Predictors of Creativity in Young People: Using Frequentist and Bayesian Approaches in Estimating the Importance of Individual and Contextual Factors

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Abstract

The development of creativity in young children has been studied extensively, but relatively few studies have examined the period of adolescence and emerging adulthood in relation to creative potential. The present study employs a combination of frequentist and Bayesian analyses to evaluate the impact of individual factors (e.g., IQ) and contextual factors (e.g., pursuit of creative hobbies) on creative ideation in three cohorts of young people aged 14-20 years. Measures of divergent thinking, specifically the Alternate Uses Task (AUT) and the Overcoming Knowledge Constraints Task, were used to this end. Openness to aesthetic and imaginative experience was the strongest predictor of creative potential for the three AUT measures. Moreover, Bayesian hypothesis testing revealed that the best predictive model for AUT ideational fluency and AUT overall originality was one that included only Openness, whereas the best predictive model for AUT peak originality, or the propensity to generate highly original responses, included Openness, as well as IQ and Engagement in Creative Hobbies. No group differences in creative potential were found between the three age cohorts (aged 14-15, 16-17, and 18-20). The study not only confirms the importance of openness to aesthetic and imaginative experience as a predictor of creative potential in adolescents and young adults, but also indicates the necessity to consider the combined and differentiated impact of individual and contextual factors in different facets of creative ideation.

Keywords: creative potential, personality, intelligence, creative hobbies, adolescents and young adults

Predictors of Creativity in Young People: Using Frequentist and Bayesian Approaches in Estimating the Importance of Individual and Contextual Factors

The development of creativity in the form of creative potential has been studied extensively in young children (Runco & Albert, 1986; G. J. W. Smith & Carlsson, 1983; Torrance, 1968), but fewer studies have examined it in adolescents and young adults. Models of creativity have proposed that this ability arises from the interaction of a number of different factors including intelligence, personality, executive functions, motivation, and the environment (e.g., Amabile, 1996; Barbot, Lubart, & Besançon, 2016; Sternberg & Lubart, 1992). However, complex interactions between two of more of these factors have been examined in relatively few studies (Davis, Kaufman, & McClure, 2011; Deng, Wang, & Zhao, 2016; Nusbaum & Silvia, 2011). The current study examines creative potential in young people aged between 14 and 20 and the impact of specific individual and contextual factors associated with it. Tasks of divergent thinking, or the ability to generate multiple responses to an open-ended problem (Runco & Acar, 2012), were used to this end.

The Development of Creativity

The standard definition of creativity comprises two key aspects: novelty or originality, and usefulness or appropriateness (Runco & Jaeger, 2012). Divergent thinking is an aspect of creative cognition that has been widely studied (Reiter-Palmon, Forthmann, & Barbot, 2019), and involves the generation of multiple solutions to a given problem or stimulus (Guilford, 1967). As such it is a measure of idea generation which is a critical component of creativity (Reiter-Palmon et al., 2019) and is predictive of creative achievement (Guilford, 1966; Kim, 2008; Plucker, 1999). Divergent thinking tasks may be used with young and older participants (McCrae, Arenberg, & Costa, 1987; Torrance, 1968), and are commonly scored on dimensions of fluency, or the quantity of ideas generated, flexibility, or the number of different categories of responses, and originality, or the uncommonness of the responses (Guilford, 1967; Reiter-Palmon et al., 2019).

The development of creativity occurs across the life span and may be expressed in different forms at different stages of life. Patterns of growth, stability and decline are non-linear and depend on the type of creativity that is being examined (Hui, He & Wong, 2019). Creative potential measured through standardised tests develops through childhood to maturity in adulthood (McCrae et al., 1987; Torrance, 1968) but does not follow a simple linear trajectory. Torrance (1968) identified slumps on entry into school, 4th grade, and 6th/ 7th grade, and others have found dips and peaks in adolescence (see Barbot et al., 2016, for a review). A number of factors have been associated with these 'slumps and bumps'. These include cognitive and biological changes, such as the stages of cognitive development, and the development of the prefrontal cortex as well as social and environmental factors, such as the need for acceptance in the peer group, and pedagogical approach (Barbot et al., 2016; Besançon & Lubart, 2008; Gralewski, Lebuda, Gajda, Jankowska, & Wiśniewska, 2016; He & Wong, 2015). Although many studies have examined the development of creativity in children from entry into school through to mid-adolescence, relatively few have examined it in young people in the periods of adolescence and emerging adulthood. Gralewski et al. (2016) studied creative potential in children and young people (4-21 years of age) and found significant decreases in creativity from age 15 to 17 before rising again. They related the dip in creativity to the maturation-based changes in the brain as well as to the development of identity at this age (Erikson, 1968) and the need to adjust to social norms, which may have a dampening effect on originality. Jastrzębska and Limont (2017) found that creative potential increased in students from ages 7 to 18, but that there were plateaus and mini-plateaus as well as drops. For instance, a drop in the scores of 16-year olds coincided with the transition to secondary school. Kleibeuker, De Dreu, and Crone (2013) examined creativity in four groups of adolescents and young adults, aged 12-13, 15-16, 18-19, and 25-30. With regard to divergent thinking, there were no group differences in fluency and flexibility, but originality was shown to increase with age. Creative potential seems therefore generally to increase over the period of adolescence through to adulthood but with sporadic temporary declines, which vary according to the type of task and the aspect of creativity that is being measured.

