JOURNAL OF
Creative Behavior
Publication of the Creative Education Foundation™

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Predictors of Change in Creative Thinking Abilities in Young People: A Longitudinal Study

ABSTRACT

Previous research has examined how creative potential develops during childhood and has identified peaks, slumps, and bumps during maturation. However, little is known about the causes of such changes. This study employed a longitudinal approach to assess predictors of change in creative ideation over 2 years in young people ($N = 76$) aged 14–20 years old at the first time point. The analysis employed frequentist and Bayesian methods to evaluate the effect of individual factors, such as openness to experience (assessed using the BFI-10 short form), and contextual factors, such as pursuing creative hobbies (measured with a leisure questionnaire). Openness at the first time point and change in openness over time predicted change in peak originality. Engagement in creative hobbies at the first time point predicted change in fluency. The findings support the contribution of individual factors, in the form of openness to experience, and contextual factors, in the form of engagement in creative hobbies, in the development of divergent thinking abilities in mid-adolescence and young adulthood. Altogether, this study suggests that interventions aimed at increasing time spent on creative activities and promoting openness to experience may enhance divergent thinking abilities, which are essential components of creative potential.

Keywords: creative ideation, young people, longitudinal analysis, openness, creative activities.

The development of creative potential has been an important topic within creativity research since E. Paul Torrance's (1963, 1968) studies of creativity in children. While the maturational trajectory of various aspects of creative potential has been explored by researchers and practitioners for several decades, little attention has been given to adolescent and young adult samples. Additionally, there has been limited research on identifying factors that predict changes in creative potential across the lifespan. In this paper, we examine changes in creative potential over a 2-year period in young people who were aged 14–20 at the first time point, and we evaluate the impact of individual and contextual factors, as well as variations in those factors over time, in predicting changes in creative ability.

Creative potential refers to a set of skills, attributes, behaviors, and motivations that contribute to creative achievement (Runco, 2007) and includes creative thinking abilities, personality traits, attitudes and values, and creative activities and actions. Divergent thinking stems from Guilford's (1967) Structure-of--Intellect model and has been the most widely studied aspect of creative thinking in creativity research (Cropley, 2006). It involves the generation of multiple responses to an open-ended stimulus, using figural tests such as the Torrance Test of Creative Thinking (Torrance, 1974) and verbal tests such as the Alternate Uses Task (Guilford, 1967). An alternative approach to the study of creative thinking abilities comes from the field of creative cognition and the Geneplore model (Finke, Ward, & Smith, 1992). The model is focused on identifying the mental processes that underpin creative thought. A number of different cognitive processes stem from the Geneplore model, including insight, conceptual expansion, the constraining influence of recently activated knowledge, conceptual combination, and creative imagery, which can be measured using a range of tasks (Abraham & Windmann, 2007).

The study reported in this paper follows up on a previous study in which we examined predictors of creative potential in adolescents and young adults aged 14–20 (Asquith, Wang, Quintana, & Abraham, 2022a). While other studies have examined individual and contextual factors separately, or in relation to single measures of creative thinking (e.g., Batey, Chamorro-Premuzic, & Furnham, 2010; Cotter, Pretz, &

Kaufman, 2016), our earlier study was unique in its examination of the combined influence of multiple individual (e.g., openness to experience) and contextual predictors (e.g., engagement in creative hobbies) on multiple indices of creative thinking. It was conducted with three cohorts of young people, two in secondary education aged 14–15 (Grade 9) and 16–17 (Grade 11), and one in the first year of university aged 18–20. The individual predictors that were found to significantly influence creative potential were openness to experience and intelligence. The sole contextual predictor of creative potential was engagement in creative hobbies. What was especially noteworthy was that the best predictive model (i.e., the combination of factors) that significantly influenced creative performance differed across indices of creative potential.

The finding that creative thinking abilities were positively predicted by openness, intelligence, and engagement in creative hobbies is consistent with previous research. The individual factors of openness to experience and intelligence have been widely studied in relation to creative potential. Batey et al. (2010), for example, found that both openness and intelligence predicted ideational behavior, but openness was a larger predictor than intelligence. The relationship between engagement in creative hobbies and creative ideation has not been studied as extensively, and the findings are mixed. Cotter et al. (2016), for example, found that engagement in arts clubs as a type of extracurricular activity did not predict divergent thinking in college students, although it did predict other forms of creativity, such as caption and performance creativity. Taken together, the Asquith et al. (2022a) findings demonstrate the usefulness of taking an approach that examines the combined influence of multiple individual and contextual factors to examine the importance of these factors for creative ideation.

Our previous study also found that there were no differences in the measures of creative potential across the three age cohorts. While the development of creative potential in mid-adolescent and young adult age groups has received less attention than the younger age groups that were the focus of Torrance's (1963, 1968) research, the findings across age groups are best characterized as mixed. For one, the presence of differences appears to depend on the aspect of creativity being examined. Kleibeuker, De Dreu, and Crone (2013), for instance, found no differences in fluency of verbal divergent thinking across four groups of adolescents and young adults. However, 25–30-year-olds showed higher verbal originality than 12–13 and 15–16-year-olds. Visuospatial divergent thinking, on the other hand, seemed to be at its peak in the 15–16-year-old age group.

Said-Metwaly et al.'s recent meta-analysis (Said-Metwaly, Fernández-Castilla, Kyndt, Van den Noortgate, & Barbot, 2021) of the development of divergent thinking from Grades 1 to 12 found an overall upward trend, with a plateau in fluency, flexibility and originality in Grade 9, and diverse patterns of slumps, plateaus, and increases across those three indicators from Grades 10 to 12. An explanation of the heterogeneity in those findings is provided by Barbot, Lubart, and Besançon (2016) "optimal-fit" view of creativity. Their theory proposes that creative potential depends on person-level resources (such as divergent thinking, cognitive abilities, and personality traits) and the characteristics and demands of the creative task. An individual therefore has multiple creative potentials and their performance is dependent on the task at hand. Discontinuity in the development of creative potential in childhood and adolescence can be explained by the asynchronous development of multiple person-level resources, environmental influences, such as socioeconomic status, parenting beliefs, and school type (e.g., Castillo-Vergara, Barrios Galleguillos, Jofré Cuello, Alvarez-Marin, & Acuña-Opazo, 2018; Dai et al., 2012; Niu, 2007) as well as task specificity and methodological artifacts. The authors emphasized the need for research to recognize the multidimensional nature of the development of creativity and for more longitudinal research in this area.

