INTRODUCING A PERSONAL-ORIGINALITY APPROACH FOR SCORING
CHILDREN'S DIVERGENT THINKING

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INTRODUCING A PERSONAL-ORIGINALITY APPROACH FOR SCORING
CHILDREN'S DIVERGENT THINKING

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and hereby certify that, in their opinion, it is worthy of acceptance.

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DEDICATION

This work is dedicated to my grandfather, William Lenhart Groth, Jr., who impressed upon me the importance and power of scientific inquiry. Thank you for modeling what it means to be a lifelong learner and educator. You taught me to view the world as a series of questions, many of which are never truly answered.

*“Like poetry in motion, wingtips fly
and awed by its beauty, I can but stare.
Soaring with the elements eye to eye,
a peregrine falcon masters the sky.”*

-Emile J. Pinet

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INTRODUCING A PERSONAL-ORIGINALITY APPROACH FOR SCORING CHILDREN'S

DIVERGENT THINKING

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ABSTRACT

Divergent thinking (DT), which can be described as the ability to conceive of and express a variety of novel solutions to open-ended problems (Gibson et al., 2009), is one of the most commonly studied constructs related to creative thinking (Runco & Acar, 2012). There is considerable evidence that DT is predictive of later creative behavior and achievement (Benedek et al., 2014; Cramond et al., 2005; Kim, 2008). However, current methods for studying DT rely extensively on cross-sectional comparisons of young children, which may diminish the ability to detect key indicators of DT, such as child-level originality. The current study introduces a personal-originality (PO) approach for scoring children's performance in common DT tasks. While originality is often assessed in terms of statistical rarity (i.e., objective scoring) or subjective ratings, the PO scoring approach used in the current study captures DT at the child level through the strategic use of incubation periods. That is, children demonstrate PO by producing new ideas after time away from the task. The current study explored the effects of both short (i.e., 2 minutes) and long (i.e., several days) incubation periods on 42 three- to six-year-olds' DT performance.

CHAPTER 1: LITERATURE REVIEW

Promoting children's creative thinking abilities has become a priority among educators, scholars, policy makers, and government officials in the United States and abroad (Cheung, 2012; McClain & Pfeiffer, 2012; Nicholson & Moran, 1986; Pang, 2015; Plucker et al., 2011; Roberts, 2006). In support of this initiative, stakeholders have attempted to identify and harness the skills that underly creative thought and behavior. Several indicators of creative potential have been studied extensively. Some aspects of creative potential are considered relatively stable characteristics of the individual (e.g., personality traits) while others are more malleable (e.g., cognitive abilities). The latter category represents a promising avenue for intervention work and is therefore the central focus of researchers interested in nurturing children's creative potential. Perhaps the most thoroughly investigated indicator of creative potential on the malleable end of the spectrum is divergent thinking (Runco & Acar, 2012).

Divergent thinking (DT) can be described as the ability to conceive of and generate a variety of novel solutions to open-ended problems (Gibson et al., 2009). Originally coined "divergent production" by J.P. Guilford (1967) in his structure of intellect theory, DT allows individuals to access various domains of background knowledge relevant to a given task (Paletz & Schunn, 2010) and to mentally transform thoughts and ideas in new and interesting ways (Kilgour, 2006). It is important to note that performance on divergent thinking tests should not be confused with creativity (Runco et al., 2016) because it does not guarantee creative achievement. That is, individuals might think divergently without ever generating a "novel and useful" product

(Plucker et al., 2004, P. 91). Instead, if properly assessed, divergent thinking can be used for identifying creative potential (Guilford, 1967).

There is considerable evidence that DT is predictive of later creative behavior and achievement (Benedek et al., 2014; Cramond et al., 2005; Kim, 2008; Plucker, 1999). For example, Kyung Hee Kim's (2008) meta-analysis of 44 studies found that DT test scores were better predictors of creative achievement across several domains (e.g., writing, art, science) compared to general intelligence scores. Similarly, Jonathan Plucker (1999) found that divergent thinking scores during childhood were predictive of creative achievement (e.g., awards, inventions, publications) 22 years later after controlling for intelligence scores. However, it is possible that the ways previous researchers have measured divergent thinking provide only partial estimates of children's overall creative potential.

Measuring Divergent Thinking

Since the introduction of the construct in the 1960s, several researchers have developed and validated tests for measuring DT. These tests typically involve a battery of verbal and/or figural tasks that examine various dimensions of divergent thought. Verbal tasks require participants to consider open-ended problems and produce verbal responses. For example, in Guilford's (1967) alternative uses task, participants are asked to list all the ways one might use a common object (e.g., uses for a brick). Similarly, Wallach and Kogan's (1965) instances task prompts participants to name things that belong to a specific category (e.g., things that make noise). Figural tests, on the other hand, are used to capture creative potential without the high language demands of verbal tasks. For example, in the picture completion task of the Torrance Test of Creative Thinking

(TTCT; 1966), participants are asked to use incomplete figures to create pictures.

Irrespective of the tools used, researchers measure DT both in terms of the quantity and quality of participants' responses.

Dimensions of Divergent Thinking

There are four scoring criteria that are frequently used to evaluate DT performance: *fluency*, *flexibility*, *elaboration*, and *originality*. Fluency is thought of as the productive aspect of DT and is often operationalized as the sheer number of responses an individual generates. Flexibility is considered the capacity to produce different *kinds* of ideas. It is measured by the number of discrete categories represented across the entire pool of responses. The third component, elaboration, captures the vividness of a response or set of responses. It is evaluated in terms of the amount of detail participants attach to their ideas. The fourth and final dimension common across DT measures is originality, which involves the novelty or uniqueness of an individual's ideas. Conceptually, originality is widely accepted as the characteristic of DT most closely related to raw creativity (Forthmann et al., 2020). However, there is disagreement as to how originality should be operationalized. The following section provides an overview of originality scoring systems frequently used in DT research.

Originality Scoring

The most common methods for exploring divergent thinking can be separated into two broad categories distinguished by the objective versus subjective approach used in scoring (Silvia, Winterstein, Willse, et al., 2008). Generally speaking, objective originality scoring attempts to capture the rarity of an individual's responses relative to a sample or population, while subjective originality scoring involves the social appraisal

(i.e., external ratings) of responses.

Objective Scoring Approaches

In objective scoring, originality is operationalized in terms of the statistical rarity of an individual's responses to an open-ended question. Three of the most common objective scoring approaches are frequency, weighted, and ratio scoring. Frequency scoring operationalizes originality as the number of responses an individual produces that are statistically rare at a specified threshold (e.g., < 10%) based on the study sample or measurement-specific norming samples. Weighted scoring is an extension of frequency scoring that recognizes different levels of rarity. For example, an idea produced by less than 1% of the sample is recognized as rarer than an idea produced by 5-10% of the sample. Though both of these empirically-based approaches are celebrated for their uniformity, they are often criticized because quantity (i.e., fluency) and quality (e.g., originality) subscales are confounded (Hocevar, 1979; Nusbaum & Silvia, 2011). That is, the greater the number of ideas produced, the higher the likelihood that produced ideas will include original, flexible, and more elaborate responses, resulting in poor discriminant validity of theoretically independent dimensions of DT.

To overcome this limitation, several proponents of objective scoring have turned to ratio scoring. In ratio scoring, quality subscales are divided by quantity subscales to eliminate the contaminating effects of fluency on originality (Hocevar & Michael, 1979; Runco, 1986). However, studies have yielded mixed results with this approach, and several researchers have instead turned to subjective scoring systems.

Subjective Scoring Approaches

Subjective scoring approaches, also referred to as rater-based scoring, require

external raters to evaluate participants' originality. These approaches represent the line of thought that ideas and actions are original if they are socially recognized as such. Though different criteria have been used for these ratings, researchers base subjective ratings on predominant definitions of originality. For example, several studies (e.g., Forthmann et al., 2017; Silvia et al., 2008b) use a Likert-scale to evaluate originality based on three criteria identified in a seminal study exploring individual differences in original ideation: uncommonness, cleverness, and remoteness (Wilson et al., 1953). Researchers have found that raters can reliably judge participants' responses by simultaneously considering these three characteristics of originality (Silvia et al., 2008b).

In some studies, raters judge each response in an ideational set independently. Though this approach is valued for its thoroughness, it can be time and energy consuming, especially with larger sample sizes and ideational pools. Instead, many studies will instruct raters to evaluate a subset of an individual's responses, or the entire ideational pool at once. One such approach is the "top-scoring" method. After completing a DT task, participants or experimenters are asked to examine an entire set of responses and to select a fixed number of responses (e.g., "top two") they perceive to be most creative (Benedek et al., 2013; Silvia et al., 2008b). Selected responses are then used to establish individual's originality scores using a fixed-rating scale (e.g., 5-point scale). Perhaps the most time-effective method to date is the "snapshot" approach introduced by Silvia et al., (2009). In this method, raters assign a single originality rating based on a participant's entire ideational pool.

While subjective approaches have been shown to mitigate the contaminating effects of quantity on quality subscales (Silvia et al., 2009), they also have the potential to

introduce substantial error and bias. For example, the volume of work involved in subjective rating, especially with large datasets, has the potential to negatively impact inter-rater reliability (Forthmann et al., 2017). Furthermore, if experimenters are charged with assigning originality scores to participants' responses, their personal views of the construct may influence their selections. Although these methods include guidelines for assessing responses and inter-rater agreement is observed, they still invite avoidable systematic factors, such as raters' expertise (Silvia et al., 2008a), which can also negatively impact the replicability of findings.

Which Approach is Superior?

There is still considerable disagreement among DT researchers as to which approach is most reliable and valid, and there is evidence to suggest participant assessment outcomes are heavily influenced by the scoring methods selected by researchers (Park et al., 2016). Many scholars have called for more work implementing both approaches within a single study to better determine how the scoring method influences outcome (Plucker et al., 2011). While both approaches have clear strengths and weaknesses, I argue there are two significant, and largely overlooked, limitations of current DT methodology. First, current methods for scoring originality are largely based on social comparison. That is, the originality ratings of one child's responses is at least partially dependent on the ratings of other children in the sample. While this is especially true of objective scoring systems, the same can be said for subjective approaches that instruct raters to familiarize themselves with the complete ideational pool prior to assigning ratings. Second, regardless of the two general scoring approaches described above, children's DT is typically studied using cross-sectional designs rather than

longitudinal designs. I believe these two limitations of current DT research, especially with young children, may restrict the understanding of originality in two primary ways: (a) they limit the ability to precisely capture personal originality, and (b) they do not adequately account for the role of time.

The Personal-Originality Approach

In its most basic form, DT is thought to be a characteristic of the individual. Even if researchers implement a large battery of DT assessments, outcome measures typically do not effectively examine individual thought processes and originality. Given this, use of social comparison as the definition of creative potential will never capture whether or not an idea is original to the child, regardless of whether the researchers implement objective or subjective scoring, or both. Kaufman and Beghetto's (2009) 4-C model of creativity proposes the importance of a “mini-c” category that represents “the creativity inherent in students’ unique and personally meaningful insights” and “highlights...more process focused aspects of creativity” (p. 4). In line with this thinking, I believe it is important to recognize *originality* that occurs at this individual and process-oriented level. Plainly stated, I believe if an idea is original for the individual, the individual is, by definition, thinking divergently.