Predictors of Creativity: Individual Factors

A large body of research has investigated personality factors that are predictive of creativity and the most consistent finding to date is that ‘openness to experience’ is the most relevant trait in this regard. Openness to experience reflects imagination, aesthetic sensitivity, attentiveness to emotional states, intellectual curiosity, and interest in new experiences and questioning conventional values (Costa & McCrae, 1985). It is a highly reliable positive predictor of creativity, whether measured by creative potential, creative achievement, self-ratings or external ratings (Puryear, Kettler, & Rinn, 2017). Although openness has been consistently associated with higher creativity, its importance may vary by domain, being more strongly related to creativity in the arts, than the sciences (de Manzano & Ullén, 2018; Feist, 1998; Hong, Peng, & O'Neil, 2014). When the two aspects of openness to experience are considered, ‘openness’, or engagement with aesthetics, perception and fantasy, and ‘intellect’, or engagement with abstract and semantic information, the former predicts achievement in the arts, whereas the latter predicts achievement in the sciences (Kaufman et al., 2016). The focus in the present study is limited to openness to aesthetic and imaginative experience.

The degree to which creativity and intelligence are related has been the subject of much study. Threshold theory (Guilford, 1967) holds that intelligence is necessary, but not sufficient, for creativity, such that creativity and intelligence are related only up to a certain point, suggested to be an IQ of 120, and beyond that, it is possible to be highly intelligent, without being highly creative. Kim's (2005) meta-analysis indicated a small positive relationship (r = .17) between creativity and intelligence, but no evidence in support of the threshold hypothesis. In contrast, more recent studies have adopted different methodological approaches to studying the relationship and have found evidence to support the existence of a threshold (Jauk, Benedek, Dunst, & Neubauer, 2013; Karwowski et al., 2016). For instance, using segmented regression analysis, Jauk et al. (2013) found that the IQ threshold differed depending on the divergent thinking measure in question, such that there was a low threshold (IQ score of 85) for creative potential as measured by fluency in a divergent thinking task, but higher thresholds (IQ scores of 102 and 120) for originality as measured by the top 2 ideas, or by many original ideas. It has also been suggested that the correlations between creativity and intelligence may be larger than found in Kim's (2005) meta-analysis, depending on the way in which creative potential is scored, and the statistical modelling approach (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014; Jauk, Benedek, & Neubauer, 2014; Silvia, 2008b). Overall, the literature indicates that there is a positive relationship between creativity and intelligence, but the size of the correlation and the extent to which thresholds apply varies depending on the creativity measure, the scoring method and statistical approach, and the sample under study.

The conditional threshold hypothesis (Harris, Williamson & Carter, 2019) offers a new perspective on the relationship between creativity and intelligence. It proposes that the relationship between creative achievement and intelligence is moderated by other variables such as individual differences or environmental factors. In contrast to the classic threshold hypothesis (Guilford, 1967), the conditional threshold hypothesis proposes an inverted relationship, such that above the threshold, the relationship between creative achievement and intelligence is stronger in people with high levels of these factors. Specifically, Harris et al.'s study (2019) found that the relationship between creative achievement and intelligence was stronger in people with high levels of openness compared to moderate or low levels, and that for this group, the strength of the relationship increased at higher levels of intelligence. Furthermore, in line with Kaufman et al.'s study (2016), the two aspects of openness, aesthetic openness and intellect, were differentially related to domain-specific achievement, such that achievement in the arts required high levels of aesthetic openness, and in the sciences, high levels of intellect.