The longitudinal research that has been carried out to date has tended to focus on establishing the developmental profile of creative abilities (e.g., Claxton, Pannells, & Rhoads, 2005; Torrance, 1968) but relatively few studies have looked at individual or environmental factors that may be associated with those changes. The little research that has been done in this context has largely focused on childhood and early adolescence. Gubbels, Segers, and Verhoeven (2017) examined the development of analytical and creative abilities in fifth- and sixth-grade children over 2 years. They found that although analytical and creative abilities were correlated at all time points, analytical ability scores at the first time point did not predict later scores in creative ability and vice versa, suggesting that these two sets of abilities develop independently. Theurer, Rogh, and Berner (2021) studied interdependencies between openness and creativity in fifth-grade children over a 1-year period and found that openness and creativity largely developed independently in this age group, although there was a weak influence of divergent thinking on openness 1 year later. While openness did not influence later creativity, the authors suggest that it is possible that the relationship between the two constructs becomes closer with increasing age (Theurer et al., 2021). There is some evidence to suggest that contextual factors such as the school environment also affect creative potential (Besançon & Lubart, 2008).

A detailed understanding of which individual difference factors and contextual or environmental variables are associated with differences in the development of creative potential is as yet lacking, particularly in mid-adolescents and young adults.

In sum, theoretical and empirical work indicates that although there may be slumps and bumps in the development of creative potential in childhood and adolescence, whether these discontinuities are experienced may depend on specific individual and contextual factors. The present study sets out to examine how several such factors predict change in creative ideation over a 2-year period in a sample of young people aged 14–20 at the first time point. To do this, we followed up with participants who took part in our first study (Asquith et al., 2022a) and asked them to complete the same set of tasks and measures. We chose to study this age group because it is an important developmental period (Blakemore & Choudhury, 2006) but creative thinking has been less studied in this than in younger age groups, and findings have been mixed (e.g., Kleibeuker et al., 2013). We examined change over a 2-year period because participants in at least one of the cohorts would make a transition during the 2 years, and such transitions are associated with slumps in the development of creative potential (Torrance, 1968; see also He & Wong, 2015; Krampen, 2012). Cohort 2 aged 16–17 would make a transition from school or college into higher education, training or work after Grade 12, and some participants in Cohort 1, aged 14–15, might transition to a different school or college after Grade 10.

We examined three factors as predictors of change in creative ideation as these were the relevant predictors of creative ideation in the original study: openness to experience, IQ, and engagement in creative hobbies. Openness to experience is the personality trait most strongly associated with creativity (Puryear, Kettler, & Rinn, 2017), but there has been little longitudinal research examining its relationship with the development of creative potential. The relationship between intelligence and creative potential seems to become stronger with age (Gerwig et al., 2021; Kim, 2005), but it is unclear whether it is associated with differences in the development of creative ideation in adolescent and young adult samples. While engagement in creative hobbies is associated with creative ideation (Asquith et al., 2022a), little is known about related maturation-based differences.

Participants first completed the tasks and measures at time point one when they were aged 14–20, and again 2 years later, and we derived new variables to measure change in the predictor factors and the outcome variables. We investigated three questions in relation to the longitudinal analysis:

a. Do predictors in Phase 1 influence creative performance 2 years later in Phase 2?
b. Do changes in predictors over 2 years correspondingly influence change in creativity over the same period?
c. Does creative performance improve, decrease, or remain unchanged over the period of 2 years?

METHOD

DESIGN

This study employed repeated measures correlational design to examine predictors of change in creative ideation over a 2-year period. Creative potential was measured using the Alternate Uses Task (AUT; Guilford, Christensen, Merrifield, & Wilson, 1960) and an overcoming knowledge constraints (OKC) task. The predictors of change were openness to experience measured with the BFI-10 (Rammstedt & John, 2007), IQ measured with a short form of Raven's SPM (Bilker et al., 2012) and engagement in creative activities measured with a self-designed questionnaire on leisure activities (see Supplementary Material). Participants completed these measures both at Time 1 and Time 2.

PARTICIPANTS

Participants were recruited in three cohorts from schools, colleges, and a university in West and North Yorkshire in the U.K. Cohort 1 was aged 14–15 years, Cohort 2 16–17 years, and Cohort 3 18–20 years at the time of their first participation in Phase 1 (details of this recruitment are written up in Asquith et al., 2022a; see Table 1 for descriptive statistics). Participants who had consented to be contacted were invited to take part in Phase 2 between October 2018 and May 2019. Data collection took place in schools or colleges or at Leeds Beckett University. In Phase 1, participants were offered entry into a prize draw for cinema vouchers, or for Cohort 3, course credit/participation points. In Phase 2, Cohort 1 participants in school/college were offered entry into a prize draw for cinema vouchers, and Cohorts 2 and 3 were offered a small payment (8 GBP) and travel expenses.

TABLE 1. Summary of Study Participants by Cohort

	All	Cohort 1	Cohort 2	Cohort 3
N Phase 1	409	134	204	71
N Phase 2	76	38	20	18
Percentage	19%	28%	10%	25%
Age (Phase 2)	18.34 (1.83)	16.76 (0.28)	18.82 (0.39)	21.15 (0.44)
Time between phases (months)	23.13 (1.93)	22.20 (1.02)	23.14 (1.99)	25.08 (1.97)
Gender (Phase 2)				
Female	68	34	17	17
Male	7	3	3	1
Non-binary	1	1		

Note. The percentage is the number of participants from Phase 1 who took part in Phase 2. Ethnicity data are provided in Table S1.