One way to study such personal originality (PO) is the old/new approach (K. J. Gilhooly et al., 2007). That is, after participants complete a DT task, researchers can ask participants to identify which responses they had thought of prior to data collection, and which responses they generated during the DT task. This is a highly cost- and time-effective method for gathering within-individual originality data and can be implemented in cross-sectional designs. However, it may be less effective to implement this approach

with younger populations due to vast individual differences in memory retrieval abilities that would have to be measured and accounted for. Further, these instructions would add an additional layer of complexity to the child's experience, especially if multiple DT tasks are implemented. In turn, this would increase the overall cognitive demands of each task and, potentially, impact children's performance. An alternative PO approach is to measure how DT unfolds over time. For example, one might compare an individual's responses at one time point to future time points and operationalize PO in terms of new additions to the original set of responses. This approach has the added benefit of helping address the second mentioned methodological limitation, time.

The Role of Time in Divergent Thinking

Cross-sectional research does not adequately account for the role of time in divergent thinking. Within single-session studies, time has been recognized as an important factor in DT measurement. For example, researchers have found that DT tasks are less effective when participants are given a time limit compared to having no time constraint (Johns & Morse, 1997). Researchers have also found that original ideas are more likely to appear later in a set of responses rather than earlier (Beaty & Silvia, 2012). This suggests the more time participants have to explore an open-ended problem, the more likely they are to produce original solutions. It stands to reason a more thorough examination of the effects of time on children's DT outcomes might provide unique insights into how to best measure the construct, and possibly inform theory about the fluidity of it.

One promising time-related construct is *incubation*, which has been defined as the unconscious processing that occurs during "voluntary abstention" from a problem

(Wallas, 1926, p. 86). Research with older populations has demonstrated the importance of incubation periods in the creative thinking process (Ellwood et al., 2009; K. J. Gilhooly et al., 2013; Kenneth J. Gilhooly et al., 2012; Sio & Ormerod, 2009). In a metaanalysis of 117 studies, Sio and Ormerod (2009) found that the length of preparation prior to incubation, the complexity of incubation tasks, and nature of the primary task were key factors that explained study outcomes. Specifically, incubation effects were more pronounced when (a) participants had more time to work on the problem prior to incubation, (b) incubation tasks had low cognitive demands, and (c) the primary task involved divergent thinking as opposed to tasks with target/fixed solutions.

To the best of my knowledge, the role of incubation in children's DT has not been studied directly, making it difficult to determine how to best structure incubation periods within early childhood DT assessments. However, it is reasonable to assume this dimension of the creative-thinking process extends to young children's DT and would therefore be a logical and meaningful methodological consideration. It is possible that both within- and between-session incubation periods will help illuminate how time away from a DT task influences children's performance. One way to test these alternative forms of incubation is to design studies that examine each independently. This approach would have the benefit of minimizing the effort expended by both the experimenters and participants. Indeed, if longitudinal data collection proves unnecessary for studying DT in the context of incubation, researchers could collect large amounts of meaningful data in a cost- and time-effective manner. However, without studying various lengths of incubation, including periods that demand longitudinal data (e.g., several days) within a single study, researchers will not be certain if, how, and to what extent children's

divergent thinking processes are influenced by time off-task.

Another approach is to invest in large-scale longitudinal studies. If researchers examine DT performance while manipulating incubation over long periods of time within large samples of children, they might be able to pinpoint incubation “sweet spots” (e.g., the ideal amount of time resulting in peak performance) or even “dead zones” (e.g., too much time resulting in worsened performance). The downside of this approach is that the knowledge gained might not be worth the effort and resources expended. Thus, I believe the logical first step is to balance feasibility with scalability. A small-scale study with two time points should provide important insights into the relation between incubation and divergent thinking among young children. Should such a study yield compelling results, more ambitious longitudinal designs will be justified.

Current Study

The current study investigates two primary research questions. First, *is the personal-originality approach a more valid method for capturing young children’s DT compared to common objective and subjective approaches?* To explore this question, an author-developed, personal-originality scoring system was used to measure children’s DT performance. The current study compares the construct validity of objective (i.e., weighted ratio scores), subjective (i.e., average external ratings), and PO scoring methods by correlating children’s DT outcomes with individual characteristics (e.g., openness to experience) and performance measures (e.g., creativity ratings of children’s drawings) commonly identified as indicators creative potential. Originality is often considered the most creativity-specific subscale of DT (Runco & Acar, 2012). Therefore, this study focuses on the validity of originality outcomes across various scoring methods. A

detailed description of all scoring methods used in the current study can be found in Appendix A. Two competing hypotheses were tested to address the first research question:

H1: *PO scoring for originality will provide a more valid estimate of children's creative potential compared to subjective and objective scoring.* PO scores demonstrating significantly better measures of convergent and discriminant validity compared to traditional scoring methods would provide support for this hypothesis.

H2: *PO, subjective, and objective ratings of originality all represent meaningful, yet distinct, constructs related to children's overall creative potential.* Said differently, children who produce ideas that are (a) original at a personal level (PO), (b) unique in the sample (objective), and (c) recognized as creative by outsiders (subjective) might be among the most creative. If this is true, the three measures will yield comparable estimates of convergent validity with other measures of creative potential but would show discriminant validity between the three originality outcomes.

The second research question investigated in the current study was *do short and/or long incubation periods help illuminate children's original ideation processes?* Due to the exploratory nature of this research question, the following hypothesis was tested:

H3: *Within-session incubation periods will provide optimal conditions for child-level original ideation to occur.* It is my thinking that briefly reallocating children's focus to an unrelated task will allow sufficient time for incubation and subsequent original ideation to occur. In contrast, between-session incubation may result in difficulty recalling previous task performance, thereby making it challenging for children to focus

their effort on producing new ideas. In addition to a visual inspection of descriptive data and an examination of correlations between short and long PO scores and other outcome variables, dependent *t*-tests were used to detect any significant differences between short and long PO scores.

A Note on the COVID-19 Pandemic

Data for the current study were collected during the COVID-19 pandemic. To ensure the safety of children and caregivers, all aspects of the study were conducted remotely. While parent data are often collected in this manner (e.g., online surveys), I recognize that remote data collection with young children is uncommon. Though this was not the topic of the current study, I believe it is important to note that children were highly engaged in study tasks and excited to interact via video conference software. The implications of remote data collection are apparent in the method section and outlined explicitly in discussion. Ultimately, the decision to prioritize safety measures was an easy one to make and I am pleased with how the study unfolded.

CHAPTER 2: METHODOLOGY

The purpose of the current study was to explore a new incubation-based, personal-originality approach for scoring children's divergent thinking and to compare this scoring system to common objective and subjective approaches. Based on the overarching goals of the study, and limitations caused by the COVID-19 pandemic, a non-experimental, longitudinal, and correlational design was used.

Recruitment and Participants

To maximize the sample for this study, online recruitment and snowball sampling were used. Recruitment ads were disseminated through university-affiliated listservs, emails to preschool directors, and social media. 57 parents initially responded to recruitment ads. Of those, 42 parents participated in the initial survey and enrolled their children in the study. The vast majority of parents (93%) who completed surveys and accompanied children during zoom sessions self-identified as the mother of the enrolled child. 42 children (64% female) between the ages of 3-6 ($M = 4.84$ years; $SD = 1.21$) completed the zoom session. Two parents did not complete the follow-up survey. After additional attempts to collect follow-up survey data from these parents, both disclosed sensitive circumstances preventing them from engaging in non-essential time commitments. All parents were entered in a lottery to receive one of ten \$25 gift cards for participating in the study.

Procedure and Measures

Overview

A two-part parent survey was used to gather information about children's divergent thinking skills, creativity, personality, and background information about the

parent, child, and family. Part 1 of the survey was distributed upon enrollment in the study through the University of Missouri Qualtrics System. After completing part 1, parents scheduled a zoom session for their enrolled children. Detailed instructions regarding the zoom session were sent 48 hours prior to the scheduled date. Parents were asked to position their children in a comfortable, quiet, and distraction-free environment, and to remain present with their children throughout the session. Parents were encouraged to redirect children's attention to the study tasks as needed but to offer no other assistance. All zoom sessions were video- and audio-recorded with parent consent. 48 hours after the zoom session, part 2 of the survey was sent to parents. Specific measure items and detailed instructions are presented in Appendix B. Detailed descriptive properties for all variables listed below are presented in Table 1.

Parent Survey Part 1

Child Demographics. At the beginning of the survey, parents were asked to write in demographic information including children's age, gender, race, and ethnicity. Age was coded as a continuous variable and was calculated using the exact number of days between date of birth and the child's zoom session. Gender was coded as male or female (female = 1). Due to minimal racial and ethnic diversity (79% were identified by parents as "White") in the current study, children were classified as *White* or *Racial-Ethnic Minority* (White = 1).

Big Five Inventory - Short Form. The Big Five Personality Inventory – Short Form (BFI-10; Rammstedt & John, 2007) is an efficient tool for measuring children's personality traits. It is an abbreviated version of the 44-item tool and consists of 2 items per scale, for a total of ten items. This tool prioritizes speed and ease of administration

while still maintaining acceptable levels of reliability and validity. The BFI-10 was primarily used to capture children's openness to experience and extraversion, both of which are theoretically and empirically linked to creative potential (Furnham & Bachtiar, 2008; Gocłowska et al., 2019; McCrae, 1987).

Parent Rating of Child Creativity. Parents were asked to rate their children's creativity on a scale from 1 (not at all) to 10 (extremely) to achieve a subjective rating of child creativity prior to child zoom sessions.

Zoom Session Tasks

After a brief period of introductions at the beginning of the recorded zoom session, children completed a total of seven tasks. Apart from the first (i.e., define creativity) and last (i.e., verbal reasoning) tasks, task order was randomized. Two variables were created to account for potential task order effects: (a) *drawing first* (yes = 1) indicates whether children completed the drawing before or after DT tasks and (b) *instances first* (yes = 1) was used to identify the order DT tasks were presented to children. In addition, an *incubation length* variable was created to determine if the amount of time (in days) between the zoom session and follow-up DT tasks influenced personal-originality scores.

Define Creativity. Children were asked if they had ever heard the word “creative” or “creativity.” Those who nodded or verbally stated they had heard of either word were asked if they knew what the word meant and, if so, to describe it. Accurate definitions (e.g., “doing something new”) were assigned a “1” and inaccurate responses/no response was scored “0.” Children were then given a formal definition of creativity prior to transitioning into the primary tasks.

Creative Drawing Task. Children were asked to think of something creative to draw and, after completing the drawing, children were asked to think of a creative name or title for their drawing. To establish a performance measure, drawings and titles were each rated on a scale from 1 (not at all creative) to 5 (extremely creative) by two independent raters using the criteria outlined in Appendix C. These two scores were added to create an overall drawing/title score. An example of a child's drawing with its corresponding title is presented in Figure 1.