Executive functions is a term used to describe a set of mental processes that include working memory, cognitive flexibility, and inhibitory control (Diamond, 2013). Working memory is the ability to maintain, update and manipulate information in one's mind in service of a goal. Cognitive flexibility reflects the ability to switch to new tasks or rule sets and to consider new perspectives. Inhibitory control is the ability to suppress unwanted thoughts or responses and focus one's attention, emotions, thoughts and behaviour. The complex relation between executive functions and creative potential is one that is receiving increasingly more focus. Studies of the relationship between divergent thinking and working memory have found mixed results (Benedek et al., 2014; Smeekens & Kane, 2016). Studies that have examined creative thinking more broadly have suggested mechanisms by which working memory and creativity are related: by directly allowing for persistence and focused attention (De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012) or indirectly through intelligence and associative fluency (Lee & Therriault, 2013).

The relationship between creativity and inhibitory control is also a complex one. Carson, Peterson, and Higgins (2003) found that greater creativity in terms of high originality scores in a divergent thinking task and high scores on the creative achievement task were associated with lower levels of latent inhibition, which is the ability "to screen from current attentional focus stimuli previously experienced as irrelevant" (p. 499). In contrast, Benedek, Franz, Heene, and Neubauer (2012) found a positive correlation between inhibition and self-report measures of creativity, as well as ideational fluency and flexibility in a divergent thinking task. The literature therefore suggests that creativity is associated with both lower and higher inhibitory control. One way to accommodate both these perspectives is to consider that creative people are able to focus or defocus their attention as required by the task (Zabelina & Ganis, 2018; Zabelina & Robinson, 2010). Others have suggested (Abraham, 2014a, 2014b; Carson, 2011) that the relationship between creativity and inhibition may take the form of an inverted-U function in which a mild disruption of inhibition may enhance creativity, but severe dysfunction is associated with poor creative performance.

Predictors of Creativity: Contextual Factors

Many theoretical models recognise that creativity is affected not only by individual factors but also by factors within the environment, which may provide motivation, stimulation, evaluation, and resources (Amabile, 1996; Sternberg & Lubart, 1996). Environmental or contextual factors that have been shown to affect creativity include working environment and organisational climate, culture, family environment, socio-economic status, and school environment (Besançon & Lubart, 2008; Deng et al., 2016; Hunter, Bedell, & Mumford, 2007; Ma, 2009; Niu, 2007). Adolescents and emerging adults become increasingly independent with age in terms of how they spend their free time and may choose to engage in a range of activities including hobbies, sports and physical activity, socialising with friends, and so on. Choice of leisure activities has been investigated in relation to a range of outcomes including academic achievement, socio-emotional outcomes, and wellbeing (Bartko & Eccles, 2003; Feldman & Matjasko, 2005; Goldstein, 2011). Extracurricular activities, including membership of arts and academic clubs is associated with creativity in college students (Cotter, Pretz, & Kaufman, 2016), and what young people choose to do out of school may display more creativity than what they do in school (Runco, Acar, & Cayirdag, 2017). It may therefore be informative to investigate young people's choice of leisure activities and its relationship with creative potential.

The Current Study

The aim of the current study was to explore the predictors of creativity in young people, aged 14-20, in secondary school and the first year of university. The study focuses on creative potential, as the participants are young, and have had limited opportunities for creative achievement. Two creativity tasks which varied in relation to the types of creative cognitive operations being engaged were included (see Abraham & Windmann, 2007; Abraham, 2014b) thereby allowing for a broader assessment of creative potential. The predictors included both individual differences, specifically intelligence and personality, and contextual factors in the form of leisure activities. Intelligence, openness to aesthetic and imaginative experience, working memory, inhibitory control and engagement in creative hobbies were expected to positively predict creative potential. The approach is similar to other studies in the field which have sought to examine the relative influence of different variables on creativity (e.g. Batey, Chamorro-Premuzic & Furnham, 2007; Davis et al., 2011; Furnham, 2015). A combination of frequentist and Bayesian approaches were employed in the data analyses.

