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Research Paper

Children's developing reflections on and understanding of creativity

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ABSTRACT

Children's creativity is often investigated through adults' subjective judging of novelty in a product, or by assessing the flexibility of children's thinking. These approaches do not explicitly ask children to reflect on what *they* think is creative and often ignore children's metacognitive understanding of creativity. We took two approaches to examining this development. First, using semi-structured interviews, we asked children, ages of 5–10 (N = 75), to define creativity and reflect theirs and others' creative actions (Study 1). As children got older, they reflected more on the novelty of the action and were more likely to describe creativity as a process that could be applied generally. Second, using more laboratory-based methods, we asked 5- to 10-year-olds (N = 137) and adults (N = 150) about the role that novelty (Study 2) and utility (Study 3) play in creative actions. In Study 2, children were more likely to judge that a novel action was more creative as they got older, and there was no difference between children and adults' responses by age 8. In Study 3, when two novel actions were contrasted, and one was more useful (but less novel), adults chose the useful action as more creative, whereas older children chose the more novel action. Overall, children's understanding of creativity as a general process undergoes significant change around mid-childhood, which has implications for its importance for informal learning environments.

1. Introduction

Children's creativity is associated with skills like divergent thinking and problem solving (Runco, 2004; Runco & Acar, 2012). Creative thinking also promotes positive emotional development and better emotional understanding in children (e.g., Russ, 1993; Seja & Russ, 1999). What creativity is, how it is used, and how it is useful for child development are important and open questions. Creativity, particularly in children, has often been studied by having children generate "deliverables" – products such as artwork, drawings, or ideas, which are then assessed by adults. Other studies use semi-structured interviews and surveys with parents and teachers to describe their views about children's creativity. But the majority of studies on children's creativity focus on children's creative potential. For example, a frequently used measure is one of divergent thinking (DT), which assesses children's ideational fluency, originality, flexibility and elaboration. DT methods focus on children aged 7 and older, and the complexity of DT tasks have shown a developmental trajectory into adulthood (e.g., Charles & Runco, 2001; Claxton, Pannells, & Rhoads, 2005; Sak & Maker, 2006; Torrance, 1967).

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What is less understood about children's creativity, particularly during the elementary-school years, is their metacognitive understanding. How do children reflect on their understanding of what is creative, and their own and others' ability to be creative? To study this question, we must understand what it means for something to be creative. However, in related research, creativity has not been well-defined (Plucker, Beghetto, & Dow, 2004). To meet this challenge, Runco and Jaeger (2012) proposed what they called the "Standard Definition" of creativity – that creative actions are a balance between *novelty* and *utility*.

Novelty has long since been suggested as fundamental for an idea or product to be creative (e.g., Barron, 1955; Csikszentmihalyi, 1996; Charles & Runco, 2001; Rogers, 1954; Rothenberg & Hausman, 1976; Stein, 1953). Charles and Runco (2001), for example, examined the extent to which children evaluated their own ideas as original and appropriate. They found significant differences in children's use of novelty as the basis for creativity between 3rd- and 5th-graders. Various studies, however, also emphasize the usefulness, effectiveness or appropriateness of outcomes when judging them as creative (e.g., Jackson & Messick, 1965; Stein, 1953). A standing desk is seen as creative because it functionally reinvents ways of doing work in a novel way; a desk made of Jello is novel (indeed, more novel than a standing desk), but not a creative solution to workplace ergonomics[1] .

Investigating children's metacognitive understanding of creativity lends relevance to practitioners working towards developing children's creative competencies. Museums, in particular, have begun to recognize creativity has an important part of their agenda. For example, the surge of makerspaces in these institutions over the last ten years demonstrates the desire to grow children's design thinking and problem-solving skills through open-ended creation (Bowler, 2014; Halverson & Sheridan, 2014). Understanding how children develop their perception of creativity can inform multiple facets of a museum's creative framework. Knowing how children articulate their thoughts about creativity helps in designing program content, establishing target age-ranges, developing parent/teacher resources, and training programming staff.

In our studies, we hypothesized that children's ability to integrate these defining features of creativity (i.e., novelty and utility) would increase with age; we also posited that as children got older, they would mention more of these features in their definitions and reflections on what creativity is and why events are creative. To this end, we used two approaches to study what children know about creativity. In Study 1, we used a semi-structured interview that asked 5- to 10-year-olds to define creativity and reflect on their own and others' creative experiences. We then examined the specific roles that novelty (Study 2) and utility (Study 3) play in children's judgments of whether others' actions are creative using forced-choice vignettes.

We chose this age range because between these ages, children's metacognition undergoes significant development (e.g., Flavell, 1979; Flavell, Green, Flavell, Harris, & Astington, 1995; Schneider, 2008). In addition, various investigations have examined older children's understanding of creativity. For example, when asked to identify creative characteristics, 7th through 12th graders listed risk-taking and inquisitiveness as important factors in their creativity while listing motivation and energy as important factors in others' creativity (Saunders Wickes & Ward, 2006). Similarly, Pizzingrilli and Antonietti (2010) explored 7- to 14-year-olds' awareness of the characteristics that made a product creative, and found that children used novelty as the basis of distinguishing between creative and non-creative drawings. Our goal was to synthesize children's understanding of novelty and utility in this younger sample.

2. Study 1

In Study 1, we asked children a set of open-ended questions designed for them to define creativity and to reflect on times when they and others were creative, as well as how they and others were creative. Our method and analysis strategy paralleled the semi-structured interview used by Sobel and Letourneau (2015) on children's understanding of learning. They showed that the ways in which children defined learning related to their ability to reflect on how they learned information. We paralleled this study by first examining how children defined creativity, and then examine whether aspects of those definitions relate to children's reflections on their examples of times of when and how they and others were creative.