Divergent Thinking. Two divergent thinking tasks were included in the current study: Wallach and Kogan's (1965) *instances* task (i.e., things that are round) and Guilford's (1967) *alternative uses* task (i.e., uses for a pencil). To introduce the *instances* task, a picture of a marble was displayed on the screen and a physical marble was held up to the camera. To introduce the *alternative uses* task, a picture of a pencil was displayed on the screen and a physical pencil was held up to the camera. Images depicting the zoom session screen share during DT tasks are displayed in Figure 2 and Figure 3. Children completed each task twice during the session (before and after incubation) and again when parents completed the follow-up survey. Because time limits can negatively affect DT performance (Johns & Morse, 1997), children were given unlimited time to complete each task. A complete list of children's responses for each DT task are outlined in Appendix D.

Filler Tasks. Two filler tasks were used to create within-session incubation periods. After children indicated they had exhausted their ideas for a given DT task, they were presented a series of simple shapes (i.e., square, heart, triangle, and star) filled in with red, blue, green, orange, and pink were presented one at a time for two minutes.

During one incubation period, children were instructed to identify the shape and in the other, children identified the color. These mundane filler tasks were selected based on the Sio and Ormerod (2009) finding that incubation tasks with low cognitive demands are most effective. The duration of the incubation period was based on findings that 2-minute incubation periods yield significant incubation effects while shorter periods (e.g., 30 seconds) do not (Smith & Blankenship, 1991).

Verbal Reasoning. Children completed five items of a guessing game adapted from the *Guess What* task of the Reynolds Intellectual Assessment Scales (Reynolds & Kamphaus, 2005). This task is designed to measure verbal reasoning and crystallized intelligence, which are established covariates of verbal divergent thinking performance (Jones & Estes, 2015; Weiss et al., 2020). Children are instructed to carefully listen to three clues and then guess what the clues describe. For example, an accurate response for the three hints “it falls from the sky, it helps plants grow, and if it falls on you it makes you wet” would be “rain.” Children received one point for each accurate response for a total possible score of five points.

Parent Survey Part 2

Follow-Up DT. Parents were asked to complete a follow-up session of the *instances* and *alternative uses* task in one sitting. A script was provided for reintroducing (e.g., “Do you remember when you played a game on the computer where a man showed you a marble and asked you to think of things that are round?”) and providing instructions (e.g., “Can you think of anything else that is round? Try to be as creative as possible!”) for each task. Parents recorded their children’s responses and, after children

indicated they had no more ideas, parents submitted the complete list via Qualtrics survey.

Divergent Thinking Scoring Approaches

Prior to scoring, the entire pre-incubation ideational pool was compiled and alphabetized with and without identifiers. Figure 4 illustrates how identical and near identical responses were treated for valid scoring. Fluency scores for *instances* and *alternative uses* were measured as the total number of unique responses produced prior to within-session incubation. In addition, four originality scores for *instances* and *alternative uses* were produced for each child: objective, subjective, short PO, and long PO (see Appendix A).

Objective Scoring. A combination of weighted and ratio scoring techniques were used to produce one *instances* and one *alternative uses* objective score using only responses produced prior to the within-session incubation period. 1 point was assigned for responses produced by <10% of children and 2 points were assigned for responses produced by <5% of children. All other responses received 0 points. Research has demonstrated that this type of weighting improves the validity of originality scores (Runco et al., 1987). The total originality score was then divided by the number of ideas produced (i.e., ratio scoring) to mitigate fluency contamination (Hocevar & Michael, 1979).

Subjective Scoring. Two raters used the uncommon, remote, and clever criteria outlined in Silvia et al. (2008), and presented in Appendix C, to score each response in the ideational pool on scale from 1 (not at all creative) to 5 (highly creative). To control for fluency, participants' total subjective scores were divided by fluency to produce one

instances and one *alternative uses* subjective score using only responses produced prior to the within-session incubation period.

Personal-Originality Scoring. Short PO scores were generated by comparing responses produced before filler tasks to those produced after filler tasks. One point was assigned for each new response to produce one *instances* and one *alternative uses* short PO score. Long PO scores were generated by comparing responses produced in the follow-up survey to all previous responses. Again, one point was assigned for new responses for each DT task.

Data Analysis Plan

To address the first research question, the current study compared the convergent and discriminant validity of scoring methods using standard correlational analyses utilized in previous DT measurement validity research (Benedek et al., 2013; Clapham, 2004). Convergent validity was evaluated by exploring the associations between various scoring approaches and established covariates of divergent thinking (e.g., openness to experience) as well as performance measures of creativity (i.e., creative drawings and titles). Discriminant validity was analyzed by examining correlations among PO, objective, and subjective outcomes, as well as between each scoring method and task-specific fluency scores.

To explore the second research question comparing the effectiveness of short (within-session) vs. long (between-session) incubation periods, descriptive and correlation analyses were conducted in addition to means difference testing. Paired sample *t*-tests were conducted to detect significant differences between short and long personal-originality score means for *instances* and *alternative uses* tasks.

Finally, a set of preliminary and post-hoc analyses were conducted to explore individual characteristics (e.g., child age) and external factors (e.g., task order) that might explain differences in personal-originality outcomes. For post-hoc analyses, a series of bivariate and multiple regression models were conducted with personal-originality scores for *instances* and *alternative uses* tasks as dependent variables and correlates revealed during preliminary and primary analyses as independent variables. Next, hierarchical regression analyses were conducted to examine the effects of PO scores on children's combined drawing/title creativity ratings while controlling for relevant child characteristics identified in preliminary and primary analyses.

CHAPTER 3: RESULTS

Preliminary Analyses

Preliminary analyses were conducted to determine which demographic and study variables should be included in primary analyses. Zero-order bivariate Pearson and point-biserial correlations revealed that *gender*, *race and ethnicity*, *drawing first*, and *instances first* were not associated with any DT outcomes, nor performance measures of creativity, and were therefore omitted from primary analyses. Furthermore, despite there being considerable variation in the length of between-session incubation ($M = 6.33$ days; $SD = 4.55$; $Range = 2$ to 22 days), *incubation length* was not significantly correlated with AUT ($r = .012$, $p = .94$) nor IT ($r = -.17$, $p = .29$) long PO scores. Statistically significant correlations were, however, identified between *age* and several performance measures. Therefore, a detailed exploration of *age* effects was included in post-hoc analyses outlined at the end of the results section.

In addition, intraclass correlations (ICC) and 95% confidence intervals, reported in Table 2, were used to assess the inter-rater reliability of two independent ratings for *subjective instances*, *subjective alternative uses*, *creative drawings*, and *creative titles*. Since the same raters were used across all subjects and tasks, two-way mixed effects models using average measures and absolute agreement were used (Shrout & Fleiss, 1979; McGraw & Wong, 1996). To briefly summarize, ICCs for *subjective instances*, *subjective alternative uses*, *creative drawings*, and *creative titles* were .747, .813, .740, and .775, respectively. All ICCs were between the “moderate” and “good” range according to Koo and Li's (2016) guidelines. Therefore, the averages of independent ratings for these variables were used in primary analyses.

Primary Analyses

Primary analyses are organized into two sections: (a) correlational analyses detailing the associations among originality scores and primary variables, and (b) exploratory analyses of incubation effects.

Correlation Analyses

As previously stated, correlational analyses were used to compare and contrast the convergent and discriminant validity of originality outcomes. Zero-order bivariate Pearson and point-biserial correlations for primary analyses variables are presented in three tables. Table 3 shows correlations among primary variables and DT *instances* task scores, Table 4 shows correlations among primary variables and DT *alternative uses* task scores, and Table 5 shows correlations between DT *instances* (IT) and DT *alternative uses* (AUT) scores. Based on the current sample size, statistically significant correlations between theoretically linked constructs were considered evidence of convergent validity, while non-significant correlations among theoretically distinct constructs were considered evidence of discriminant validity.

Convergent Validity. The current study failed to demonstrate correlations between originality outcomes and personality traits associated with divergent thinking. However, this is at least partially explained by the minimal variance in parent ratings of openness to experience and extraversion. All ratings for extraversion ranged between 3 and 6 despite the scale ranging from 0 to 10, and while the overall range of scores for extraversion was greater, approximately 70% of children were rated 6 or 7. As a result, the remaining comparison of convergent validity between objective, subjective, and PO scoring is limited to parent ratings of child creativity, children's understanding of

creativity (i.e., ability to define the construct), verbal reasoning, and performance measures of creativity (i.e., drawings and titles).

Objective originality, using weighted ratio scores, performed poorly in the current study. Objective originality was not significantly correlated with parent ratings of creativity, children's understanding of creativity, performance measures of creativity, nor verbal reasoning. Further, objective originality scores for *instances* and *alternative uses* were not significantly related. It should be noted that other approaches to objective scoring (e.g., weighted only, ratio only, total) were tested and did not produce any observable differences in evidence for convergent validity. Previous research has suggested objective originality scoring is most effective with larger sample sizes (e.g., $N = 300-400$; Forthmann et al., 2020), and it is possible that my sample of 42 children was not sufficiently large for a "statistical rarity in the sample" definition of originality to perform well. Despite this, findings from the current study suggest objective scoring has poor convergent validity.

In comparison to objective scoring, subjective originality scoring performed better and demonstrated some evidence of convergent validity. Subjective originality scores, based on the average score of two independent raters and divided by fluency, were significantly associated with children's drawing and title creativity ratings, as well as verbal reasoning scores, with Pearson correlations between .37 and .44. However, these associations were only apparent using DT scores from the alternative uses task. IT subjective ratings, despite being significantly associated with AUT scores ($r = .38$), were not significantly correlated with any primary study variables apart from other DT outcomes. It is not uncommon in DT research for analyses to reveal task-specific effects,

which has led to theoretical discussions about the potential domain specificity of divergent thinking (Baer, 2012; Han, 2003). That aside, evidence of convergent validity for subjective originality scores was related to the specific divergent thinking task.

Overall, personal-originality scoring, and particularly short PO scores, had the most compelling evidence for convergent validity. PO scoring using the long-incubation technique (i.e., between sessions) showed similar trends as subjective scoring. Long PO scores for the instances task were associated with performance measures of creativity and verbal reasoning, but no significant correlations were revealed for alternative uses task long PO scores. Short PO scores across DT tasks were significantly correlated with parent ratings of creativity, creative drawings and titles, and verbal reasoning. In addition, short PO scores were the only originality outcomes associated with children's ability to define creativity. Both short and long PO showed strong, positive, between-task correlations, $r = .53$ and $r = .62$, respectively. Altogether, current study findings indicate that personal-originality scores after a short (i.e., 2 minute) incubation period have high convergent validity, long PO and subjective ratings of originality have task-dependent convergent validity, and objective ratings have poor convergent validity.