MATERIALS

Creativity Task 1: Alternate uses task

Participants completed the AUT (Guilford et al., 1960) in which participants were asked to come up with as many uses as they could think of for a common object. Three items were used in each phase (newspaper, shoe, and paperclip in Phase 1; bucket, comb, and belt in Phase 2). Participants were given 2 min to respond to each item and were instructed to think of uses that were different from the normal use. Responses for all age groups were scored as a single data set (409 participants in Phase 1 and 76 in Phase 2) by the first author. Uses that were normal use (e.g., shoe: wear it) were deleted from the data set. Uses that were generic (i.e., they would apply to many different objects, e.g., recycle it), unclear, or nonsensical (e.g., paperclip: a choking hazard) were also deleted. Uses were merged if they were the same as another use. The proposed deletions and merges were reviewed and agreed upon by the second and fourth authors and followed the manual instructions for the AUT (Guilford et al., 1960). Three measures were derived: fluency, calculated as the average number of valid responses generated across the three items; overall originality, based on the relative frequency of the uses across participants (Abraham, Asquith, Ahmed, & Bourisly, 2019; Runco, Okuda, & Thurston, 1987); and peak originality, calculated as the number of responses given by the participant that were generated by 10% or less of the sample. See Asquith et al. (2022a) for further details of the scoring approach.

Creativity Task 2: Overcoming knowledge constraints (OKC)

The OKC task required participants to think of and draw a new idea for a toy (Phase 1; Abraham & Windmann, 2007; Smith, Ward, & Schumacher, 1993) or a creature living on a planet like Earth (Phase 2; Smith et al., 1993). They were first shown three examples, which each contained three common elements. For the toy (Phase 1), these common elements were a ball, the use of electronics, and the need for physical exertion. For the creature (Phase 2), the common elements were having four limbs, two antennae, and a tail. The drawings were scored based on how many of these common elements they contained, with scores between 0 and 3. The scores reflected the degree to which the participant's drawing was constrained by the recently activated knowledge in the examples they were shown. The ideas produced by more creative people should be less constrained by the examples (Abraham & Windmann, 2007). For ease of interpretation, the scores were reversed so that a higher score meant a greater ability to overcome knowledge constraints.

Personality Scale: BFI-10

A 10-item version of the Big Five Inventory was used (Rammstedt & John, 2007). The scale contains two items for each trait (e.g., "I see myself as someone who... is generally trusting"). Participants responded on a 5-point scale (1 = disagree strongly, 5 = agree strongly) producing scores of 2–10 for the five traits. Scores produced by the BFI-10 have shown acceptable correlations with the BFI and test–retest reliability (Rammstedt & John, 2007). The wording of one item for openness "...has few artistic interests" was reversed to "...has lots of artistic interests" for ease of understanding. As Cronbach's alpha may underestimate reliability of a two-item scale (Eisinga, te Grotenhuis, & Pelzer, 2013), the Spearman-Brown split half statistic was used to determine reliability. For Openness, it was .615 in Phase 1, and .577 in Phase 2.

Intelligence: 9-item short form of Raven's Standard Progressive Matrices (SPM)

A 9-item short form (Bilker et al., 2012) of Raven's Standard Progressive Matrices (SPM; Raven, Court, & Raven, 1995) was used to measure intelligence. Raven's SPM is a test of fluid intelligence that uses pattern-matching tasks. The short forms reduce administration time by over 75% while providing psychometric properties comparable to a 30-item abbreviated form and the full test (Bilker et al., 2012). A predicted total SPM score was calculated using the formula provided by Bilker et al. (2012) and translated into an IQ score using the table developed by Jensen, Saccuzzo, and Larson (1988). The test has two forms; Form A was used in Phase 1, with a maximum possible IQ score of 117, and Form B in Phase 2, with a maximum possible IQ score of 111.

Leisure Questionnaire

Participants completed a questionnaire on activities they participated in over the last month in four areas: creative hobbies, physical activity, socializing, and sedentary activities (Asquith et al., 2022a). It was adapted from examples of questionnaires within the leisure literature (Ábrahám, Velenczei, & Szabo, 2012; Badia, Orgaz, Verdugo, & Ullan, 2013; Jopp & Hertzog, 2010; Passmore & French, 2001). Scores for engagement were calculated based on the number of activities and how often they engaged in them per week (less than once = 0.5, 1–2 days = 1.5, 3–4 days = 3.5, 5–6 days = 5.5, and every day = 7).

Participants also completed tasks that are not the focus of this paper. The same three measures of well-being in Phase 1 were used again in Phase 2 alongside a measure of schizotypy.[1]

PROCEDURE

Ethical approval for the study was granted by the Local Research Ethics Committee at Leeds Beckett University, UK. Participants in Phase 1 took part within group sessions in schools and colleges or at the university, between October 2016 and March 2017. Participants in Phase 2 took part between November 2018 and May 2019 either in group settings (Cohort 1 participants still in school and most Cohort 3 participants at university) or in individual settings (Cohort 1 participants who had left school, Cohort 2, and some Cohort 3 participants). The session was a maximum of 1 h and 15 min in Phase 1 and 1 h in Phase 2. Participants completed the tasks and questionnaires on paper. The first author collected all the data and used a standard script and PowerPoint slides to give the instructions for each task and the three examples for the drawing task, to maintain consistency across the data collection sessions. Some participants did not complete all the tasks (see Table S2 for the descriptive statistics and sample sizes for the tasks and measures in Phase 1 and Phase 2). Students first provided information pertaining to their sociodemographics, their studies/work status, and their GCSE school grades. They then completed the well-being measures, the creativity measures, the SPM short-form intelligence test, the BFI-10 personality scale, and the leisure questionnaire. The data were coded and scored by the first author (see the Materials section for details).

APPROACH TO STATISTICAL ANALYSIS

Frequentist data analysis was carried out using IBM SPSS Statistics version 25, and Bayesian hypothesis testing was performed using JASP software version 0.9.2 (JASP Team, 2019). Bayesian hypothesis testing facilitates the quantification of relative evidence for alternative and null hypotheses (Quintana & Williams, 2017; Wagenmakers et al., 2018). Unlike traditional frequentist analysis, using a Bayesian framework can help make inferences regarding the null hypothesis. Moreover, using these two inference approaches increases robustness via triangulation (Munafò & Davey Smith, 2018). To answer research questions (a) and (b) (outlined at the end of the Introduction), the data were analyzed using linear regression and we compared the results of the frequentist models to the Bayesian models, which calculate the performance of models with all possible combinations of the predictors. For the Bayesian regression models, we used a Jeffreys-Zellner-Siow prior with a r scale of 0.354 and a uniform model prior (i.e., all regression models had equal model prior probability). If the 95% credible intervals of the identified predictors contained zero, this is indicated in footnotes (Wetzels et al., 2011). To answer the research question (c), frequentist and Bayesian *t*-tests were used. The Bayesian *t*-test used the JASP default Cauchy scale of 0.707 for the prior distribution. For both the Bayesian regression and *t*-tests, we selected a Bayes factor threshold of 3 (and its inverse), as