2.1. Methods

2.1.1. Participants

Seventy-five children between the ages of 5–10 (34 female, 41 male; M_{age} = 95.06 months, Range = 61.50–131.60) were recruited for this study. For purposes of recruitment, children were categorized into three age groups: twenty-five 5 − 6-year-olds (M_{age} = 71.79, SD = 6.58), twenty-five 7 − 8-year-olds (M_{age} = 96.58, SD = 7.26) and twenty-five 9 − 10-year-olds (M_{age} = 116.82, SD = 7.07). The mean age of boys (94.06 months) and girls (96.28 months) did not significantly differ. The majority of participants were tested at Providence Children's Museum, a museum that focuses on learning through play and exploration with varied exhibition and programming content. No formal measure of race or SES was taken, but the majority of children who participated were Caucasian and from middle- to high-SES families (as documented by visitor surveys from the museum).

2.1.2. Procedure

One-on-one interviews took place in a quiet space off the museum floor. The interviews were videotaped and transcribed for later coding. At the start of the interview, the researcher began by telling children she would ask them a few questions and that there were no wrong answers to the questions. Then, the researcher asked "What do you think it means to be creative?" After children

[1] We thank Chris Hitchcock (2011) for this creative example (of counterfactual inference), which we applied to examples of creativity.

Table 1
Examples of Coding Categories for Open-Ended Interview.

Category	Transcribed response
Definitions of creativity	
Action	"Making something new out of something old."
	"To make anything."
	"Inventing things."
	"Drawing. Building."
Mental State	"Thinking of your own ideas instead of copying someone else's."
	"You can express whatever you're thinking inside your head."
	"To be able to imagine stuff."
Talk of Novelty	
New	"Making a design that no one else made."
	"To be different and unique and you try new things."
	"Something that you've never thinked before and it's different than other ideas."
Not New	"You make special art…"
	"To have fun and do whatever your mind does."
	"Making what you want."
Examples of Creativity	
Activity	"A long time ago I made a birdhouse."
	"I made a flower crown…with my friends."
Both Activity and Mental State	"When we were building a bike jump, [friend] thought to put a support piece in the middle of it and it actually worked."
	"If you have a piece of paper, you use your imagination to draw something on there."
Talk of creative outputs	
Not Specific	"To create stuff."
	"All the times when I draw."
	"I am very creative with Legos because I like to build and I like to take things apart and make new things…"
Specific	"Making a stack of blocks."
	"When I made a book."
	"[My aunt] made this big painting…and it was like a picture of the snowy trees and like a driveway."

responded, the researcher asked, "Can you tell me about a time when you did something that was creative?" The researcher followed up by asking children to describe their example in detail ("What do you do when [answer]?") and provide reasoning for how their example was creative ("How is [answer] creative?"). We repeated this line of questioning so children could provide us with two examples of their own creativity.

The interview then continued by asking about children's descriptions of others' creativity. The researcher asked, "Can you tell me about a time when someone else did something that was creative?" The researcher then asked "What do they do when [answer]?" before asking "How is [answer] creative?" Again, we repeated these questions, giving children the opportunity to generate two examples of someone else's creativity. The interview concluded with two final questions, "Are there any other ways that somebody can be creative?" and "Can you think of any other ways?"

The interviews lasted no longer than ten minutes. The researcher asked children to tell her more if their response needed more details or clarification (e.g., "Can you tell me more about that?"). If children did not know or were unsure about an answer, the researcher continued onto the next question.

2.1.3. Coding

We coded children's definition of creativity into four categories: (1) *Irrelevant* answers, which included children not responding, saying "I don't know" or generating nonsensical responses (2) *Identity* answers, meaning children defined creativity using the word creative (e.g., "creative is being creative"); (3) *Action* answers, which described actions such as making, building, or playing; (4) *Mental State* answers, which involved children generating mental state language in their definition (e.g., "thinking about something differently"). We also coded to see if children's definitions included language relating to novelty, which we conceptualized as being a key component of creativity. Coders looked for words such as "new," "different," or "original" in definitions. Examples of these (and all codes described in this section) are shown in Table 1.

Next, we examined examples of children's own and others' creativity. We first coded whether each example was relevant – that is, whether coders believed that the example had appropriate semantic content. Irrelevant examples were not coded further. If the example was relevant, we divided examples into being about *activities* (e.g., I drew a picture or she built a Lego tower), *mental states* (e.g., I had an idea, she thought about the problem) or both. Further coding of this response is described in the supplemental materials

We then looked at justifications for how children's examples were creative. Coders organized responses into three groups: (1) *Irrelevant*, which included cases where children did not respond to the question, "I don't know" responses, or responses that were nonsensical to the question at hand; (2) *Identity* answers, meaning children used the word creative to reason their example (e.g., because it was creative) or that simply repeated the action in their example (e.g., because I drew it/made it/built it, etc.); (3) *Relevant* answers, in which children generated a semantically appropriate response. These relevant answers were then coded into seven non-mutually exclusive categories which included: (a) Novelty; (b) Enjoyment; (c) Social; (d) Use of Object (e.g., it was creative because I used paint); (e) Effort (e.g., I worked hard and I took my time); (f) Mental state; (g) Other. Examples of these codes are given in the Supplemental Materials section. Here, we will only focus on novelty and mental states.

Table 2
Distribution of children's definitions of creativity and their talk about novelty with mean age of children generating these definitions.

	No Response/IDK (n = 8)	Action Definition (n = 37)	Mental State Definition (n = 30)
Mean Age (months)	87.38	91.22	102.66
	(24.58)	(19.01)	(17.12)
	No Novelty (n = 54)		Novelty (n = 21)
Mean Age (months)	91.33		104.65
	(20.63)		(19.77)
	Specific Outcome (n = 64)		Non-Specific Outcome (n = 11)
Mean Age (months)	96.40		87.26
	(18.70)		(24.73)

Finally, to examine children's definitions and examples of creativity for reference to utility, we coded examples for talk related to specific creative outputs or products. Coders examined all relevant responses and separated them into two categories: (0) Not Specific, in which children's responses did not include a specific product in their definition of creativity or their creative examples (e.g., When I build, making something you've never thought of) or (1) Specific, meaning children's responses included a specific product in their definition of creativity or their creative examples (e.g., I built a tower, when you make a picture of a unicorn).