Discriminant Validity. Discriminant validity was evaluated by examining correlations (see Table 5) among task-specific originality scoring approaches and between task-specific originality and fluency scores. Objective, subjective, and personal originality represent distinct theoretical views of originality and should, therefore, be minimally correlated. Similarly, originality and fluency are thought of as independent dimensions of divergent thinking.

While objective scoring showed low convergent validity, it demonstrated the greatest evidence for discriminant validity. Objective originality was not correlated with fluency in either task, and the only significant correlations between objective scores and other measures of originality were between AUT objective and subjective scores and IT objective and long PO. This finding suggests weighting originality and dividing the total score by fluency helped prevent contamination and promoted discriminant validity in the current study.

Similar to findings about convergent validity, evidence for the discriminant validity of subjective ratings was task specific. IT subjective scores showed strong discriminant validity with no significant correlations with other IT outcome measures. However, AUT subjective scores showed significant positive correlations with objective, short PO, and fluency scores, indicating poor discriminant validity in this task.

Long personal originality showed similar levels of discriminant validity across tasks. AUT long PO scores were positively correlated with fluency, but not other originality scores. IT long PO scores significantly related to fluency and short PO, but not subjective nor objective originality. Though evidence for short PO discriminant validity is implicitly stated previously in this section, it can be summarized as follows: both short PO scores were significantly associated with fluency and one other originality score, within-task. Though this evidence collectively suggests poor discriminant validity for short PO, and moderate task-specific discriminant validity for long PO, these findings warrant further investigation with larger and more diverse samples.

Incubation Effects

As can be seen in Table 1, children's short and long PO scores are relatively

comparable within each task. For IT, children generated between 0 and 13 responses ($M = 4.69$) after short incubation and 0 and 16 responses ($M = 5.43$) after long incubation. Paired samples t -tests revealed no significant differences between IT short and long PO means $t(39) = -0.844, p = .40$. For AUT, children generated between 0 and 9 responses ($M = 2.64$) after short incubation and 0 and 8 responses ($M = 2.10$) after long incubation. Again, means differences between short PO and long PO scores were not statistically significant $t(39) = 1.521, p = .14$. There were, however, significant differences in PO performance across tasks. Children produced significantly more new ideas after short incubation during the IT compared to the AUT, $t(41) = 4.504, p < .001$. Similarly, children produced significantly more new responses after long incubation for the IT compared to AUT performance $t(39) = 8.645, p < .001$. Given these between-task differences in short and long personal-originality scores, it is interesting to note that DT task order was not significantly related to performance.

Post-hoc Analyses

Based on correlational analyses, only three personal-originality outcomes warranted further exploration. IT short and long PO scores, and AUT short PO scores demonstrated significant associations with primary study variables. A series of multiple regression models with PO scores as dependent variables and identified correlates as independent variables are presented in the following paragraphs. As previously stated, *age* was revealed as the only child demographic factor significantly correlated with DT outcomes and child performance measures and was therefore included in all regression analyses. Fluency and verbal reasoning scores were correlated with all dependent

variables and were included stepwise, based on correlation strength, to identify the best-fitting models using *F*-Change statistics.

Linear Regression Assumptions Testing

The linear relation between independent variables and dependent variables was verified through a visual inspection of scatterplots. Extreme outliers were identified through visual inspection of boxplots, and standardized residuals ± 3 were removed prior to each set of analyses (Field, 2009). Evidence that assumptions for multicollinearity, normal distribution of residuals, and homoscedasticity were not violated are presented in Appendix E.

Post-Hoc Analysis Results

Overall model results are briefly described in this section. Unstandardized beta coefficients, standard errors, and standardized coefficients for individual predictors in each model are presented in Table 6. The best fitting model for alternative uses task short PO and subjective ratings included age and fluency as independent variables. Age and AUT fluency explained 71.7% of the variance in AUT short PO $F(2, 36) = 45.57, p < .001$. This finding indicates that within-session personal-originality scores increase linearly with age and fluency.

The best fitting model for short PO in the instances task included only age as an independent variable, which explained 26.4% of variance in IT short PO, $F(1, 40) = 14.33, p < .05$. As was the case for the alternative uses task, children's within-session personal originality for the instances task had a positive linear relationship with age. Though age was not a significant predictor of IT long PO, its inclusion in the model did not change model summary results and was therefore included for consistency. Age and

IT fluency explained 24.4% of variance in long PO scores, $F(2, 37) = 5.98, p < .05$. In this case, increases in ideational output (i.e., fluency) were associated with increases in between-session personal-originality scores for the instances task.

Finally, hierarchical regression analyses were conducted with the combined drawing/title creativity ratings as the dependent variable. Children's age was included as an independent variable in block one for all models due to its strong significant association with the dependent variable. Three separate models were conducted with AUT short PO, IT short PO, and IT long PO included as block two independent variables. A separate model for AUT long PO was not conducted because it was not significantly correlated with the dependent variable. Results, presented in Table 7, indicate that AUT short PO scores did not significantly predict combined drawing/title ratings when controlling for age, and did not significantly improve the fit of the model that only included age as predictor. However, both IT personal-originality scores were significant predictors of combined drawing/title ratings when controlling for age.

The inclusion of long PO significantly improved model fit and resulted in an R^2 change of .159 (from .229 to .388), indicating the model including both age and long PO explained 15.9% more variance in children's combined drawing/title scores compared to the model that only included age. Similarly, the addition of short PO significantly improved model fit and resulted in an R^2 change of .11 (from .214 to .323), which suggests the second model explained 11% more variance in children's combined drawing/title scores. After a visual inspection of regression coefficients in the IT short PO model, follow-up bootstrapping tests were conducted and indicated full mediation (see Figure 7). The total effect of age on combined drawing/title scores in model 1 was

statistically significant, $B = .863$, $t(40) = 3.30$, $p < .05$. However, the direct effect of age after including IT short PO was no longer statistically significant, $B = .493$, $t(39) = 1.72$, $p = .09$, while the direct effect of IT short PO was statistically significant, $B = .253$, $t(39) = 2.51$, $p < .05$. This finding suggests that the relation between age and creative drawing/title ratings is explained by within-session personal-originality scores for the instances task.

CHAPTER 4: DISCUSSION

The discussion of the current study is organized in five sections. The first two sections address study research questions and hypotheses. In section one, I discuss empirical support for the construct validity of each originality scoring approach used in the current study. In section two, I contextualize findings about the effects of short and long incubation periods on children's personal originality. Next, I interpret the results of post-hoc analyses and discuss child characteristics associated with divergent thinking outcome measures. Fourth, I briefly discuss my experience collecting data remotely and the implications of this "contactless" method of data collection with young children. Finally, I outline study limitations and implications, and present ideas for future research based upon my findings.

Evidence for Construct Validity

The primary objective of the current study was to address the research question *is the personal-originality approach a more valid method for capturing young children's DT compared to common objective and subjective approaches?* Previous research testing the convergent validity of originality outcomes has analyzed correlations among divergent thinking scores and other established indicators of creative potential. The current study followed this approach and investigated associations between objective, subjective, and PO originality scores, child characteristics (i.e., personality, parent ratings of child creativity), performance measures of creativity (e.g., creative drawings), and verbal reasoning skills.

Based on the findings of the current study, personal-originality scoring produced considerably better evidence of convergent validity compared to subjective and objective

approaches. This was especially the case for personal-originality scores after within-session incubation periods (i.e., short PO). Conversely, personal-originality scoring showed poor evidence of discriminant validity when compared to objective scoring, and similarly levels of discriminant validity when compared to subjective scoring. However, if correlations between short and long PO scores are not considered, which is reasonable due to conceptual overlap, the primary distinguishing feature between personal-originality scoring and objective scoring, in terms of discriminant validity, are correlations with fluency. The relation between PO and fluency is intriguing. Intuitively, one might expect a negative correlation between these constructs (e.g., exhausting background knowledge prior to incubation could negatively impact original ideation post incubation). Instead, generative ability prior to incubation was positively related to original ideation after incubation in the current study. Though this finding does not support the discriminant validity of incubation-based PO scoring in the current study, it does serve as an interesting topic for future research.

Neither set of *a priori* criteria established for hypothesis 1 (*PO is a more valid indicator of creative potential*), nor hypothesis 2 (*all three originality scores are meaningful*), were fully satisfied in the current study. However, the compelling evidence for the convergent validity of personal-originality scoring warrants further consideration in the methodological and theoretical discussions surrounding children's divergent thinking.

The Role of Incubation in Children's Divergent Thinking

The second research question was *do short and/or long incubation periods help illuminate children's original ideation processes?* I offered the exploratory hypothesis

that within-session incubation periods would “provide optimal conditions” for divergent thinking and original ideation to take place. Descriptive statistics and paired-samples *t*-tests did not support this hypothesis. Overall, children produced a similar number of new ideas after short (e.g., within session) and long (e.g., between session) incubation periods. As previously demonstrated, however, short PO scores were strongly associated with variables theoretically linked with divergent thinking, and long PO scores were comparable to subjective scores in that regard.

The current study findings suggest that short *and* long incubation periods do, indeed, “help illuminate children’s original ideation processes.” The incubation-based PO approach provides useful insights into the role of time in children’s divergent thinking. Specifically, it shows: (a) time off task has a positive effect on children’s ability to produce new ideas, and (b) that a single set of responses provides an incomplete picture of children’s DT. It should be noted that incubation did not result in original ideation for *all* children. For the alternative uses task, nine children did not produce new ideas after short incubation, and eight children did not produce new ideas after long incubation. For the instances task, the number of children who did not produce new ideas after short and long incubation were four and one, respectively. Altogether, findings support the continued use and exploration of incubation periods in child DT research.

Child Characteristics and Divergent Thinking Scores

Post-hoc analyses revealed that age and task-specific fluency scores explained significant variance in several originality outcome measures. I have previously discussed the interesting finding that fluency scores were positively correlated with personal-originality scores. This was also true for AUT subjective scores, which does not align

with previous research demonstrating negative correlations between average subjective ratings and fluency (Benedek et al., 2013). However, correlations between fluency and originality scores ranging from .34 to .56 are not uncommon and can be expected given their joint association with a shared construct.

I believe the more interesting child characteristic to investigate further is age. Though the wide range of ages represented in the current study poses some issues, it also provided useful insights into the developmental nature of divergent thinking. Figures 5 and 6 help illustrate how age, transformed into a categorical variable grouped by year, relates to divergent thinking outcomes. Mean objective, subjective, and long PO scores are relatively stable across age groups for both *instances* (Figure 5) and *alternative uses* (Figure 6). However, interesting developmental trends emerge for fluency and short PO scores. Fluency mean scores were consistent for children between 3-5 years and increased dramatically among 6-year-olds, suggesting an increase in ideational output for the oldest age group. Short PO scores, on the other hand, showed a gradual increase between 3-6 years. Though this finding should be interpreted and generalized tentatively, the current study suggests that as children get older, within-session incubation effects have a more profound effect on original ideation. Furthermore, these trends appear to be independent of developmental trends in pre-incubation fluency.

Finally, despite considerable variance in personal originality being explained by age and strong positive correlations between age and children's combined drawing/title scores, post-hoc analyses revealed that PO scores for the instances task predicted children's performance measure of creativity above and beyond age. Moreover, short PO scores mediated the relation between age and combined drawing/title creativity ratings.