[1] The research aims of this second study were to uncover predictors of well-being and the relationship between creativity and well-being in young people (see Asquith, Wang, Quintana, & Abraham, 2022b). Well-being and schizotypy measures were included to address Phase 2 aims of this separate study.

this closely corresponds to a p value of .05 (Wetzels et al., 2011). A Bayes factor of 3 suggests that an alternative model is three times more favored than a null model, given the data.[2]

One of the aims of this study is to examine predictors of within-person change in creative potential over the 2-year period. To achieve this, change variables were calculated to determine within-subject change by the participant. Barbot et al. (2016) have highlighted the difficulties associated with using creativity tasks in longitudinal studies: the use of slightly different tasks on different measurement occasions avoids the problem of memory or carry-over effects but makes it difficult to identify true changes. As different objects were used in the AUT in the two phases, the divergent thinking indicators (fluency, overall originality, and peak originality) in Phase 1 and Phase 2 were first transformed into z-scores, and then the change variables were calculated by subtracting the z-score in Phase 1 from the z-score in Phase 2. The overcoming knowledge constraints tasks were different in the two phases but were scored on the same basis (possible scores of 0–3), so the change variable was calculated by subtracting the score in Phase 1 from the score in Phase 2. The same calculation was performed to determine the change scores in openness to experience and engagement in leisure activities. Change in IQ was not calculated because we did not expect any changes in IQ, and the differences between the maximum scores obtainable with Form A and Form B of the short forms of Raven's SPM made such a calculation unsuitable.

Potential predictors were identified using frequentist linear regressions. A change in a variable's score is related to its initial score, both the change score and the Phase 1 score were included as predictors, as well as the initial level of the outcome variable (Toon, 2000; Wilder, 1967). For example, to examine change in openness as a potential predictor of change in fluency, a linear regression was fitted with change in fluency as the outcome variable and the following three variables as predictors: Phase 1 fluency score, Phase 1 openness score, and openness change score (Δ Openness = Phase 2 Openness - Phase 1 Openness). If either the Phase 1 openness score or the openness change score were identified as significant predictors, both variables were included in the multiple regressions.

This approach identified a set of four predictors which included Phase 1 openness score, openness change score, Phase 1 creative hobbies score, and creative hobbies change score (see Table S3). Phase 1 IQ was retained as a fifth predictor because of its importance in the creativity literature (Sternberg & O'Hara, 1999). The same set of predictors was used for all four creative potential outcome variables. The analyses were conducted on complete cases.

Predictors of change in creative potential were examined using multiple regressions. As the small sample size means that the residuals may not be normally distributed, bootstrapped p values, and 95% confidence intervals are reported for the frequentist regressions. Including both the initial level of the predictor and the change variable, as advised by Toon (2000), increases the chance of multicollinearity in the regressions but checks following the guidelines proposed by Miles and Shevlin (2001) and Field (2013) indicated no major problems due to multicollinearity.

RESULTS

The descriptive data for all variables is included in the Supplementary Information (see Table S2). Regression analyses were carried out to examine questions (a) and (b) which were outlined at the end of the Introduction section. Analyses of variance were carried out to examine question (c).

LONGITUDINAL REGRESSION RESULTS

Multiple regressions were used to determine the predictors of change in each of the creative potential variables from Phase 1 to Phase 2; the change in (a) fluency, (b) overall originality, (c) peak originality, and

[2] Following the proposals made by Wetzels, van Ravenzwaaij, and Wagenmakers (2015) based on Jeffreys (1961) the Bayesian findings were interpreted as follows.

I. Clear evidence for the alternate hypothesis (extremely strong evidence: $BF_{10} > 100$; very strong evidence: 30–100; strong evidence: 10–30; moderate evidence: 3–10);

II. Anecdotal evidence for the alternate hypothesis: $BF_{10} = 1–3$;

III. No evidence: $BF_{10} = 1$;

IV. Anecdotal evidence for the null hypothesis: $BF_{10} = 1/3–1$;

V. Clear evidence for the null hypothesis (moderate evidence: $BF_{10} = 1/10–1/3$; strong evidence: $BF_{10} = 1/30–1/10$; very strong evidence: $BF_{10} = 1/100–1/30$; extremely strong evidence:< 1/100).

(d) OKC scores. The results of the frequentist multiple regressions are shown in Table 2 and the Bayesian multiple regressions are in Table 3.

The results of the frequentist regression analysis are reported first. Common to all creativity outcome variables was that within-person change for each outcome measure (e.g., change in fluency) was predicted by the level of that outcome measure in Phase 1 (e.g., phase 1 fluency). The creativity outcome measures differed from one another though in terms of further predictive factors. Within-person *change in fluency* was additionally predicted by engagement in creative hobbies in Phase 1 and change in openness. So, lower levels of fluency in Phase 1, higher levels of engagement in creative hobbies in Phase 1, and increases in openness from Phase 1 to Phase 2 predicted increases in fluency ($p = .001$, $p = .047$, and $p = .049$, respectively).[3] Within-person *change in overall originality* was additionally predicted by openness in Phase 1. So, lower levels of overall originality in Phase 1 and higher levels of openness in Phase 1 predicted increases in overall originality ($p = .001$ and $p = .038$, respectively). Within-person *change in peak originality* was additionally predicted by openness in Phase 1 and change in openness. So, lower levels of peak originality in Phase 1, higher levels of openness in Phase 1, and increases in openness from Phase 1 to Phase 2 predicted increases in peak originality ($p = .001$, $p = .007$, and $p = .004$, respectively). Within-person *change in OKC* scores was predicted only by OKC score in Phase 1 ($p = .001$), such that lower scores in Phase 1 predicted larger increases in OKC scores.