Interviews were coded by two research assistants, blind to the purpose of the study, using video transcripts. Agreement was 95 % (Kappa = .89) for coding related to children's definition of creativity, their creative examples, and their justifications. Agreement for specific creative output coding was 93 % (Kappa = .80). All disagreements were resolved through discussion with the first author.

3. Results and discussion

The distribution of responses to the initial question (What does it mean to be creative?) is shown in Table 2. Children never generated an identity response to this question, so this code was not considered in our analyses. Preliminary analyses of children's sex found no difference in their distributions of responses, $\chi^2(2, N = 75) = 0.23$, $p = .89$.

Age and whether children generated a mental state in their definition were significantly correlated, $r_s(73) = .30$, $p = .008$. Age and whether children talked about novelty were also significantly correlated, $r_s(73) = .31$, $p = .008$. Age was not correlated with whether children generated a specific outcome in their definition, $r_s(73) = -.16$, $p = .18$. To consider whether the variance in age explained by talk about novelty and mental states were unique (as opposed to related to a more general factor, like children's language ability), we looked at whether children talked about novelty, about mental states, and about specific outputs by building a generalized linear model with age as the dependent variable. The overall model was significant, Likelihood $\chi^2(3) = 15.41$, $p = .002$. Whether children mentioned novelty, $B = 12.75$, SE = 4.63, 95 % CI [3.67, 21.82], Wald $\chi^2(1) = 7.58$, $p = .006$ and whether children mentioned mental states, $B = 12.07$, SE = 4.44, 95 % CI [3.36, 20.77], Wald $\chi^2(1) = 7.39$, $p = .007$ both independently (and positively) predicted children's age.

Next, we considered how children responded to being asked to give examples of their own and others' creativity. In general, children provided more relevant examples of their own creativity than of others, Wilcoxon Signed Rank Test, $z = -3.47$, $p = .001$, $r = .28$. When asked to justify why these actions were creative, children appealed to novelty 36 % of the time for their own examples and 32 % of the time for examples of when others were creative, which was not significantly different, McNemar $\chi^2(1) = 0.00$, $p = 1.00$. In both cases, children were more likely to appeal to novelty for each one of their examples as they got older, $r_s(73) = .28$, $p = .02$ and $r_s(73) = .33$, $p = .004$ for own and others' examples respectively.

We also looked at the relation between generating these explanations for why children's own or others' actions were creative and children's definitions of creativity (their responses to the first question). Generating a definition of creativity based on mental states did not correlate with generating any kind of explanation of one's own creativity. Generating a definition that involved novelty correlated with explaining why one's own actions were creative because it was novel, $r_s(73) = .46$, $p < .001$. This correlation was significant when age was factored out, $r_s(72) = .41$, $p < .001$. Appealing to novelty to explain why another's actions were creative also correlated with defining creativity in terms of novelty, $r_s(73) = .40$, $p < .001$. This finding was also significant when age was factored out, $r_s(72) = .33$, $p = .004$. No other relations between children's initial definitions and their justifications for why their own or others' actions were creative were significant when age was factored out.

Finally, we considered whether children talked more about specific or nonspecific outcomes in their descriptions of creativity. We coded children's own examples, their examples of others' actions, and whether they could think of any other way one could be creative. Children generated 1.24 specific examples of their own creative actions, 1.05 examples of others' creativity, and 0.41 examples of other ways one could be creative (all out of a possible 2). To control for within-subject variance, we constructed a GEE on the number of times children generated a specific outcome in each of their two possible examples, assuming an ordinal distribution. We examined the effects of question type (own creative action, others' creative action, or any other way one can be creative) and age. This model showed a main effect of question type, Wald $\chi^2(2) = 49.14$, $p < .001$, and a main effect of age, Wald $\chi^2(1) = 7.98$, $p = .005$. Investigating the effect of question type further, we found that children were more likely to offer specific examples when asked about their own and others' creative actions than the final follow-up about other ways one could be creative, B = 2.11 and 1.62, SE = 0.30 and 0.31, 95 % CI [1.51, 2.70] [1.02, 2.22], Wald $\chi^2(1) = 48.30$ and 27.65, both p-values $< .001$ respectively. Children were

also more likely to generate specific examples for their own creative acts than others', B = −0.49, SE = .25, 95 % CI [−0.98, 0.10], Wald $\chi^2(1) = 3.68$, $p = .05$. The effect of question type is potentially related to the linguistic demands of the interview. The self and others' creative examples are cases where children are asked to tell the experimenter about a time when they or another person was creative. The final question, however, was more open ended, and after children generated their previous examples. This might have made them think they had to generate different responses.

To summarize, older children were more likely to include metacognitive thought, as well as novelty, in their definitions of creativity. In addition, as they got older, they began to see novelty and mental states as independent factors important to creativity. Finally, children who included novelty in their definitions were more likely to relate novelty to their justification of creativity.

What these results do not tell us is how children make inferences about whether actions or ideas are creative based on their novelty or utility. We suggest that children might come to understand novelty between the ages of 5 and 10, but we did not find any differences among the age groups' mentions of specific outcomes (that might indicate they understand utility). Studies 2 and 3 investigate children's use of these features when making inferences about what is creative more directly using more laboratory-based investigations.

4. Study 2

Study 2 investigated children's use of novelty when making inferences about whether others' actions are creative. Children were read stories about two characters engaging in a set of different actions. Both characters completed the goal of the action they engaged with, but one character did so by following instructions, and thus were told what to do; the other character did so by making up instructions in their head. Children were asked to judge which character was more creative and justify their response. Critically, we wanted to investigate the age at which children would reliably choose the character who made up the instructions for the final product, and whether children could explain their choice in terms of the character doing something novel. To consider the age at which children might respond to these questions like adults, we also included an adult sample.

4.1. Methods

4.1.1. Participants

Sixty-two children between the ages of 5–10 participated in this experiment (36 girls, 26 boys, M_{age} = 90.21, range = 60.00–131.20 months). Children were recruited from a local children's museum. No formal measure of race or SES was taken, but the majority of children who participated were Caucasian and from middle- to high-SES families (as documented by visitor surveys from the museum).

