an ant see a table differently than an adult human?).

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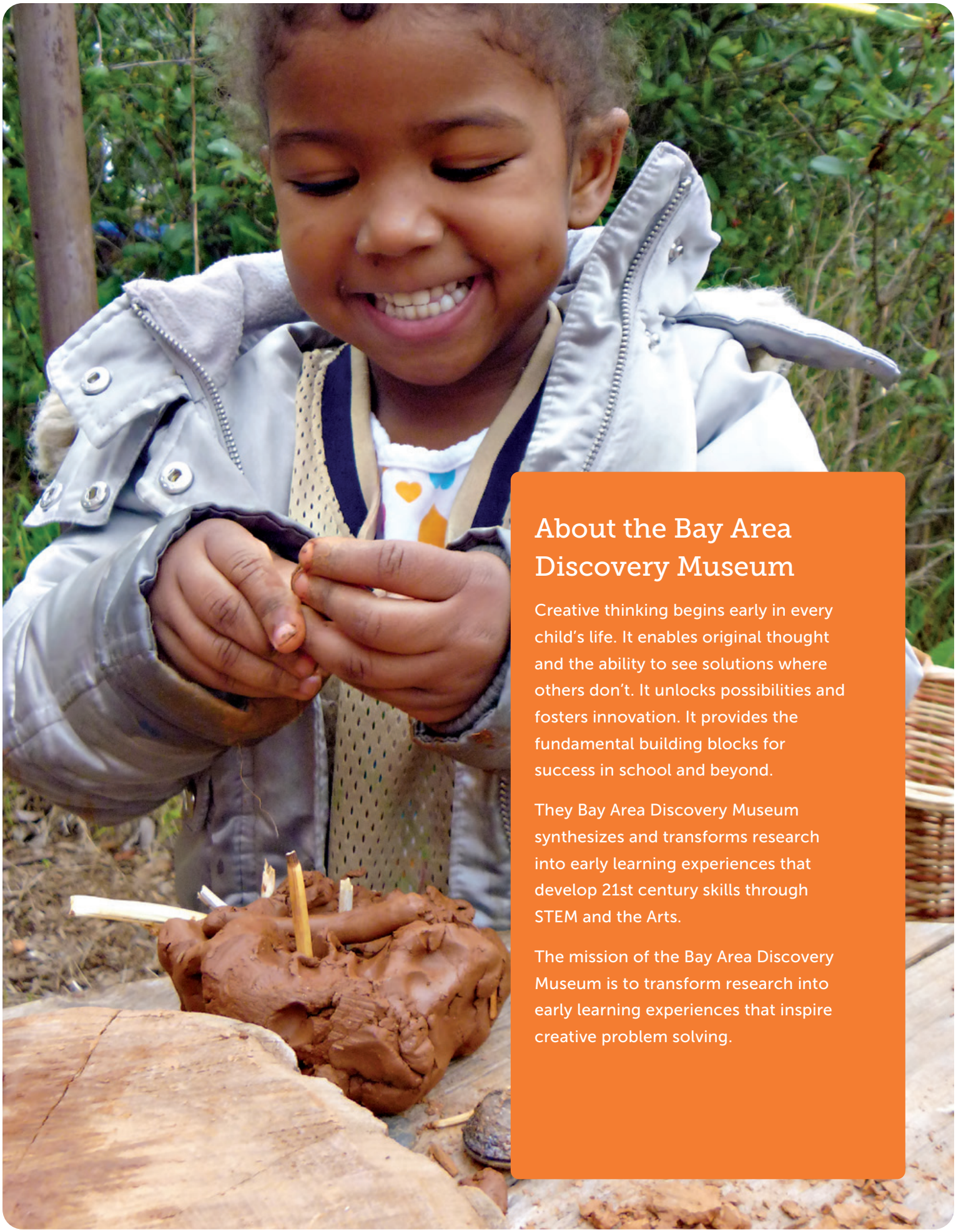

About the Bay Area Discovery Museum

Creative thinking begins early in every child's life. It enables original thought and the ability to see solutions where others don't. It unlocks possibilities and fosters innovation. It provides the fundamental building blocks for success in school and beyond.

They Bay Area Discovery Museum synthesizes and transforms research into early learning experiences that develop 21st century skills through STEM and the Arts.

The mission of the Bay Area Discovery Museum is to transform research into early learning experiences that inspire creative problem solving.

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Bay Area Discovery Museum
557 McReynolds Road
Sausalito, CA 94965

(415) 339-3900

BayAreaDiscoveryMuseum.org