The results of the Bayesian regressions are reported next. For all four creativity measures, every noteworthy model indicated that the score of that measure in Phase 1 predicted the change score in that measure. For all the creativity measures, all five of the predictor variables featured in one or more of the top five models. The creativity measures differed though in which predictor variables featured in their best model. While the best model for change in OKC scores and change in overall originality included creative hobbies in Phase 1, the best model for change in fluency included both IQ and creative hobbies in Phase 1.[4] The best model for change in peak originality included creative hobbies in Phase 1, Openness in Phase 1 and change in openness from Phase 1 to Phase 2. While the specific combination of the other predictor variables differed in the best model for each measure, what can be gleaned from the table is that creative hobbies in Phase 1 consistently featured as a noteworthy predictor in the top Bayesian model for every creativity measure.

To summarize, the use of frequentist and Bayesian approaches revealed both consistencies and differences in the predictors of change in creative potential that were identified (see Table 4 for a summary of the pattern of the findings). Both approaches found engagement in creative hobbies in Phase 1 as a predictor of increases in fluency, as well as openness in Phase 1 and change in openness as predictors of increases in peak originality. The differences in the findings were as follows: The frequentist analyses alone supported openness in Phase 1 as a predictor of changes in fluency and overall originality. The Bayesian analyses alone supported engagement in creative hobbies in Phase 1 as a predictor of increases in overall originality, peak originality, and OKC. Bayesian analyses also alone supported IQ in Phase 1 as a predictor of increases in fluency.

LONGITUDINAL *T*-TEST RESULTS

The results revealed some significant differences in creative potential between phase 1 and phase 2 (see Table 5), with a mix of increases, decreases, and unchanged scores over a period of 2 years (see Figure 1 for a graph of the mean creative potential scores in Phase 1 and Phase 2, and Figure 2 for a raincloud plot which visualizes the group differences). These tests remained statistically significant after correction using Benjamini-Hochberg adjusted *p*-values. Fluency scores increased, supported by both frequentist and Bayesian analyses ($p = .01$, $BF_{10} = 3.21$, $d = 0.30$), but overall originality decreased, supported by both frequentist and Bayesian analyses ($p < .001$, $BF_{10} > 100$, $d = 0.83$). There was also partial support (i.e., from the frequentist analysis but not the Bayesian analysis) for a decrease in peak originality scores ($p = .011$, $BF_{10} = 2.83$, $d = 0.30$). There was no significant difference in the OKC scores. Frequentist correlations were also carried out to examine the relationship between creative potential variables in Phase 1 and Phase 2, and these are reported in Table S4 and Figure S1.

[3] Note that the 95% confidence interval for openness in Phase 1 included zero and therefore it is possible that the true value of the coefficient is zero.

[4] Note that the 95% credible interval for the coefficient of IQ in Phase 1 included zero.

TABLE 2. Summary of the Frequentist Multiple Regressions Predicting Change in Creative Potential

Predictor	Change in fluency			Change in overall originality			Change in peak originality			Change in OKC		
	B	95% CI	β	B	95% CI	β	B	95% CI	β	B	95% CI	β
Outcome P1	−0.68**	−0.90, −0.46	−.66	−1.11**	−1.39, −0.82	−.76	−0.87**	−1.14, −0.66	−.76	−1.13**	−1.42, −0.87	−.78
Openness P1	0.12*	−0.00, 0.23	.24	0.16*	0.02, 0.30	.23	0.19**	0.08, 0.30	.34	−0.02	−0.20, 0.16	−.02
Δ openness	0.16*	0.02, 0.32	.24	0.11	−0.07, 0.32	.12	0.23**	0.10, 0.35	.31	0.05	−0.16, 0.25	.05
IQ P1	−0.04†	−0.08, 0.01	−.21	−0.02	−0.07, 0.03	−.10	−0.03	−0.07, 0.03	−.14	−0.02	−0.06, 0.05	−.08
Creative hobbies P1	0.04*	0.01, 0.08	.33	0.02	−0.02, 0.07	.10	0.03†	0.00, 0.07	.23	0.05†	0.01, 0.11	.27
Δ creative hobbies	−0.02	−0.07, 0.03	−.09	−0.04	−0.10, 0.02	−.17	−0.04†	−0.09, 0.01	−.23	−0.02	−0.09, 0.05	−.10
R^2	.62			.70			.72			.69		
F	10.21			14.89			16.19			13.57		
p	<.001			<.001			<.001			<.001		
n	45			45			45			44		

Note. The table shows the results of frequentist multiple regressions predicting change in creative potential from individual and contextual factors. AUT P1 and change variables are z-transformed. Outcome P1 refers to the level of the variable in Phase 1. Δ indicates change in the variable between Phase 1 and Phase 2. †$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

TABLE 3. Bayesian Multiple Regression Analyses Predicting Change in Creative Potential

Variable	Predictors	BF_{10}	R^2
Change in fluency	1. Fluency P1 + IQ P1 + creative hobbies P1	69716.00	.56
	2. Fluency P1 + creative hobbies P1	68309.37	.52
	3. Fluency P1 + Δ openness + creative hobbies P1	63762.84	.55
	4. Fluency P1 + openness P1 + Δ openness + IQ P1 + creative hobbies P1	59099.10	.61
	5. Fluency P1 + Δ openness + IQ P1 + creative hobbies P1	57979.61	.58
Change in overall originality	1. Originality P1 + creative hobbies P1	6.685e + 7	.66
	2. Originality P1 + openness P1 + creative hobbies P1	2.768e + 7	.68
	3. Originality P1 + openness P1 + Δ creative hobbies	2.351e + 7	.67
	4. Originality P1 + openness P1	2.035e + 7	.64
	5. Originality P1 + Δ openness + creative hobbies P1	1.534e + 7	.67
Change in peak originality	1. Peak originality P1 + openness P1 + Δ openness + creative hobbies P1	1.197e + 7	.69
	2. Peak originality P1 + openness P1 + Δ openness + creative hobbies P1 + Δ creative hobbies	6.423e + 6	.70
	3. Peak originality P1 + openness P1 + Δ openness + Δ creative hobbies	5.879e + 6	.68
	4. Peak originality P1 + openness P1 + Δ openness + IQ P1 + Δ creative hobbies	4.527e + 6	.70
	5. Peak originality P1 + openness P1 + Δ openness + IQ P1 + creative hobbies P1 + Δ creative hobbies	4.056e + 6	.72
Change in OKC	1. OKC score P1 + creative hobbies P1	8.195e + 7	.67
	2. OKC score P1+ openness P1 + creative hobbies P1	1.854e + 7	.68
	3. OKC score P1 + creative hobbies P1 + Δ openness	1.830e + 7	.68
	4. OKC score P1 + IQ P1 + creative hobbies P1	1.795e + 7	.68
	5. OKC score P1 + creative hobbies P1 + Δ creative hobbies	1.762e + 7	.68

Note. The table presents the top five models The Bayes factor BF_{10} shows the comparison to the null model. P1 indicates the level of the variable in Phase 1. AUT variables are *z*-transformed. Δ indicates change in the variable between Phase 1 and Phase 2.