Seventy-five adults also participated in this experiment (37 females, 38 males). Adult participants were recruited using the crowdsourcing platform, Amazon Mechanical Turk (MTurk) and were tested remotely. They received 20 cents for their participation. Eighteen participants responded with two or more incoherent or incomplete justifications and were excluded from analysis. No formal measures of race or SES was taken. However, respondents were required to be over 18, in the United States, and have MTURK HIT approval rating greater than 90 to participate.

4.1.2. Materials

We created a total of 12 pictures to use as experiment stimuli. Stimuli were originally hand-drawn with pencil and paper, then photographed and uploaded to FireAlpaca 2.0.1, a free painting software. Once uploaded, they were traced and colored using the application's painting tools.

Stimuli were printed on 8.5 × 11" standard white paper and laminated. For each story, children were shown two pictures. These pictures were similar in that both characters were engaged in an action. One was described as completing that action by following instructions. The other was described as completing the action by using what they thought of in their head. Example stimuli are shown in Fig. 1.

The adult portion of this study was created as a survey in Qualtrics. We used the same stimuli that was used in the child experiment. Each image was uploaded to using the Text/Graphic question type and fit to size 500 × 647 pixels.

4.1.3. Procedure

Children were recruited from the museum floor and brought to a private testing area in the museum with their parent/legal guardian. The experimenter began by telling children she had three short stories to tell the children with a question at the end of each one. The stories were about two characters each engaged in (a) building a castle out of Legos, (b) drawing a castle, and (c) playing a board game. The two characters in the story were gender-matched to the child.

The experimenter introduced both characters and then described what they were doing. For example, in the building story, the experimenter said, "The other day, my two friends DJ and Cam were playing with Legos. The Legos came in a box with directions on how to build a castle. They both decided they wanted to build a castle." Then the experimenter pulled one of two pictures. She said "DJ looked at the directions." The experimenter pointed to the instructions in the character's hand, which had a picture of a castle on it. The experimenter then said, "She built her castle using the directions from the box." She then brought out the other picture and said, "Cam never looked at the directions." The experimenter pointed to the character's thought bubble, which had the same picture of the castle in it, and said "She built her castle using what she pictured in her head."

With both pictures on the table in front of the child, the experimenter then asked, "Which one of my friends was more creative?"

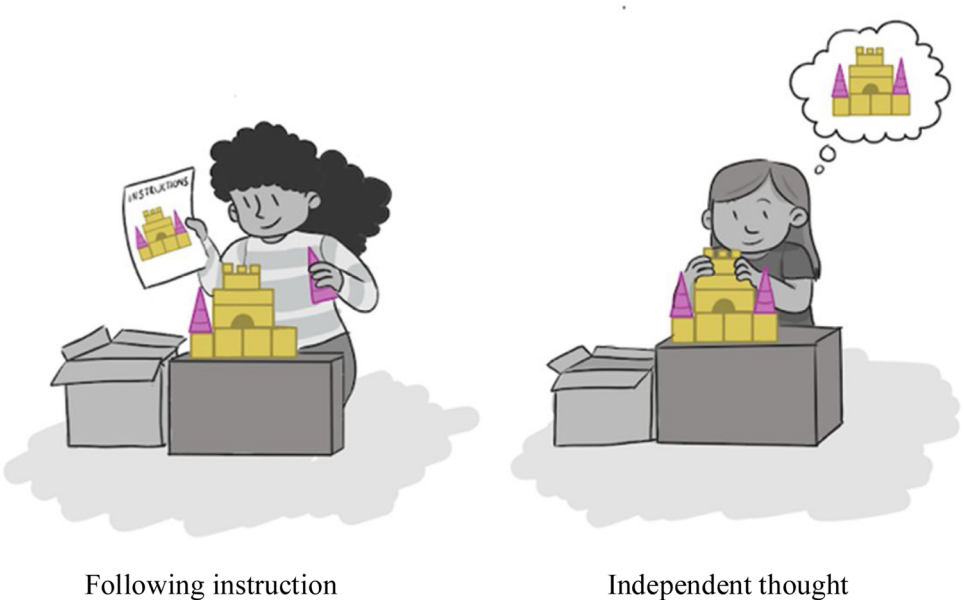

Fig. 1. Female stimuli used in building story (note that only pictures were shown to participants, not the text "Following instructions" or "Independent thought").

After children gave a response, she asked children to justify their answer, "Why do you think [character's name] was more creative?" The full scripts of the stories are shown in Appendix A. Which character was introduced first and the order of the stories presented to children were counterbalanced.

Adults participated in the experiment online. The stories and stimuli used in this experiment were the same as what was used in the child experiment. Adults, however, were required to read the stories and respond via text (as opposed to the verbal procedure in the child portion of the study). The order in which the stories were presented, as well as which character was first introduced, were randomized by the survey. Participants could save and return to the survey within 24 h.

4.1.4. Coding

We video recoded and transcribed all children's character choices and verbal reasoning. Qualtrics documented all adults' character choices and written reasoning. We downloaded responses into a SPSS file for analysis. We coded both children and adult responses the same way. First, we considered responses to the question "Which one of my friends was more creative?" For each vignette, participants who chose the character using novel thought were coded as responding correctly, while participants who chose the character using the instructions were coded as responding incorrectly.

The open-ended responses to the question "Why do you think [choice] was more creative?" were coded into four categories: (1) *I don't know* responses; (2) *Irrelevant* reasoning, which were answers unrelated to the question; (3) *Not Creative Character Relevant* reasoning, meaning participants answered with a justification related to the character's use of instruction and; (4) *Creative Character Relevant*, which involved participants generating reasoning related to the character's independent thought. Examples of the latter three codes are shown in Table 3.