These preliminary findings suggests that personal originality is an important consideration in the identification of creative potential.

Collecting Child Data Remotely

As previously stated, the current study was conducted during atypical times. Safety precautions, including remote data collection, were necessitated due to the COVID-19 pandemic. I should note that previous research with older populations has demonstrated the reliability of online DT assessment (Hass, 2015), but to the best of my knowledge, this is the first study that has collected child DT data remotely. There were several strengths of this “contactless” approach to child data collection, but also drawbacks that must be acknowledged. Perhaps the greatest advantages of this approach were flexibility and efficiency. Data collection with young children is often restricted to the normal operating hours of childcare centers and schools. Collecting data via zoom afforded parents considerable flexibility in terms of scheduling, including morning, afternoon, and evening options, and both weekday and weekend availability. Several parents explicitly mentioned their appreciation for this convenience.

The efficiency of remote data collection also became quite apparent. Under typical (e.g., in person, lab setting) conditions, the transition from one session to the next includes unproductive factors, such as the time it takes to locate a child enrolled in the study, help them transition from the classroom to assessment room, and return them to the class upon completion. In the current study, parents had their children prepared to engage in the study at a predetermined time, and the transition from one session to the next was seamless and predictable. In addition, there were no limitations nor scheduling issues related to assessment space. Zoom sessions lasted approximately 20 minutes, and

recordings could be processed in 10 minutes or less. During that processing time, I was able to reset all materials and prepare for the next scheduled session without any additional concerns. With additional experimenters, the efficiency of remote data collection could be maximized. These advantages cannot be overstated, but there were disadvantages of remote data collection, as well.

Two key disadvantages became evident during data collection. The first was related to dependence on stable internet connections. There were instances when data collection had to be rescheduled due to inclement weather. Fortunately, there was never a case when a zoom session was disrupted by weather conditions in the current study, but researchers considering remote data collection should be aware of this possibility. Second, there are uncontrollable differences in children's environments. Despite parents being instructed to prepare a "quiet and distraction-free" space for children to complete the study, these environments were not identical. Controlled lab settings are not necessarily "distraction free," but they likely have fewer possible, and more consistent, distractions compared to the range of disturbances (e.g., dog barking, doorbell ringing) children might experience during remote data collection.

Differences in study environments also provide different visual cues that may influence performance on divergent thinking tasks. However, given the overarching goal of the current study, to test a personal-originality approach, it is important to recognize that these between-child differences are less likely to threaten my within-subject measure of originality compared to between-subjects measures. It is undisputable that children may have access to visual stimuli that provide advantages in terms of objective and subjective ratings (e.g., uncommon items in the room), but personal originality requires

thinking beyond readily accessible responses. This distinction provides additional support for the PO approach, especially under conditions (e.g., remote data collection) where environmental differences in the setting of data collection are a potential concern.

Limitations, Implications, and Future Directions

Limitations

In addition to previously mentioned limitations, there are two others that I believe warrant further discussion. First, the external validity of the study is constrained by several factors. The unique sociohistorical conditions and their impact on the current study (e.g., convenience sampling, non-traditional data collection methods) should not be overlooked. Further, the relatively small sample and homogeneity of children, both in terms of key demographics (i.e., minimal racial and ethnic diversity) and internal characteristics (e.g., extraversion) restricts the generalizability of findings. For example, the current study was unable to replicate well-established associations between divergent thinking and key personality traits, and while variance issues were likely the root cause of this non-finding, it is impossible to determine if this was a measurement issue, a sampling issue, or both.

The second major limitation is the questionable reliability and validity of long PO scores. In order to minimize the burden on parents and promote participant retention, I elected not to conduct a second zoom session. Instead, long PO scores were based on divergent thinking data collected by parents. Though clear instructions for conducting DT tasks were provided (e.g., “Please feel free to offer some encouragement and help keep your child focused on the task, but do not help your child come up with answers.”), I cannot say with certainty that parents did not provide varying degrees of assistance.

Further, it is impossible to account for all individual differences in experiences between the zoom session and follow-up DT assessment. However, this would also be the case had I conducted a second child zoom session. Finally, the varying lengths of between-session incubation should be acknowledged. Despite no significant association between *incubation length* and long-PO scores, it is likely that the amount of time that passed between the zoom session and follow-up DT assessment had at least some impact on children's task performance. Future research should emphasize the systematicity of between-session incubation to improve the validity of findings. All limitations aside, I believe the current study offers several methodological and theoretical contributions.

Implications and Future Directions

The primary innovation of the current study was the use of incubation periods as a device for studying personal (i.e., within-subject) originality. My findings indicate that the personal-originality approach is comparable to, and in some cases better than, the subjective and objective scoring methods used in terms of construct validity. Further, I would be remiss if I did not mention the practicality and efficiency of PO scoring. For example, compared to independently rating each response in an ideational pool, repopulating those ratings to child identifiers, and producing an average rating based on fluency scores (i.e., average subjective ratings), incubation-based PO can be quickly calculated using simple excel formulas to compare columns and identify new responses at the child level. Also, the time and energy required to calculate PO scores is independent of sample size, which cannot be said for the objective and subjective approaches used in the current study.

There were also significant theoretical contributions of the current study. First,

incubation appears to be just as important for children's original ideation as it is for adults. Current study findings suggest both short (2 minutes) and long (several days) breaks from divergent thinking, initiated only after children have exhausted their available ideas, promote future original ideation in that domain. In addition, PO outcome measures showed strong between-task correlations, which provides initial evidence for the potential domain-generalizability of personal originality. I believe this speaks to the individual and internal processes responsible for divergent thinking and, when studied in this manner, findings more closely approximate real-world divergent thinking. Second, the compelling evidence for convergent validity suggests child-level originality is a meaningful dimension of children's divergent thinking. Though I did not establish conclusive evidence that all three scoring approaches highlight unique dimensions of creative potential, I believe future research will support that hypothesis. Considering one of the primary goals of DT assessment is to identify and support children's creative potential, it stands to reason that both social comparison (e.g., average subjective ratings) and self comparison (i.e., personal originality) measures of originality should be evaluated.

Based on the findings and limitations of the current study, I believe there are several key considerations for future research. First, a larger and more diverse sample of children should be studied to replicate findings and improving upon the validity of my incubation-based, personal-originality scoring system. Second, based on the advantages of remote data collection, future research should compare the effects of in-person versus remote data collection on children's DT outcomes. Third, the personal-originality approach should be tested with both verbal and non-verbal (e.g., figural) divergent

thinking tasks in a single study.

Regarding incubation effects, there are also many methodological considerations and topics to explore. For example, between-session incubation effects should be assessed under the same conditions as within-session incubation to improve measurement validity and reliability. In addition, various lengths of short (e.g., 2-10 minutes) and long (e.g., 5-24 hours) incubation, as well as different types (e.g., immediate vs. delayed) of incubation should be thoroughly and systematically studied with children. Finally, I believe a large-scale longitudinal examination of divergent thinking using short and long incubation periods would provide useful insights into the developmental nature of personal originality. Though the current study revealed intriguing developmental trends in fluency and personal originality based on sample means, it would be more enlightening to examine child-level developmental trajectories. A deeper understanding of individual differences in personal originality and how it develops would help inform parenting and educational practices intended to promote divergent thinking skills.

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Table 1*Descriptive Statistics for All Primary Study Variables*

<i>Variable</i>	<i>N</i>	<i>Range</i>	<i>M or %</i>	<i>SD</i>
<i>Child Demographic Information</i>				
Gender (Female = 1)	42	0, 1	64%	-
Race/Ethnicity (White = 1)	42	0, 1	79%	-
Age in Years	42	3.05 - 6.98	4.84	1.21
<i>Child Originality Scores – Instances</i>				
Objective	42	0 - 1.17	.57	.34
Subjective	42	1 - 3.04	3.80	1.06
Personal – Short Incubation	42	0 - 13	4.69	3.43
Personal – Long Incubation	40	0 - 16	5.43	3.10
Fluency	42	1 - 15	6.95	3.33
<i>Child Originality Scores – Alternative Uses</i>				
Objective	42	0 - 1.17	.44	.35
Subjective	42	1 - 3.04	1.70	.54
Personal – Short Incubation	42	0 - 9	2.64	2.22
Personal – Long Incubation	40	0 - 8	2.10	1.84
Fluency	42	1 - 14	5.1	3.09
<i>Parent Ratings of Children</i>				
Openness to Experience	42	4 - 10	6.76	1.32
Extraversion	42	3 – 6	5.05	.94
Creativity	42	3 – 10	7.00	1.75
<i>Child Performance Measures</i>				
Defined Creativity (Yes = 1)	42	0, 1	43%	-
Creative Drawing	42	1 - 5	2.60	1.23
Creative Title	42	1 - 5	2.74	1.38
Combined Drawing/Title	42	2.5 – 10	5.37	2.25
Verbal Reasoning	42	0 – 5	3.24	1.62

Note. Subjective, Creative Drawing, and Creative Title scores represent the average score of two raters. Combined Drawing/Title scores represent the sum of Creative Drawing and Creative Title scores.

Table 2*Intraclass Correlation Coefficients for Subjective Ratings, Drawings, and Drawing Titles*

Measure	ICC (95% Confidence Interval)	F Test with True Value 0			
		Value	df1	df2	p- Value
Creative Drawings	0.740 (0.508-0.861)	4.180	41	41	.000
Creative Titles	0.775 (0.577-0.879)	4.744	41	41	.000
Subjective IT	0.747 (0.623-0.825)	4.386	179	179	.000
Subjective AUT	0.813 (0.685-0.882)	6.207	153	153	.000

Note. Average measures, two-way mixed effects models with absolute agreement definition. IT = Instances Task. AU = Alternative Uses Task.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3*Correlations Among Instances Task Scores and Other Primary Study Variables*

	<i>N</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Age in Years	42													
2. Objective IT	42	.072												
3. Subjective IT	42	.034	.181											
4. Short PO IT	42	.514**	.234	.006										
5. Long PO IT	40	.189	.317*	.051	.327*									
6. Fluency IT	42	.386*	.247	.055	.338*	.494**								
7. Openness to Experiences	42	.061	.189	.073	-.178	.088	.258							
8. Extraversion	42	-.092	-.095	.010	-.238	-.091	-.007	-.168						
9. Parent Rating CC	42	.226	.279	-.086	.454**	.131	.226	-.042	-.119					
10. Defined Creativity (Yes = 1)	42	.433**	.132	.157	.306*	.095	.100	-.174	-.045	-.028				
11. Creative Drawing	42	.515***	.219	.129	.564***	.399*	.518***	-.091	.017	.323*	.309*			
12. Creative Title	42	.309*	.133	.145	.380*	.464**	.347*	.045	0.057	.126	.254	.565***		
13. Combined Drawing/Title	42	.462**	.189	.159	.521***	.482**	.518***	-.039	0.061	.253	.364*	.872***	.882***	
14. Verbal Reasoning	42	.610***	.138	.004	.479**	.321*	.455**	.004	-.104	.275	.442**	.473**	.448**	.504**