DISCUSSION

There is relatively limited literature examining predictors of change in creative potential, particularly within the age groups examined in this study. One of the novel elements of the experimental design of the current study was the evaluation of individual factors in the form of openness to experience and intelligence, and contextual factors in the form of engagement in creative hobbies in order to examine their combined effect on change in creative potential over time. Interestingly, markers from 2 years prior, in the form of openness to experience and engagement in creative hobbies, as well as change in openness, positively predicted change in creative potential measured 2 years later.

The most robust findings (i.e., consistent results between the frequentist and Bayesian analyses) were found in relation to the peak originality and fluency measures. Higher levels of openness at the first testing point and increases in the level of openness over the course of 2 years predicted increases in peak originality, the propensity to generate many highly original ideas. Higher levels of engagement in creative hobbies at the first time point predicted increases 2 years later in fluency, the propensity to generate many ideas. The role of IQ in predicting change in creative potential was much lower, with only partial support for it predicting change in a single facet of divergent thinking—fluency.

That openness to experiences and change in openness predicted change in multiple measures of creative potential is noteworthy as openness is consistently associated with creativity in the literature. Openness is associated with all aspects of divergent thinking (fluency, originality, flexibility, and elaboration) and with

TABLE 4. Summary of the pattern of findings from the frequentist and Bayesian regression analyses

Outcome	Predictors					
	Phase 1 Openness	Change p2-p1 Openness	Phase 1 Cr hobbies	Change p2-p1 Cr hobbies	Phase 1 IQ	Phase 1 Outcome variable
Frequentist						
Change in fluency	Yes	Yes	Yes			Yes
Change in overall originality	Yes					Yes
Change in peak originality	Yes	Yes				Yes
Change in OKC						Yes
Bayesian						
Change in fluency			Yes		Yes	Yes
Change in overall originality			Yes			Yes
Change in peak originality	Yes	Yes	Yes			Yes
Change in OKC			Yes			Yes

Note. In the frequentist summary of predictors, 'yes' indicates that the predictor was significant at $p < .05$. In the Bayesian summary of predictors, 'yes' indicates that the predictor was included in the best-fitting model. Cr = creative; p1 = phase 1; p2 = phase 2.

TABLE 5. Descriptive Statistics and Differences in Creative Potential Variables between Phase 1 and Phase 2

Variable	Phase 1			Phase 2				Bayes factor (BF_{10})	
	N	Mean	*SD*	*N*	Mean	SD	NHST		
Fluency	76	4.42	1.70	76	4.91	1.54	**Significant ($t(75) = -2.65$, $p = .010$)**	**3.21**	**Moderate support for the alternate hypothesis**
Overall originality	76	6.52	2.06	76	4.95	1.19	**Significant ($t(75) = 5.87$, $p < .001$)**	**>100**	**Extremely strong support for the alternate hypothesis**
Peak originality	76	6.37	3.73	76	5.21	3.08	**Significant ($t(75) = 2.59$, $p = .011$)**	2.83	Anecdotal support for the alternate hypothesis
OKC	74	1.28	0.99	76	1.59	0.94	Non-significant ($t(74) = -1.77$, $p = .081$)	0.56	Anecdotal support for the null hypothesis

Note: Results where the p value < .05 or the Bayes Factor >3 are highlighted in bold.

performance in the AUT (Puryear et al., 2017), in primary and high school-aged children (Niu, 2007; Shi, Dai, & Lu, 2016) as well as in adult samples. Openness also predicts creative activities and accomplishments (Hong, Peng, & O'Neil, 2014; Jauk, Benedek, & Neubauer, 2014) as well as creative achievement in later life (Helson & Pals, 2000). The findings of this study suggest that openness to experience has a role in the ongoing development of creative potential, in that higher levels of this personality trait at the first time point were associated with increases in creative potential 2 years later. Theurer et al. (2021) found that openness did not contribute to the development of divergent thinking in fifth-grade children aged 10–11 but

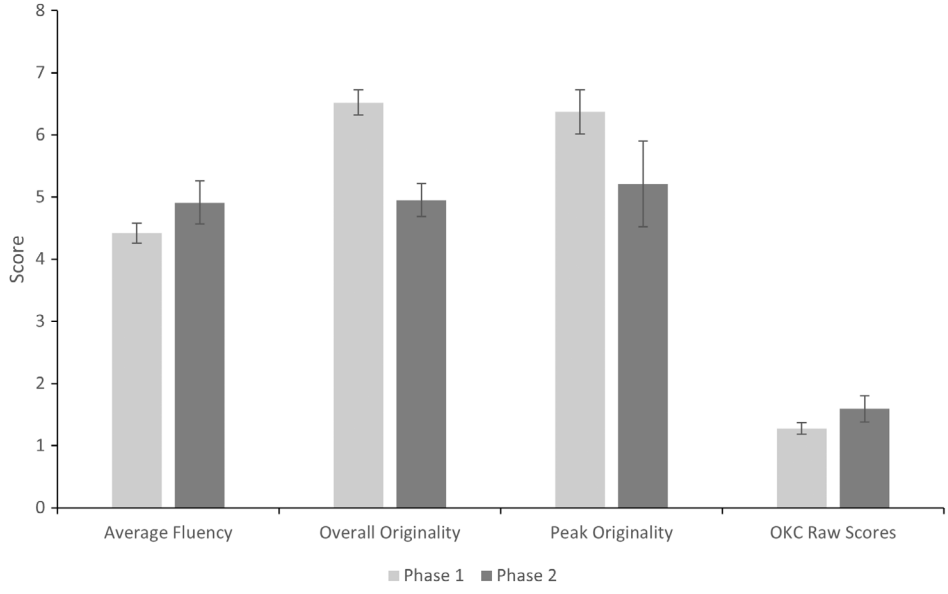

FIGURE 1. Mean Creative Potential Scores in Phase 1 and Phase 2. *Note*. Error bars represent the 95% confidence intervals.