5. Results and discussion

Overall, children chose the character engaging in the novel process on 81 % of the building vignettes (SD = 40 %), 79 % of the drawing vignettes (SD = 41 %) and 77 % of the game play vignettes (SD = 42 %). We constructed a Generalized Estimating Equations (GEE) model with a binomial distribution, and a cumulative logit link function was used to investigate the influence of age

Table 3
Examples of justification categories for Study 2.

Category	Transcribed response
Irrelevant	"Because she is happy."
	"Because he had like…the flags were like more up more."
Not Creative Character Relevant	"She wasn't thinking about it, she was looking at the example on the box."
	"He wanted to do the same thing as the picture."
Creative Character Relevant	"She didn't look at the game's instructions."
	"He wanted to think of something on his own."

and question type on these responses. A main effect-only model proved to have a better overall fit than a factorial model (as measured by QICC values, 165.63 vs 161.73), so we report this model. Age was the only significant factor, Wald $\chi^2(1) = 19.50$, $p < .001$.

To investigate the role of age further, we ran a median split on these data. On all three vignettes, the younger group of children (below the age of 86.80 months) performed at chance levels, (60 % correct, 60 % correct, and 53 % correct, Binomial tests, $p = .36$, .36, and .86 for the building, drawing, and game play vignettes respectively). The older group of children (86.80 months or above) performed at greater than chance levels (100 % correct, 97 % correct, and 100 % correct, Binomial tests, all p-values $< .001$ for these respective vignettes).

We next considered how children justified their responses. Ninety-two percent of children who chose the character who engaged in a novel action generated a relevant justification for their choice in the building vignette. Ninety-four percent of children did so for the drawing vignette and 96 % of children did so for the game play vignette. Children never generated relevant justifications if they chose the other character in any of the three vignettes. We ran a similar GEE analysis on whether children generated a relevant justification. Age, again, was the only significant factor, Wald $\chi^2(1) = 21.87$, $p < .001$. As with children's responses, when we applied a median split to these data, we found that the younger group generated a relevant justification on 49 % of the vignettes, while the older children generated a relevant justification on 98 % of the vignettes, Mann-Whitney $U = 198.00$, $z = -5.00$, $p < .001$.

Adults chose the character engaging in the novel process on 93 % of the building vignettes (SD = 26 %), 96 % of the drawing vignettes (SD = 19 %) and 93 % of the game play vignettes (SD = 26 %), and generate relevant justifications 88 % of the time for the building vignette, 91 % of the time on the drawing vignette, and 93 % of the time on the board game vignette. This pattern of performance was no different from children in the upper half of the age range. In general, these data show that there is a distinct difference among 5- to 10-year-olds' understanding of the role of novelty in creativity, with 7–8 years of age being the transition point. By age 8, children looked no different from adults in terms of how they responded to these vignettes or justified their answers.

6. Study 3

In Study 3, we investigated 5- to 10-year-olds' understanding of utility, or usefulness, in their assessment of creativity. Like Study 2, children were read a set of vignettes about two characters engaging in goal-directed actions. Both characters encountered the same problem accomplishing their goals. One character generated a novel solution to the problem, which was effective (and therefore was useful). The other generated a novel solution to the problem, which was ineffective (and thus not useful). We then asked children to judge which character was more creative and to justify their response. We also collected an adult sample to contrast with children's performance.

6.1. Methods

6.1.1. Participants

Seventy-five children between the ages of 5 and 10 participated in this experiment (38 female, 37 male; $M_{age} = 95.3$, Range = 60.70–130.70). Children were recruited from a local children's museum. No formal measure of race or SES was taken, but the majority of children who participated were Caucasian and from middle- to high-SES families (as documented by visitor surveys from the museum).

Seventy-three adults also participated in this experiment (42 females, 31 males). Respondents were recruited in the same manner as in Study 2. Nineteen participants responded with two or more incoherent or incomplete justifications and were excluded from analysis.

6.1.2. Materials

File images from Study 2 were edited and reworked in FireAlpaca 2.0.1 to create the stimuli for Study 3. Stimuli were printed on 8.5 × 11" white paper and laminated. For each story, children were shown two pictures. These pictures were similar in that both characters were engaged in the same action, trying to solve the same problem. One was described as engaging in the action using a solution to the problem that worked. The other was described as engaging in the action using a solution to the problem that didn't work. Example stimuli are shown in Fig. 2.

The adult experiment, like Study 2, was created as a survey in Qualtrics. We used the same stimuli in both the child and adult portions of this study. Each image was uploaded using the same question type and image size as Study 2.

6.1.3. Procedure

Children were recruited from the museum floor and brought to a private testing area in the museum with their parent/legal guardian. The experimenter began by telling children she had three short stories for the children with a question at the end of each one. The stories were about two characters who wanted to (a) build a castle but didn't have any blocks, (b) draw a castle but didn't have any crayons, and (c) play a board game but didn't have any game pieces. The two characters in the story were gender-matched to the child.

The experimenter introduced both characters and then described what they were doing. For example, in the game play story, the experimenter said, "The other day, my two friends Sam and Jesse decided they wanted to play a board game but they couldn't find any game pieces. They had to choose something else to use as a game piece." Then the experimenter pulled out the first picture and placed it on the table. She said "Sam wanted to use a pebble so he tried playing the game using a pebble as his game piece and it