Note. IT = Instances Task. PO = Personal Originality. CC = Child Creativity.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4*Correlations Among Alternative Uses Task Scores and Other Primary Study Variables*

	<i>N</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Age in Years	42													
2. Objective AUT	42	.201												
3. Subjective AUT	42	.402**	.428**											
4. Short PO AUT	42	.524***	.300	.565***										
5. Long PO AUT	40	-.049	-.056	.184	.195									
6. Fluency AUT	42	.322*	.223	.556***	.429**	.356*								
7. Openness to Experiences	42	.061	.092	.209	.112	.094	.179							
8. Extraversion	42	-.092	-.171	-.112	-.227	-.090	-.010	-.168						
9. Parent Rating CC	42	.226	.302	.105	.320*	.029	.041	-.042	-.119					
10. Defined Creativity (Yes = 1)	42	.433**	-.125	.207	.317*	.036	.272	-.174	-.045	-.028				
11. Creative Drawing	42	.515***	.156	.391*	.425**	.096	.220	-.091	.017	.323*	.309*			
12. Creative Title	42	.309*	.137	.417**	.314*	.119	.177	.045	0.057	.126	.254	.565***		
13. Combined Drawing/Title	42	.462**	.152	.439**	.403**	.116	.221	-.039	0.061	.253	.364*	.872***	.882***	
14. Verbal Reasoning	42	.610***	.165	.370*	.499**	.188	.366*	.004	-.104	.275	.442**	.473**	.448**	.504**

Note. PO = Personal Originality. AUT = Alternative Uses Task. CC = Child Creativity.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 5*Correlations Among Divergent Thinking Task Outcomes*

	<i>N</i>	1	2	3	4	5	6	7	8	9
1. Objective AUT	42									
2. Subjective AUT	42	.428**								
3. Short PO AUT	42	.300	.565***							
4. Long PO AUT	40	-.056	.184	.195						
5. Fluency AUT	42	.223	.556***	.429**	.356*					
6. Objective IT	42	-.092	.399**	.239	.375*	.303				
7. Subjective IT	42	.124	.376*	.162	.122	.358*	.181			
8. Short PO IT	42	.090	.259	.527***	.210	.148	.234	.006		
9. Long PO IT	40	-.043	.388*	.243	.622***	.278	.317*	.051	.327*	
10. Fluency IT	42	.190	.448**	.378*	.301	.506**	.247	.055	.338*	.494**

Note. AUT = Alternative Uses Task. PO = Personal Originality. IT = Instances Task.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 6

Results of Linear Regression Analyses Examining the Influence of Child Age and Task-Specific Fluency on Personal Originality

DV	Predictors	<i>B</i> (<i>SE</i>)	β	<i>t</i>	<i>p</i>
AUT Short PO	Age	.76(.14)	.50	5.31	< .001
	Fluency	.32(.07)	.53	5.63	< .001
IT Short PO	Age	1.46(.39)	.51	3.79	< .05
IT Long PO	Age	-.03(.40)	-.01	-.08	<i>NS</i>
	Fluency	.48(.15)	.50	3.19	<.05

Note. AUT = Alternative Uses Task. PO = Personal Originality. IT = Instances Task.
NS = not statistically significant.

Table 7

Hierarchical Linear Regression Exploring the Effects of Age and Personal-Originality Scores on Children's Combined Drawing/Title Scores

Step	Predictors	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	<i>R</i> ²	<i>R</i> ² Change	<i>F</i> Change	<i>p</i>
1	Age	.86	.26	3.30	.002	.21	.21	10.86	.002
2	Age	.65	.30	2.12	.040	.25	.04	1.85	.182
	AUT Short PO	.23	.17	1.36	.182				
1	Age	.86	.26	3.30	.002	.21	.21	10.86	.002
2	Age	.49	.29	1.72	.094	.32	.11	6.32	.016
	IT Short PO	.25	.10	2.51	.016				
1	Age	.86	.26	3.36	.002	.23	.23	11.31	.002
2	Age	.75	.25	3.07	.004	.39	.16	9.61	.004
	IT Long PO	.29	.10	3.1	.004				

Note. AUT = Alternative Uses Task. IT = Instances Task. PO = Personal Originality.

Figure 1

Sample Drawing with Title for Performance Measure of Creativity

Note. Titles were not visible during rating of drawing. This child received a “5” rating for drawing and title by both raters.

Figure 2

Screenshot of Zoom Session Screen-Share During Instances Task

Note. Image reflects experimenter's point of view.

Figure 3

Screenshot of Zoom Session Screen-Share During Alternative Uses Task

Note. Image reflects experimenter's point of view.

Figure 4

Coding Raw Responses for Objective Originality Scoring

<u>Raw Responses</u>	<u>Categorically Identical Responses</u>	<u>Coded Responses</u>
	Color	Color
	Coloring	Color
Color		
Color a spider	Color a spider	Color specific
Coloring	Coloring eyes	Color specific
Coloring eyes		
Draw	Draw	Draw
Draw a face	Drawing	Draw
Drawing		
Drawing cats	Draw a face	Draw specific
Drawing a house	Drawing cats	Draw specific
Drawing on a wall	Drawing a house	Draw specific
	Drawing on a wall	Drawing On

Note. Responses sampled from alternative uses task ideational pool.

Figure 5

Developmental Trajectories of Instances Task Fluency and Originality Scores

Note. IT = Instances Task. PO = Personal Originality.

Figure 6

Developmental Trajectories of Alternative Uses Task Fluency and Originality Scores

Note. AUT = Alternative Uses Task. PO = Personal Originality.

Figure 7

Visual Representation of Within-Session Personal Originality Mediating the Relation Between Age and Combined Drawing/Title Creativity Ratings

Note. IT = Instances Task. PO = Personal Originality.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix A

Originality Scoring Protocol

This appendix depicts the step-by-step process through which divergent thinking task responses were organized and scored. *Objective*, *Subjective*, *Short Personal-Originality*, and *Long Personal-Originality* scoring protocols are presented in two sections: preparation and scoring.

Objective Originality Scoring Protocol

Preparation

1. Two pre-incubation ideational pools were generated: one for *instances* and one for *alternative uses*.
2. Responses were organized in alphabetical order and by Child ID.
3. Identical, near identical, and categorically identical responses were collapsed to ensure fair and accurate originality scoring (see Figure 4 for examples).
4. Excel-formulas were used to detect responses at two levels of statistical rarity: 10% and 5%.

Scoring

1. Responses produced by < 10% of the sample received a score of 1; responses produced by < 5% of the sample received a score of 2.
2. Ratio scores for *instances* and *alternative uses* were calculated by dividing the sum of weighted scores by the total number of responses.

Subjective Originality Scoring Protocol

Preparation

1. Two pre-incubation ideational pools were generated: one for *instances* and one for *alternative uses*.
2. Responses were organized in alphabetical order and de-identified.
3. Raters conducted a thorough inspection of the entire (alphabetized) ideational pool.
4. After inspection, raters received an abridged ideational pool such that each response was only listed once.

Scoring

1. Raters assigned a score of 1 (not at all creative) to 5 (highly creative) to all responses in the abridged pool based on: uncommonness, remoteness, and cleverness (see Appendix C).
2. The average of ratings for each response were repopulated to the full ideational pool with child identifiers.
3. Ratio scores for *instances* and *alternative uses* were calculated by dividing the sum of subjective scores by the total number of responses.

Short Personal-Originality Scoring Protocol

Preparation

1. Complete ideational pools were generated by child ID and separated into two columns: pre-filler task and post-filler task.
2. Excel formulas were used to detect new responses (within-child) in the post-incubation column.

Scoring

1. Short personal-originality scores for *instances* and *alternative uses* were measured as the total number of new responses in post-filler task lists.

Long Personal-Originality Scoring Protocol

Preparation

1. Complete ideational pools were generated by child ID and separated into two columns: all Time 1 responses (i.e., pre- and post-filler task) and all Time 2 responses (collected in part 2 of the parent survey).
2. Excel formulas were used to detect new responses (within-child) in the Time 2 responses column.

Scoring

1. Long personal-originality scores for *instances* and *alternative uses* were measured as the total number of new responses in the Time 2 response list.

Appendix B

Measures and Child Task Instructions

This appendix presents all primary study measures not fully described in the manuscript, including the personality measure from the parent survey and tasks completed during child zoom sessions.

Big Five Inventory 10 – Child Form (BFI-10)

The BFI-10 was used to measure children's *openness to experience* (the sum of item 5 reverse coded and item 10) and *extraversion* (the sum of item 1 reverse coded and item 6).

Instructions

Here are a number of characteristics that may or may not apply to your child. For example, do you agree that your child is someone who likes to spend time with others? Please circle the number to indicate the extent to which you agree or disagree with that statement.

I see my child as someone who...	Disagree Strongly	Disagree a Little	Neither Agree nor Disagree	Agree A little	Agree Strongly
1. ...is reserved	1	2	3	4	5
2. ...is generally trusting	1	2	3	4	5
3. ...tends to be lazy	1	2	3	4	5
4. ...is relaxed, handles stress well	1	2	3	4	5
5. ...has few artistic interests	1	2	3	4	5
6. ...is outgoing, sociable	1	2	3	4	5
7. ...tends to find fault with others	1	2	3	4	5
8. ...does a thorough job	1	2	3	4	5
9. ...gets nervous easily	1	2	3	4	5
10. ...has an active imagination	1	2	3	4	5

Child Task Instructions

Below is the exact script used during the child zoom sessions detailing specific instructions for each child task. Note the order of child tasks was randomized with the

exception of *define creativity*, which occurred first in each session, and *verbal reasoning* which occurred last in each session.

Define Creativity

1.1. Okay {child name} have you ever heard the word “creative” before? I was wondering if you could tell me what the word creative means?

- *If child is unsure, try two follow up prompts → Can you give me your best guess for what the word creative means? How about you give it your best shot?*
- *If unsure/unresponsive/inaccurate, transition to 1.2. If participant demonstrates an understanding of the word creative, transition to 1.3*

1.2. That’s okay, {child name} When someone is creative, it means they come up with new and interesting ideas. We are going to play a few games where I want you to show me how creative you can be. Being creative is fun because there is never a wrong answer!

1.3. That’s right, {child name} [*reaffirm participant’s definition here*]. When someone is creative, it means they come up with new and interesting ideas. We are going to play a few games where I want you to show me how creative you can be. Being creative is fun because there is never a wrong answer!

Alternative Uses Task

2.1. [*Display pencil on screen and hold pencil to camera*]. Do you know what this is?

- *If unsure/unresponsive/inaccurate: This is a pencil*
- *If accurate: That’s right! [*reaffirm child’s response*].*

2.2. Can you tell me what a pencil is used for?

- *If unsure/unresponsive/inaccurate: Sometimes we use a pencil for things like writing our name! [*demonstrate*]*
- *If accurate: That’s right! [*reaffirm child’s response*].*

2.3. In this game, I want you to tell me all of the ways you could use a pencil! Try to think of all the ways you could use a pencil and be as creative as you can.