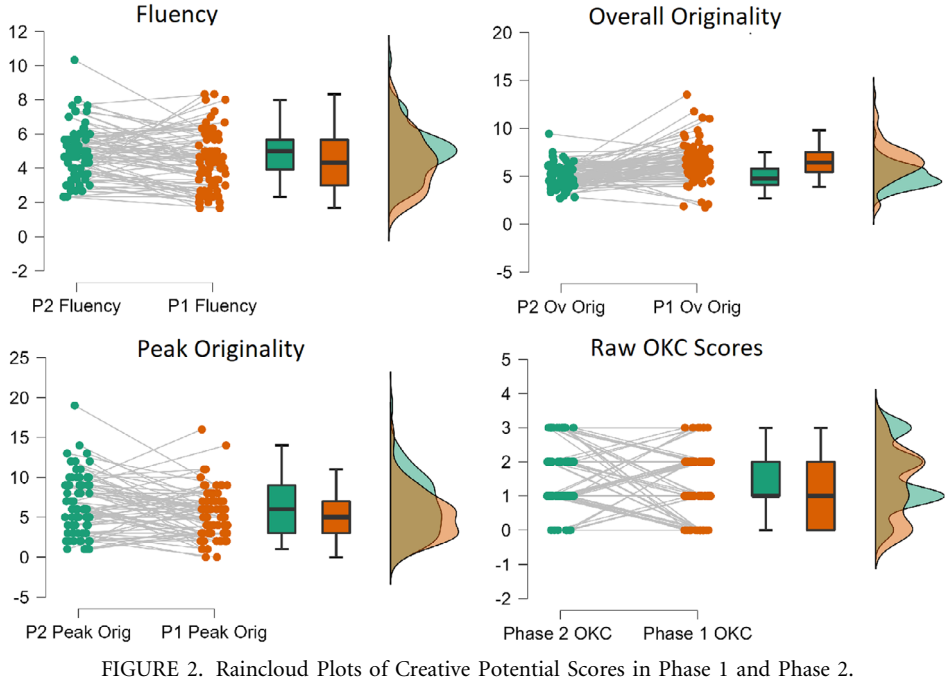

FIGURE 2. Raincloud Plots of Creative Potential Scores in Phase 1 and Phase 2.

suggested that the relationship between those two constructs may become closer with age. The findings of the present study indicate that this relationship is significant in mid-adolescent and young adult samples and that increases in openness over time predict increases in creative potential, particularly in the context of peak originality or the propensity to generate highly creative ideas.

Explanations of the relationship between openness and creative thinking typically focus on aspects of cognition. McCrae (1987) suggested that people high in openness may develop divergent thinking skills by exercising their cognitive faculties through cumulative practice. In a similar vein, it has been suggested that openness promotes the acquisition of knowledge and expertise through new experiences (Jauk, 2019; Kandler et al., 2016). McCrae (1987) suggested that this process should therefore produce stronger associations in older samples compared to younger samples. A comparison of the correlations between openness and divergent thinking in Phase 1 and Phase 2 of the current study (see Table S5) lends some support to this explanation. Correlations between openness and the measures of divergent thinking were all larger in Phase 2 (r range: .22–.49) than in Phase 1 (r range: .16–.39).[5] Therefore "the recurrent need to enlarge and examine experience" (McCrae & Costa, 1997, p. 826) may provide an impetus for continued growth in divergent thinking abilities.

The level of engagement in creative hobbies at the first time point was also positively associated with development of creative potential 2 years later. The creative hobbies in this study included performing and expressive arts, crafts, photography, and using technology to create animation or computer games and were carried out in a class/with a tutor, with family and friends, or alone. Research into the relationship between engagement in creative activities and creative thinking has tended to focus on artistic activities and has largely found that such activities are associated with higher levels of creative potential in children (Burton, Horowitz, & Abeles, 1999; Krumm & Lemos, 2012). However, in an undergraduate adult sample, there was no relationship between involvement in arts clubs and divergent thinking scores (Cotter et al., 2016).

Although creative practice seems to be an important step towards creative achievement (Jauk et al., 2014), it is less clear how creative activities in a specific domain or domains contribute to the development of creative potential. Cotter et al. (2016) have suggested that extracurricular activities that encourage the exploration of ideas in an open-ended way may lead to improvements in creative abilities, and studies have shown that a range of arts-related interventions increased creative thinking skills. Sowden, Clements, Redlich, and Lewis (2015) found that dance and drama improvisation produced domain-general benefits in divergent thinking ability. Certain forms of creative activity may benefit specific aspects of creative thinking. For example, creative drama, which is open-ended and semi-structured in nature, may contribute to the development of tolerance for uncertainty which is associated with creative people (Amabile, 1996; Karakelle, 2009), and also contribute to the development of verbal fluency (Hui & Lau, 2006).

There was limited evidence for intelligence predicting change in creative potential, supported only by the Bayesian analysis, and only for one of the outcomes, change in fluency. The relationship between creativity and intelligence has been extensively debated, with much research on threshold theory which proposes that intelligence and creativity are correlated, but only up to a certain level or threshold (Guilford, 1967). More recent research using a range of statistical techniques does not however support such a threshold (Weiss, Steger, Schroeders, & Wilhelm, 2020) and the strength of the relationship seems to depend on a number of factors including the way in which creativity is measured and scored, and the instructions given in the creativity task (Gerwig et al., 2021; Plucker, Karwowski, & Kaufman, 2020), The strength of the relationship is also affected by the age and gender of the sample in that the age of the sample is positively associated with the correlation between creativity and divergent thinking, and negatively associated with the proportion of females in the sample (Gerwig et al., 2021). The lack of an association between intelligence and change in creative ideation in the present study lends support to the idea that the strength of the relationship is sensitive to the age of the sample (e.g., Gubbels et al., 2017) and the gender imbalance within the sample.