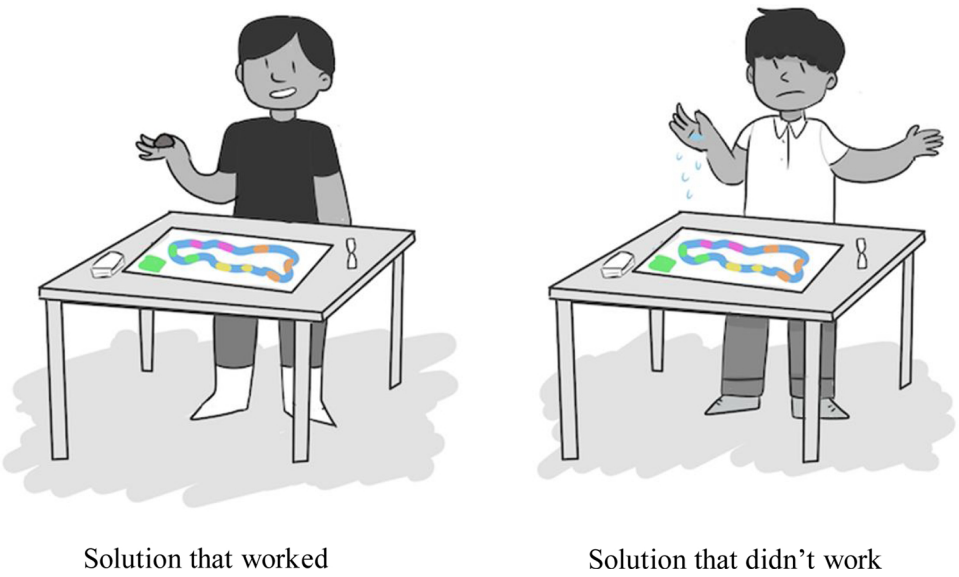

Fig. 2. Male stimuli used in game play story (note only pictures were shown to participants, not the text "Solution that (didn't) work.").

worked." She then pointed to the pebble in the character's hand. Next, she brought out the second picture and said, "Jesse wanted to use a drop of water so he tried playing the game using a drop of water as his game piece but it didn't work." The experimenter pointed to the drop of water in the character's hand. With both pictures on the table in front of the child, the experimenter then asked, "Which one of my friends was more creative?". After children gave a response, she asked children to justify their answer, "Why do you think [character's name] was more creative?" The full scripts of the stories are shown in Appendix B. Which character was introduced first and the order of the stories presented to children were counterbalanced.

Adults participated in an identical manner as the adults in Study 2. The stories and stimuli adults responded to were the same stories and stimuli we used with children in Study 3. Again, the order in which the stories were presented, as well as which character was first introduced, were randomized by the survey.

6.1.4. Coding

Coding for Study 3 was similar to Study 2. We coded both children and adult responses the same way. We first looked at participants' response to the question "Which one of my friends was more creative?" Participants who chose the character with the successful solution were coded as responding correctly while participants who chose the character with the unsuccessful solution were coded as responding incorrectly. We then coded participants' justifications. Participants' responses to the question "Why do you think [choice] was more creative?" were coded into four categories. These categories were: (0) *I don't know* responses; (1) *Irrelevant* reasoning, which were answers unrelated to the question; (2) *Not Creative Character Relevant* reasoning, meaning participants answered with a relevant justification related to the use of the character's (whose solution didn't work) material, their attempt to solve the problem, or their new/different action in trying to solving the problem and; (3) *Creative Character Relevant*, which included relevant reasoning related to the character's (whose solution worked) material usage or the success at their task. See Table 4 for examples related to the latter three coding categories.

7. Results and discussion

Overall, children chose the character engaging in the useful process on 72 % of the building vignettes (SD = 45 %), 60 % of the drawing vignettes (SD = 49 %) and 64 % of the game play vignettes (SD = 48 %). We constructed a Generalized Estimating

Table 4
Examples of justification categories for Study 3.

Category	Transcribed response
Irrelevant	"Because a lake needs water."
	"She used something that could be used to make different designs."
Not Creative Character Relevant	"Cooked spaghetti would make the tower weirder, stranger and better."
	"She found something that might work but might not."
	"He used water and no one would use water"
Creative Character Relevant	"It would work better if she uses this spaghetti because it's harder."
	"Because the pebble worked as a game piece.

Equations (GEE) model with a binomial distribution, and a cumulative logit link function that was used to investigate the influence of age and question type on these responses. A main effect-only model proved to have a better overall fit than a factorial model (as measured by QICC values, 265.31 vs 269.27), so we report this model. This model revealed a main effect of question type, Wald $\chi^2(2) = 5.95$, $p = .05$ and a main effect of age, Wald $\chi^2(1) = 10.67$, $p = .001$. The main effect of question type indicated that children were less likely to select the character who engaged in the useful process on the drawing and board game vignettes than the building vignettes, B = 0.42 and 0.62, SE = 0.19 and 0.28, 95 % CI = [0.04, 0.80] and [0.07, 1,17], Wald $\chi^2(1) = 4.73$ and 4.96, respectively, both p-values = .03.

Unlike Study 2, in which older children chose the character who used the novel process more than younger children, the effect of age in Study 3 was inverted. For all three stories, as children got older, they were less likely to choose the character in the vignette whose actions accomplished the goal, $r_s(73) = -.32$, $-.38$, and $-.38$ for the building, drawing, and board game stories respectively, $p = .005$, .001, and .001 respectively[2] . As in Study 2, we performed a median split (Median = 95.20 months), which showed that the younger group (roughly 5- to 7-year-olds) chose the character who accomplished the goal on all three stories greater than chance levels, Binomial tests, all p-values $< .001$. The older group (roughly 8- to 10-year-olds) chose this character at chance levels, Binomial tests, $p = .34$, .34, and 1.00 for the building, drawing, and board game vignettes respectively.

Next, we examined the frequency with which children generated a relevant justification. Eighty-three percent of children who chose the character who engaged in a successful action generated a relevant justification for their choice in the building vignette. Eighty-nine percent of children did so for the drawing vignette and 88 % of children did so for the game play vignette. Children generated relevant justifications if they chose the other character 9 %, 7 %, and 7 % of the time, respectively. We ran a similar GEE analysis on whether children generated a relevant justification, looking at age and question type. In this analysis, age was the only significant factor, Wald $\chi^2(1) = 6.40$, $p = .01$. As with children's responses, when we applied a median split to these data, we found that the younger group generated a relevant justification on 73 % of the vignettes, while the older children generated a relevant justification on 46 % of the vignettes, Mann-Whitney $U = 482.50$, $z = -2.47$, $p = .01$.