- *Positively reaffirm every response.*
- *In the case of a >5 second pause → Can you think of any more ways you could use a pencil?*
- *Once participant communicates s/he can no longer think of more responses, transition to filler task. After filler task, transition to 2.4*

2.4. Nice work, {child name}. Do you remember the game we were playing about things we could use a pencil for? You came up with a lot of creative things you could use a pencil for. You said you could use a pencil for [*list participant’s responses here*]. Can you think of any more creative ways you could use a pencil?

- *Positively reaffirm every response.*
- *In the case of a >5 second pause → Can you think of any more creative things you could use a pencil for?*

- *Once participant communicates s/he can no longer think of more responses, transition to next task.*

Instances Task

3.1. *Display marble on screen and hold marble to camera.* Do you know what this is?

- *If unsure/unresponsive/inaccurate:* This is a marble/marbles are round
- *If accurate:* That's right! [*reaffirm child's response*].

3.2. Can you think of anything else that is round?

- *If unsure/unresponsive/inaccurate:* [*draw circle on paper*] this is a circle. Just like a marble, circles are round.
- *If accurate:* That's right! [*reaffirm child's response*].

3.3. In this game, I want you to tell me all of the things you can think of that are round. Try to think of all the round things you can and remember to be as creative as you can.

- *Positively reaffirm every response.*
- *In the case of a >5 second pause →* Can you think of any more things that are round?
- *Once participant communicates s/he can no longer think of more responses, transition to filler task. After filler task, transition to 3.4*

3.4. Nice work, {child name}. Do you remember the game we were playing about things that are round? You came up with a lot of creative things that are round. You said [*list participant's responses here*] were all round. Can you think of any more creative things that are round?

- *Positively reaffirm every response.*
- *In the case of a >5 second pause →* Can you think of any more things that are round?
- *Once participant communicates s/he can no longer think of more responses, transition to next task*

Filler Tasks

FT-Colors. You were great at that game, {child name}! Now I have a(nother) game I would like to play with you. In this game, you will see a color on the screen. I just want you to tell me what color you see

FT-Shapes. Awesome work, {child name}! You were really good at that game. Now I have a(nother) card game I would like to play with you. In this game, you will see a shape appear on the screen. I just want you to tell me what shape you see.

Creative Drawing Task

4.1. [*Ask parent to bring out art supplies*] The next game I want to play is a coloring game. I want you to draw something really creative like a magical creature or an

imaginary friend, or maybe even something no one has ever seen or thought of before!
Can you think of something really creative that you want to draw?

- *If unsure/unresponsive/not particularly creative, brainstorm ideas with participant until s/he identifies one*
- *If participant articulates a creative idea → That's a great idea!*
- *After participant indicates s/he is finished, transition to 4.2*

4.2. This is a very creative drawing! [*compliment features of drawing*]. You know what this drawing needs? A title! Do you think you could give this drawing a creative title?

- *Use follow-up prompt if necessary → What is a creative name we could give this drawing?*
- *If participant does not give drawing title use response to 4.1 "what do you think we should draw?" (Ask parent to write title on drawing). Otherwise, transition to 4.3*

4.3 That is a very creative name for your drawing! [*Ask parent to write title on drawing and transition to next task*]

Verbal Reasoning ("Guess What") Task

5.1. The last game I want to play is a guessing game! I'm going to give you three clues, or hints, and then I want you to guess the thing I'm talking about. Let's try a practice one. This one is a bug with no legs, you can find it in the dirt, and sometimes birds eat it. Can you get what it is!

- *If unsure/unresponsive/or incorrect, repeat the hints one more time. If still no (correct) answer → It's a worm! Display picture on screen, explain how it relates to the hints, and provide encouragement. You did a good job trying to figure it out. Let's try a few more!*
- *If participant answers correctly → That's right! It's a worm! Let's try a few more*

5.2. Ok, let's try another one. I'm going to give you three hints, and then I want you to try to guess what it is! It has four legs and a tail, some people like to keep it as a pet, and it has whiskers. Can you guess what it is?

- *If unsure/unresponsive/or incorrect, repeat the hints one more time. If still no (correct) answer → It's a cat! Display picture on screen, explain how it relates to the hints, and provide encouragement. Let's try a few more!*
- *If participant provides an acceptable answer → That's right! It is a {child response} Great guess, {child name} Let's try a few more*

5.3. Here are your three hints. It falls from the sky, it helps plants grow, and it will get you wet if it touches you. Can you guess what it is?

- *If unsure/unresponsive/or incorrect, repeat the hints one more time. If still no (correct) answer → It's rain! Display picture on screen, explain how it relates to the hints, and provide encouragement. Let's try a few more!*
- *If participant provides an acceptable answer → That's right! It is {child response} Great guess, {child name} Let's try two more.*

5.4. Here are your three hints: It has words in it, sometimes it has pictures, and you can find it on a shelf. Can you guess what it is?

- *If unsure/unresponsive/or incorrect, repeat the hints one more time. If still no (correct) answer → It's a book! Explain how it relates to the hints and then provide encouragement. Let's try a few more!*
- *If participant provides an acceptable answer → That's right! It is {child response} Great guess, {child name} Let's try one more.*

5.5. Here are your three hints: It's yellow, it grows on a tall plant that looks like a tree, and you peel it before you eat it. Can you guess what it is?

- *If unsure/unresponsive/or incorrect, repeat the hints one more time. If still no (correct) answer → It's a banana! Display picture on screen, explain how it relates to the hints, and provide encouragement. You were really good at that game, {child name}.*
- *If participant provides an acceptable answer → That's right! It is {child response} Great guess, {child name}! Thank you so much for playing these games with me, {child name}*

Appendix C

Subjective Rating Instructions

This appendix presents the instructions used for the subjective ratings. Instructions and criteria were adopted from Silvia et al., (2008) “Assessing Creativity with Divergent Thinking Tasks: Exploring the Reliability and Validity of New Subjective Scoring Methods.” Instructions and criteria were slightly modified to align with the current study divergent thinking tasks. Raters considered these same criteria when evaluating children’s drawings and titles.

Rating Divergent Thinking Task Responses

Creativity can be viewed as having three facets. Creative responses will generally be high on all three, although being low on one of them does not disqualify a response from getting a high rating. We will use a 1(not at all creative) to 5 (highly creative) scale. Please carefully read the criteria below before completing your ratings

1. **Uncommon:** Creative ideas are uncommon: they will occur infrequently in our sample. Any response that is given by a lot of people is common, by definition. Unique responses will tend to be creative responses, although a response given only once need not be judged as creative. For example, a random or inappropriate response would be uncommon but not creative.
2. **Remote:** Creative ideas are remotely linked to everyday objects and ideas. For example, creative uses for a pencil are “far from” common, everyday, normal uses for a pencil, and creative instances of things that are round are “far from” common round objects. Responses that stray from obvious ideas will tend to be creative, whereas responses close to obvious ideas will tend to be uncreative.
3. **Clever:** Creative ideas are often clever: they strike people as insightful, ironic, humorous, fitting, or smart. Responses that are clever will tend to be creative responses. Keep in mind that cleverness can compensate for the other facets. For example, a common use cleverly expressed could receive a high score.

Appendix D

Complete Ideational Pools for Divergent Thinking Tasks

This appendix presents children's raw responses for *alternative uses* and *instances* tasks. Due to the size of each ideational pool, separate tables are presented for pre-incubation, short incubation, and long incubation for both DT tasks.

Table D1

Uses for a Pencil – Pre-Incubation Alphabetized Responses

bake with it	draw another pencil	drop it (2)	make something	push it	use it as a measurer
balance it on your finger	draw butts	drop them	make something cool	put it in mouth	use it as a trap
being artistic	draw everywhere	drumming	make squares	put it on a computer	use it at school
bite the eraser off	draw humans	erase (3)	makeup on dolls	put it on a desk	use it to flatten playdough
bookmark	draw in the car	erase stuff	making shapes	put it on a dog	use on walls
break it in half	draw letters	erasing (5)	measuring things	put it on a house	when I'm a big girl
build letters	draw mini mouse	fill in erased spots	mix hot chocolate	put it on a monkey's drink	with paper (4)
building	draw numbers	for buttons	move it in a circle	put them away	words
color (2)	draw on a glass	handle for a sign	on paper	roll it	write (2)
color a spider	draw on the back	have colored ones	open things with it	roll it in your hands	write a name
color the pencil	draw on the front	hold it	outlining	rolling	write a note
coloring (6)	draw on the side	holding it on the end	paint	scribble (3)	write books (2)
coloring a picture	draw squiggly line	homework	paint it	sharpen	write cards
coloring an outline	drawing (26)	important stuff	paint with it	sharpen it (3)	write creative things
coloring eyes	drawing a gift card	jab something	pick them up	sharpen them	write letters
coloring on face	drawing a tractor	make a flag with it	play tic tac toe	sign contracts	write name of card
cover eyes with it	drawing books	make a line	poke yourself	slide it through a tube	write notes (2)
do not use it	drawing cats	make a pencil rainbow	pop things with it	something good	write on a wall or desk
do projects	drawing circles (2)	make a pickle pencil	pretend it is a marker	stick a whole in a window	write on stuff
dolls eyes	drawing comic books	make art with it	pretend it is a straw	stick it in the ground	write with your brain
dolls head	drawing letters	make designs	pretend it's a person	tap it on a table	write with your toes
draw (3)	drawing name	make fireworks	pretend it's a tree	tell people what it does	write words (2)
draw a face	drawing numbers	make lines	pretend it's treasure	throw them away	writing (11)
draw a hundred things	drawing on paper	make rectangle windows	pretend it's your pet	to learn	
draw a Michigan State logo	drawing words in books	make shapes	pretend you're giving a shot	tracing things	

Note. Responses repeated by more than one child display the number of children who produced that response in parentheses.

Table D2

Uses for a Pencil – Short Incubation Alphabetized Responses

block a camera	draw purses	make a ghost	pretend it is a sword	shape clay
block sound	draw silly face	make a letter "A"	pretend it is a wand	share them with friends
break it	draw something else	make a mask	pretend it is a zoo	spaceship
break it in a fan	draw things that are cool	make a pencil out of other things*	pretend to use it	stick it in a candle
break through a light bulb	draw trees		put a pencil in crayon	tap it on a box
build a car	draw with it	make a square (2)	put a pencil in paper	tap it on a door
build a house	draw your name	make a triangle	put it behind your ear	tap it on a kennel
color a tree	draw zig zags	make it a race car	put it in a light	tap it on a phone screen
color the floor	drawing	make letters	put it on a bunch of things	throw it away
coloring on paper (2)	drawing trains	make numbers	put it on a phone	use it as a spoon
curling hair	drink with it	make shapes	put it on the floor	use it in a show
cut off eraser to make it double-ended	erase stuff	making a box	put liquid on it	use metal part to make fire
dig holes	erase things	making squares	put your hand on it	use them as knitting sticks
draw a toy	for my sister's room	move a cockroach	putting it in hair	with animals
draw an animal	give it away	play	roll it around the room	with cheese
draw birds	hold a paper towel	play with clay	roll out some dough	with either hand
draw bushes	hold stuff	play with it	roll out some playdough	with grandpa
draw cheeks	homework	poke holes in slime	rub it on a rock	write a story
draw dog pop	light a fire with it	poking	save page in a book	write someone's name
draw ears	like a comb	pretend it is a broke stick	school work	writing books
draw helicopters	make a calendar	pretend it is a spoon	see what color it is	writing numbers
draw on clay	make a city out of them	pretend it is a stick	set it on a box	

Note. Responses repeated by more than one child display the number of children who produced that response in parentheses.