The longitudinal analysis also showed different patterns of increases and decreases for the different indicators of creative potential over a 2-year period. Fluency increased, whereas originality, as measured by the two variables overall originality and peak originality, decreased. These differences may be related to the stimuli used in the study. Two different sets of objects were used in the AUT task in Phase 1 and Phase 2. Doing so avoided retesting effects from presenting the same stimuli at both time points, but it is possible that the sets of items presented different degrees of difficulty in producing original uses (Barbot, 2019; Forthmann

[5] It has not been possible to compare the correlations statistically, as the data were collected at two time points with a smaller number of participants in Phase 2.

et al., 2016). This would not, however, explain why originality decreased and fluency increased. An explanation may lie in the constraining effect of acquired knowledge. Agogué, Poirel, Pineau, Houdé, and Cassotti (2014) demonstrated that age and training affect the proportions of answers proposed in different categories of solutions to a creative problem-solving task. It is possible therefore that 2 years later, knowledge gained by participants over that period increases the number of solutions that they generate, but restricts the originality of those solutions.

Relatively little research has examined developmental profiles of creative potential from mid-adolescence to early adulthood. Cross-sectional studies found no differences in fluency of verbal divergent thinking between children aged 10–12 and adults aged 19–22 (Wu, Cheng, Ip, & McBride-Chang, 2005) and four age groups from early adolescents aged 12–13 and adults aged 25–30 (Kleibeuker et al., 2013) although originality was higher in late adolescents and adults (aged 18–19 and 25–30) than in early and mid-adolescents (aged 12–13 and 14–15; Kleibeuker et al., 2013). Longitudinal research on adolescents aged 14–17 and emerging adults aged 18–21 found increases over 3 years in figural creative thinking (He, 2018). Taken together, the diversity of findings in this and previous studies points to the need to undertake more longitudinal research with these age groups, as well as new measures and scoring methods for such longitudinal research (Barbot et al., 2016).

There are a number of limitations to consider in relation to the present study. Attrition is a common problem in longitudinal research which can limit the generalisability of the results, as there may be differences between those who drop out and those who do not (Barbot, 2019). The findings of this study could therefore apply only to a subset of participants who were sufficiently interested in creativity and motivated to take part. However, the effects of attrition depend on the field and the parameters that are studied (e.g., Gustavson, von Soest, Karevold, & Røysamb, 2012; Pan & Zhan, 2020). Research examining attrition in longitudinal studies of cognitive performance found that although individuals who drop out tend to have lower levels of cognitive performance in some areas, these differences applied only to those aged 45 and older, and there were no differences in rates of change in cognitive performance between those who participated and those who did not (Salthouse, 2019). More research is needed to understand the effects of attrition in longitudinal creativity studies. Attrition may also result in small sample sizes (Barbot, 2019). We have therefore employed both frequentist and Bayesian approaches to ensure robust statistical analyses and have exercised caution in the interpretation of ensuing findings. The sample was also predominantly female. Research indicates that there are different developmental patterns for creative thinking in males and females from childhood to young adulthood (He, 2018) and for the personality trait openness to experience (Borghuis et al., 2017), and therefore, findings may differ in a sample with a more equal gender balance. The study also used a short-form measure of personality, which limits sensitivity in assessing the breadth of the trait of openness to experience (see Asquith et al., 2022a) and change in the trait over time. However, that there should be change in openness in the sample in this study is consistent with studies that have used more extensive personality scales, and which support a degree of individual differences in change in openness in adolescence, emerging adulthood, and later adulthood (e.g., Borghuis et al., 2017; Schwaba, Luhmann, Denissen, Chung, & Bleidorn, 2018).

The findings of this study suggest several avenues for future research. We found that openness and change in openness predicted change in verbal creative thinking abilities, but we did not test whether this is the case in the figural domain, or in older age groups. We also found that engagement in creative hobbies predicted change in creative thinking abilities 2 years later. As participants in this study engaged in a wide variety of activities, future research should examine whether the effects are associated with particular activity types. For example, an activity such as writing stories or music may have different effects compared to expressive activities such as playing a musical instrument. Another factor to consider is the extent to which instruction is important. Arts-based interventions that have enhanced creative thinking involve structured learning (novice—expert), but it is not clear whether and how creativity is enhanced through informal activities with friends (who might offer different approaches and perspectives) and through self-directed learning. Lastly, it would be interesting to know whether the effects of engagement in creative activities continue to be present in adult samples. Adolescents have been shown to benefit more from training in creative cognition, perhaps because they are at a developmental stage with greater sensitivity to learning and exploratory behavior (Stevenson, Kleibeuker, De Dreu, & Crone, 2014).

CONCLUSION

This study adopted a novel approach in examining individual and contextual factors associated with longitudinal changes in creative potential over a period of 2 years, in a sample of young people who were aged 14–20 at the beginning of the study. Although the sample was small, we have been cautious in interpreting the results only where supported by both the frequentist and Bayesian analyses. Change in peak originality after 2 years was predicted by levels of openness at the first time point as well as increases in openness over the same period. Change in fluency after 2 years was predicted by levels of engagement in creative hobbies at the first time point. The study reveals the importance of considering individual and contextual markers at the first time point, and change in those markers, in predicting change in creative potential. While the association of the personality trait openness to experience with creativity is well documented in the literature, the findings of the present study indicate that openness predicts the development of creative thinking abilities 2 years later. Finally, the findings suggest that engagement in creative hobbies is also associated with the continuing development of creative ideation. There is some evidence to suggest that activities such as increases in cultural engagement, for example, may increase trait openness (Schwaba et al., 2018). Encouraging young people to participate in cultural activities and engage in creative hobbies (and providing access and opportunities for the same) may therefore provide a relatively simple way to enhance creative thinking abilities.

FUNDING

The authors received no financial support for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS APPROVAL STATEMENT

The study received ethical approval from the Local Research Ethics Committee of the Psychology department at Leeds Beckett University.

DATA AVAILABILITY STATEMENT

The data sets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1. Ethnicity of the sample.
Table S2. Descriptive statistics of the creativity, personality and leisure variables in Phase 1 and Phase 2.
Table S3. Significant predictors of change in creative potential as indicated by simple regressions.
Table S4. Correlations between creative potential variables in Phase 1 and Phase 2.
Table S5. Correlations between openness and divergent thinking in Phase 1 and Phase 2.
Figure S1. Scatterplots of correlations between creative potential variables in Phase 1 (P1) and Phase 2 (P2).