The adult sample responded that the character who accomplished their goal was more creative 76 % of the time on the building vignette, 68 % of the time on the drawing vignette, and 77 % of the time on the board game vignette. A GEE analysis looking at the role of question type found that these frequencies were significantly different, Wald $\chi^2(1) = 10.88$, $p = .004$, with responses on the drawing vignette significantly lower than the building vignette, B = -1.45, SE = 0.48, 95 % CI = [-2.40, -0.50], Wald $\chi^2(1) = 8.93$, $p = .003$, or the board game vignette, B = -0.73, SE = 0.33, 95 % CI = [-1.39, -0.08], Wald $\chi^2(1) = 4.87$, $p = .03$. We then compared adults' performance with children's responses. Overall, looking at the two age groups of children (defined by the median split) and adults together, there were overall differences in responses, Kruskal-Wallis $\chi^2(2) = 9.91$, 13.02, and 13.86 for the building, drawing, and board game vignettes respectively, $p = .007$, .001, and .001 respectively. Simple effect analysis with a Dunn-Bonferroni correction showed that in each case, adults' responses on each vignette were no different from the younger group of children (5- to 7-year-olds), $z = 0.30$, 1.33, and -0.10, $p = .99$, .55, and .99 respectively, but were different from the older group of children (8- to 10-year-olds), $z = -2.73 - 2.52$, and -3.43 $p = .02$, .03, and .002 respectively.

A GEE analysis on adults' justifications revealed that there was no difference among their generating a relevant justification across the three vignettes, Wald $\chi^2(2) = 1.98$, $p = .37$. Given this finding, we analyzed the justifications across the vignettes, which revealed a significant difference in the number of relevant justifications adults generated compared with the two age groups, Kruskal-Wallis $\chi^2(2) = 11.69$, $p = .003$. Simple effect analysis with a Dunn-Bonferroni correction showed that adults were no different from the younger group of children, $z = -0.57$, $p = .99$, but adults were significantly different from the older group of children, $z = -3.31$, $p = .003$. This analysis also revealed that the younger and older groups of children differed from one another, $z = 2.47$, $p = .04$.

Looking at the results of the child and adult data together, we observed different patterns of responses between Studies 2 and 3. When asked about the relation between novelty and creativity, children showed a linear pattern of development, coming to appreciate the role of novelty in being creative around age 8. Study 3 shows that around that same age, however, children start to differ from adults in their judgments about the role of utility or usefulness in creativity. Younger children (5- to 7-year-olds) and adults choose the successful character as more creative, while older children (8- to 10-year-olds) responded at chance levels.

8. General discussion

We investigated 5- to 10-year-olds' understanding of creativity. As a basis for our studies, we took the extent to which children could articulate the "standard definition" of creativity (following Runco & Jaeger, 2012), which centered on generating novel and useful information or actions. We first investigated definitions of creativity in children in this age range, and their reflections on times they and others were creative (Study 1). This semi-structured interview showed that as children got older, they talked more about both novelty as part of both their definitions of creativity and examples of why particular actions or events were creative. Moreover, they often talked about specific outcomes in their definitions, which was a way of measuring whether they believed the action resulted in something useful (or at least, worth describing), and this did not change with age. They also mentioned specific outcomes in more than half of their examples of being creative, suggesting they talk about usefulness in actions (or at least, doing something

[2] Because of the significant effect of question type, we analyzed each vignette separately, unlike Study 2 where we combined these data. If we replicate the analyses of Study 2 here, we get the same patterns of significance as what is reported in the text. Similarly, if we reanalyze the results of Study 2 using the analysis strategy presented here, we get the same pattern of significance as reported in Study 2.

with a fixed outcome) as part of the creative process.

In Study 2, we asked children forced-choice questions to examine whether they would judge characters who engaged in actions that were equally useful but more novel as more creative. We found 8 – 10-year-olds responded no different than adults when asked to choose and reason between characters with novel ideas and characters who follow instructions. These findings are consistent with research that asked children to assess originality related to creativity (e.g., Charles & Runco, 2001; Pizzingrilli & Antonietti, 2010). Age 8 is also when children on average began to talk spontaneously about novelty within their definitions of creativity in Study 1. However, children who included novelty in their definitions, regardless of their age, were more likely to relate novelty to their justification of creativity, suggesting that understanding novelty might emerge earlier in development, and when it does, it is understood coherently as part of children's appreciation of what is creative.

In Study 3, we used a similar methodology as Study 2, but specifically contrasted characters who did novel actions, but differed in the utility of those actions. Here, we found a surprising pattern of results. Younger children (specifically, 5- to 7-year-olds) chose the character whose actions were useful, and did so no differently from adults, while older children in our sample (8- to 10-year-olds) responded at chance.

There are two possible interpretations of these results. The first is that the younger children we surveyed have a generally immature understanding of creativity, and simply equate it with success. This would result in the chance-level responses in Study 2 (where both characters are successful) and above-chance level performance in Study 3 (where they choose the successful character, but not because they appreciate the role of utility in creative actions). At age 8, children learn to recognize the role of novelty in creative thinking and actions, and potentially overgeneralize novelty as being sufficient for creativity. The unsuccessful actions in Study 3 are potentially more novel than the successful actions, and older children might be influenced by this factor. Sometime later in development, but before adulthood, they come to recognize that creative actions must be novel, but also useful.

The alternate possibility is that younger children have an adult-like understanding of utility when making judgments about what is creative – again resulting in chance-level responses in Study 2 (where both characters do useful things) and above chance-level performance in Study 3 (where children, like adults, judge that the novel action is only creative if it applies to the situation). As before, around the age of 8, they come to appreciate the importance of novelty, which might cause them to respond correctly in Study 2 and prevents them from responding correctly in Study 3. At some point later in development, children come to balance novelty and utility in their judgments, consistent with the standard definition of creativity (Runco & Jaeger, 2012). That children often generate specific outcomes in both their definitions of creativity and their examples of being creative in Study 1 mildly suggests this latter possibility.