Asterisks indicate responses that continue from the previous line.

Table D3*Uses for a Pencil – Long Incubation Alphabetized Responses*

as a block	put it on a fork and roll it around	drawing
as a fork	roll it around	drawing a map
as a spoon	roll it back and forth with hands	to make little holes to plant plants
bake cookies	stick it in a candle	give it back
balance in both hands	throw it in a freezer until it's an ice cube then take it out	make a microphone
bounce in both hands	and put it in the sun*	make a race car but we'll have to put buttons on it for the wheels*
break it	to play games	make a star out of them
throw it	to poke little holes in play dough	make an elf out of it
cannot throw it outside our window	to poke things	on paper
color on things	to write in the space where you're battling*	painting
color things pencil color	tractor color	paper
color with it	we can break it with a tree	pretend it's a guy
draw Christmas trees	we could write NSG	scribble
draw my hand	write letters and numbers too	smash it on your tv
draw people	write my name	smash stuff
draw shapes (2)	write on the wall	snap it apart and put it on a crayon
draw your stuffed animal	write words	tap it
drawing humans	help someone get something unstuck	to color on the paper
erase stuff with it	you can roll it	to draw an eyeball
hitting stuff	a pencil could be a dog	to write my name
hot glue it and make a building	a wand	use it for a mixer
juggle with fun thing	a worm	use it to unjam stuff
magnets	an art project	we can draw with it
make an alligator	break it	write with it upside down
making a drum set	building	write your name
on dresses	coloring	writing (2)
on puzzles	do anything I want	you could roll a pencil
put an arrow on it to launch it	draw	you could use it in battle to throw it when it's sharp to poke them*
paint it blue and black and gray	draw notes	
pin stuff	draw pictures	
poke someone on accident	draw some draw with it	
put it in the pencil sharpener	thing important	

Note. Responses repeated by more than one child display the number of children who produced that response in parentheses.

Asterisks indicate responses that continue from the previous line.

Table D4*Things that are Round – Pre-Incubation Alphabetized Responses*

apples (3)	button	dot of glue	jar	paper	sticks
<i>arms held in a circle</i>	buttons	dots	jars (2)	pen holder	strings like yarn
around	cakes	drew circle	knobs (3)	pencil tips	stuffed animal
baby bottles	cannon balls	DVD players	lamp shades	pencils	sun (5)
baby toys	cap for something	ears (2)	lamps (2)	pictures	sunglasses (2)
bagels	cardboard rocket	earth (2)	lemons	pigs	teeth
bags	carpets	end of a marker	letter "o" (6)	planets (3)	the top of nails
ball (5)	cars (2)	exercise balls	lid for a marker	plates	tip of an arrow
balloons	chapstick	eye	lid on lotion	playdough	tire on a car
balls (22)	cheerios (3)	eyes (10)	lids (4)	ponytail bands	tires
baseball	circle (2)	fans	light bulb	pools	top of a can
basketball (2)	circle frames	fat dogs	light fixture	popcorn balls	top of a crayon
basketballs	circle stickers	flowers	lightbulbs (2)	rings	top of a lightbulb
beach ball	circles (10)	football	lights (5)	rock	top of lotion
beach balls	clock	full moon	lights outside	rocks	torch light
beads (3)	clocks	glass	<i>made lips in a kissy face</i>	rose on a bow	tracks in the snow
bellies	coffee pots	glasses lens	little balls	round things on wires	tractors
big circle	colors	grapes	<i>made circle with hands</i>	scissors handles	trees
bigger balls	compass	gumballs	markers (5)	sharks	tubes
birds' nests	cookies (2)	hair (2)	mirrors	shoes	wagon tire
blankets	corks	hair ties	moon	signs	water bottle
blue ball	corners	handle on a drawer	mouth	snow globes	water fountains
blue berries	cupcakes (2)	handles	necks	snowballs	wheel
bottles (2)	cups	hats (2)	noses	soccer balls (3)	wheels (6)
bottom of a marker	deer neck	head (5)	nostrils (2)	sound machine	wheels on trucks
bouncy ball (2)	<i>did somersault</i>	heads (7)	open mouth	<i>spun in circle</i>	wine glass
bouncy balls (2)	dog's heads	holes (2)	oranges (3)	squishy ball	you are round
bowls (2)	donuts (2)	huge circle	ornaments	statues	zebra's nose
bracelets	doorknob	human neck	pacifiers	steering wheels	zero
bushes	doorknobs (2)	inside bottle	palm of your hand	stickers on bottles	

Note. Responses repeated by more than one child display the number of children who produced that response in parentheses.

Italicized text indicates behavioral responses.

Table 5D*Things that are Round – Short-Incubation Alphabetized Responses*

a bunny's tail	car wheels	eyelids	leaf	pillows	tooth
a fist	CDs	eyes (2)	leaves	planets	tootie fruitie
a hole on a coffee cup	chairs	faces	lens on a camera	plant holders	top of a nail
a hole on a straw	chocolate	fans	letter "o"	plate	top of a stool
a water cup	circle buttons	faucets	lid	plates	top of a top
an eye	circle eggs	fingernails	light button	Pluto	tops of chalk (2)
ant traps	circles (4)	flashlights	lights	pockets	toy trucks
apples	circles inside of a square	floaties	lint	Polka dot	toys
baby toys	circles made of fuse beads	flowers (2)	logos	poles	traffic lights
backpacks	circles on a ceiling	fruits	markers	pools	truffles
ball	circles on an "8"	fuse beads	Mars	poop	tummies
balls	clay	glasses	mats	pop socket	tuna can
basketball hoops	clocks (2)	globes	middle of flower	popcorn	Uranus
beads	coconuts	glue stick (2)	monkey eyes	power wheel	vegetables
blanket rolled into a ball	coffee	gumballs	monkeys	pumpkins	wheels (4)
bolts	coffee mugs	Halloween skateboards	moon (2)	puppy dogs	windows
bones	cords	handrails	mushrooms	quarter	yarmulkes
books	crews	hands	nails	rafts	yoyos
bottom of jar	cup holders	hats	napkins	rain	zero (2)
bottle of apple juice	cups (5)	heads (3)	octopus	rectangle	
bottom of a trashcan	disco balls	hearts	oranges	rectangles	
bowl	dogs	hedgehogs	paddleboard ball	rubber bands	
bowling balls	donuts	helicopter toy	paint balls	Saturn	
bowls (3)	doorknobs (2)	honey nut cheerios	paintings	scissor holes	
bracelets	dot	inside of a bowl	paper	sinks	
bubble tops	dots	jack-o-lantern	paper towels	spears	
bubbles	earrings	jars	paws	steering wheels (2)	
buttons	earth	Jupiter	pencil	sun (3)	
candles (2)	eraser	lamp	pencils	tires	
caps	erasers	lamps	pets	toes	

Note. Responses repeated by more than one child display the number of children who produced that response in parentheses.

Table 6D*Things that are Round – Long-Incubation Alphabetized Responses*

Alexa speaker	circles on LEGOS	grandma	nails	presents	tail
apple (3)	circular part of a	grapes	nest	pretty dragon fruit	tape
apples	transformer*	gumball	nose (2)	pumpkins (2)	teddies
baby toy	climbing block	hat	noses (2)	railings	teapot
ball (2)	clouds	head (4)	orange (2)	red stop sign	the back of my heel is
balloon	coin	heads	oranges	rice	round
balls (4)	cookie	helmets	ornament	rolled up blankets	the circle trees
basketball	cup (3)	hole	ornaments	roller	the ends of your sleeves
bath bomb	cupholder	holes	our ankles	Santa's nose	the inside of our ears
bead	cups	jingle bell	our ears	sirens	the little dot on the tv that
bean bag	Daisy's ball	jingle bells	our face	sled	lets us know if it's on or*
beet	deer bodies	knob on headboard	our neck	smiley face	off*
berries	dot	LEGO ball that opens	our nose holes	snow globe	the middle of a flower
beyblade	dragon tears	LEGO head	our round arms	snow man	the other fruit like a lime
bologna goes around in	earmuffs	lens of glasses	our toes	soccer ball	that's yellow*
circles*	earring	letter "o" (2)	ovals	soccer balls	the thing on the remote
bowl (5)	Easter eggs	lid (3)	pacifiers	some leaves on trees	the world (2)
Bread	egg	lids	paint brush	space that holds a ball on a	tomatoes
bunny tail	eggs (2)	light	paper plates	catapult	top of a LEGO lamppost
bunny tails	elf's head	lightbulbs (2)	part of a heart	speakers	top of road cones
button	eye	lights (3)	pear	spinner toy	trashcan (2)
buttons	eyeball (2)	lime	peas	spoon	trees
butts	eyeballs	marble	pillows	spoon's head	vase
cakes	eyes (2)	marker	pizza	spots (2)	water bottle
cannonball	fingers	markers	plain ball	stoplights	watermelon
cap	fish	masking tape	planet	stop sign	wheel (2)
carrots	flashlights	Mickey Mouse ears	plate	stove knob	wheels (6)
chicken nugget	flower (2)	Mickey Mouse nose	plates	stroller wheels	wood
Christmas lights	flowers	middle of a flower	playmobil toy	square	yellow marble
cinnamon roll	freckle	mommy's eye	polka dots	sun (2)	your eyes
circle (2)	frosty the snowman	moon (2)	pom poms	table	zero (2)
circles (3)	glasses	my owl's head	pot	table downstairs	

Note. Responses repeated by more than one child display the number of children who produced that response in parentheses. Asterisks indicate responses that continue from the previous line.

Appendix E

Linear Regression Assumptions Tests

This appendix presents visual and statistical evidence for the normality (i.e., Shapiro-Wilk tests and Normal P-P Plots of standardized residuals), and homoscedasticity of residuals (i.e., scatterplots) and, in the case of multiple regression, the absence of multicollinearity issues (VIF).

Model 1: Age and Fluency as Predictors of AUT Short PO

Shapiro-Wilk Test Result: $W(39) = .987, p = .92$ | VIF = 1.13

Model 2: Age as a Predictor of IT Short PO

Shapiro-Wilk Test Result: $W(42) = .987, p = .90$.

Model 3: Age and Fluency as Predictors of IT Long PO

Shapiro-Wilk Test Result: $W(40) = .965, p = .256$ | $VIF = 1.20$

VITA

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