Further studies could examine the distinction between these two possibilities. For example, the first possibility suggests that young children believe effective solutions are considered creative, regardless of their novelty. If the characters in Study 2 both generated ineffective solutions, one might not expect similar results. Similarly, in Study 3, using a pebble to signify a game piece is novel, but conventional, so children might have based their judgment on the conventionality of the actions. If an unconventional, but effective solution was implemented children might choose this as the more creative option over an unconventional, but ineffective solution. This would potentially be more consistent with the second possibility.

To conclude, children show general development in their metacognitive understanding of creativity between the ages of 5–10. In our sample, children showed more of an adult-like understanding of the importance of novelty in their definitions and decisions about what actions were creative around age 8. An interesting speculation is how children's metacognitive understanding of creativity relates to their own ability to find creative solutions. Carr, Kendal, and Flynn (2015), for example, showed that innovation in children's tool use was relatively rare when children could also imitate a less elegant solution to a problem in as sample of 4- to 9-year-olds. Children only began to innovate over imitate around age 8. These findings suggest the possibility that as children come to recognize more about their own creative thinking, they can implement such creative solutions in their problem solving. Such a possibility would fit with goals in museum settings that recognize creativity in their educational framework, designing programs that challenge children to think outside the box, take risks, explore interests and ask questions (Center for Childhood Creativity, 2019; Foley, 2014).

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Declaration of Competing Interest

None.

Appendix A

Study 2 Story Scripts: Novelty

Domain One: Building

The other day, my two friends DJ and Cam were playing with Legos. The Legos came in a box with directions on how to build a castle. They both decided they wanted to build a castle.

[Pull out illustration of character using directions, place on table and point to the directions] DJ looked at the directions. He/she built his/her castle using the directions from the box.

[Leave first illustration out on table and pull out second illustration of character with thought bubble, place on table and point to thought bubble] Cam never looked at the directions. He/she built his/her castle using what he/she pictured in her head.

[Leave both illustrations on table side by side] Which one of my friends was more creative?

If follow up is needed: Which of my friends do you think was more creative? DJ [point to direction illustration] or Cam [point to thought bubble illustration]?

Why do you think DJ/Cam was more creative?

Domain Two: Drawing

E: The other day, my two friends Alex and Quinn were in art class. There was a picture of a castle on their table. They both decided they wanted to draw a castle.

E: [Pull out illustration of character looking at castle picture, place on table and point to the picture of the castle] Alex looked at the picture of the castle. He/she drew her castle by tracing the picture of the castle.

E: [Leave first illustration out on table and pull out second illustration of character with thought bubble, place on table and point to thought bubble] Quinn never looked at the picture of the castle. He/she drew his/her castle using what he/she pictured in hear head.

E: [Leave both illustrations on table side by side] Which one of my friends was more creative?

If follow up is needed: Which of my friends do you think was more creative? Alex [point to picture of castle illustration] or Quinn [point to thought bubble illustration]?

E: Why do you think Alex/Quinn was more creative?

Domain Three: Game Play

E: The other day, my two friends Jesse and Sam were playing. They both decided they wanted to play a board game.

E: [Pull out illustration of character playing game with rules, place on table and point to the rules] Jesse wanted to play the board game with its regular rules.

E: [Leave first illustration out on table and pull out second illustration of character with thought bubble, place on table and point to thought bubble] Sam wanted to play the board game with the rules he/she made up in her head.

E: [Leave both illustrations on table side by side] Which one of my friends was more creative?

If follow up is needed: Which of my friends do you think was more creative?

Jesse [point to rules illustration] or Sam [point to thought bubble illustration]?

E: Why do you think Jesse/Sam was more creative?

Appendix B

Study 3 Story Scripts: Utility

Domain One: Building

E: The other day, my two friends Cam and DJ decided they wanted to build a castle but they couldn't find any blocks. They had to choose something else to build with.

E: [Pull out illustration of character using hard spaghetti, place on table and point to the hard spaghetti castle] Cam wanted to use hard spaghetti to build his/her castle so he/she tried to build his/her castle using hard spaghetti and it worked.

E: [Leave first illustration out on table and pull out second illustration of character with cooked spaghetti castle, point to cooked spaghetti castle] DJ wanted to use cooked spaghetti to build his/her castle so he/she tried to build his/her castle using cooked spaghetti but it didn't work.

E: [Leave both illustrations on table side by side] Which one of my friends was more creative?

If follow up is needed: Which of my friends do you think was more creative? Cam [point to hard spaghetti illustration] or DJ [point to soft spaghetti illustration]?

E: Why do you think DJ/Cam was more creative?

Domain Two: Drawing

E: The other day, my two friends Quinn and Alex decided they wanted to draw a castle but they couldn't find any crayons. They had to choose something else to draw with.

E: [Pull out illustration of character using lipstick to draw, place on table and point to the picture of the castle] Quinn wanted to use lipstick to draw his/her castle so he/her tried to draw his/her castle using lipstick and it worked.

E: [Leave first illustration out on table and pull out second illustration of character drawing with a popsicle, point the picture of the castle] Alex wanted to use a popsicle to draw his/her castle so he/she tried to draw his/her castle using a popsicle but it didn't work.

E: [Leave both illustrations on table side by side] Which one of my friends was more creative?

If follow up is needed: Which of my friends do you think was more creative? Quinn [point to lipstick picture] or Alex [point to popsicle picture]?

E: Why do you think Alex/Quinn was more creative?

Domain Three: Game Play

E: The other day, my two friends Sam and Jesse decided they wanted to play a board game but they couldn't find any game pieces. They had to choose something else to use a game piece.

E: [Pull out illustration of character using pebble, place on table and point to the pebble] Sam wanted to use a pebble so he/she tried playing the game using a pebble as his/her game piece and it worked.

E: [Leave first illustration out on table and pull out second illustration of character with water droplet, place on table and point to water droplet] Jesse wanted to use a drop of water so he/she tried playing the game using a drop of water as his/her game piece but it didn't work.

E: [Leave both illustrations on table side by side] Which one of my friends was more creative?

If follow up is needed: Which of my friends do you think was more creative? Sam [point to pebble] or Jesse [point to water droplet]?

E: Why do you think Jesse/Sam was more creative?

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