Method

Participants

Participants were recruited in three cohorts (aged 14-15, 16-17, and 18-20), (N = 409, male = 80, female = 328, non-binary = 1). Participants in cohort 1 (M_{age} = 14.91, SD = 0.32) and cohort 2 (M_{age} = 16.91, SD = 0.41) were recruited from secondary schools and colleges in West and North Yorkshire, UK. All schools and colleges in five towns and cities in the region were contacted to recruit participants for the two youngest age groups, and 11 institutions out of 132 agreed to take part (seven for cohort 1 and the same seven and a further four schools and colleges for cohort 2). The schools were offered a workshop for their students on creativity, research methods, or applying to study at university, in return for their involvement. Cohort 3 (M_{age} = 19.00, SD = 0.59) was recruited from first year university students at the lead author's institution. The sample was predominantly female (80%). This was largely due to gender bias in students of Psychology: in cohort 3 the majority were Psychology undergraduates, and in cohorts 1 and 2, it was typically Psychology teachers who responded and arranged for their Psychology classes to take part (two out of seven schools in cohort 1, and ten out of 11 schools and colleges in cohort 2). In addition, two of the schools that responded were single sex girls' schools. Participants had the opportunity to enter a prize draw for cinema vouchers, and university students on the Psychology undergraduate degree could opt for course credit. The sociodemographic information associated with the samples is presented in Table S1 and the findings in relation to the same are presented in the supplemental material.

Materials

Creativity task 1. The Alternate Uses Task (AUT) (Guilford, Christensen, Merrifield, & Wilson, 1960) requires participants to generate many different uses for a common object. Participants were given two minutes per item to think of uses for three items (newspaper, shoe, and paperclip) and were instructed to think of uses which were different from their customary use. The responses for all age groups were scored together and three dependent measures were derived from the responses. *Fluency* was calculated as the average number of valid responses generated across the three items. *Overall originality* was calculated based on the relative frequency of the uses across participants (Abraham, Asquith, Ahmed, & Bourisly, 2019; Runco, Okuda, & Thurston, 1987). For example, if a use is given by 45 participants out of 409, the relative frequency is 0.11. The relative frequency of each participant's uses was totalled and divided by the fluency score to give an average relative frequency, and this was subtracted from 1 so that a high score relates to high originality. The scores were averaged across the three items. The data for cohorts 1 and 2 was highly skewed (*z*-score = -10.61 and -18.44 respectively), and so the data was transformed for all three cohorts, using a reverse inverse approach, overall originality = 1 / (1- average originality index). *Peak originality* was calculated as the number of responses given by the participant that were generated by 10% or less of the participants in the sample (Abraham et al., 2019).

Creativity task 2. The overcoming knowledge constraints task (OKC) requires participants to come up with a new idea for a toy and to draw it (Abraham & Windmann, 2007; S. M. Smith, Ward, & Schumacher, 1993). Before they do so, they are shown three examples of novel toys invented by others, each of which contains three common elements, a ball, the use of electronics, and the need for physical exertion. The toys are scored based on how many of these three elements they contain, and possible scores range from 0 to 3. For ease of interpretation the scores were reversed so that a higher score (OKC raw score) means a greater ability to inhibit the task-relevant information in the form of the presented examples (Abraham, 2014b). Relatively few participants (29/390) achieved a score of 3, so the OKC raw score was recoded into a binary variable, OKC (scores of 0 and 1 = 0, scores of 2 and 3 = 1).

Personality. A ten-item version of the Big Five Inventory (John, Donahue, & Kentle, 1991) was used (BFI-10; Rammstedt & John, 2007) to reduce testing demands on the young participants. There are two items for each trait (e.g., 'I see myself as someone who… is outgoing, sociable'). Participants respond on a 5-point scale (1 = *disagree strongly*, 5 = *agree strongly*), resulting in scores of 2-10 for extraversion, agreeableness, conscientiousness, neuroticism and openness. Scores from the BFI-10 have been shown to have acceptable correlations with the BFI and acceptable test-retest reliability (Rammstedt & John, 2007). The wording of one of the two items for openness '…has few artistic interests' was changed to 'has lots of artistic interests' as the negative phrasing may have been difficult to understand within young samples in relation to the response scale. The wording of the other item for openness was 'has an active imagination'. Cronbach's alpha for openness was .61, which is acceptable for a two-item scale (Brailovskaia & Margraf, 2018; Götz, Ebert, & Rentfrow, 2018; Whaite, Shensa, Sidani, Colditz, & Primack, 2018). In taking a 2-item scale, we assess only the aesthetic and imaginative aspects of openness to experience.

Intelligence. A nine-item short form of Raven's Standard Progressive Matrices (SPM; Raven, Court, & Raven, 1995) was used (Bilker et al., 2012) to reduce testing demands on the young participants. The short form was developed to reduce administration time while providing good psychometric properties and correlations to the 60-item form equal to other abbreviated forms (Bilker et al., 2012). The obtained score was translated into an IQ score using the table developed by Jensen, Saccuzzo, and Larson (1988).

Executive functions. Two tasks were used, one to assess working memory (the digit span task from the WAIS; Wechsler, 2010) and one to assess response inhibition (the Hayling Sentence Completion Test) (Burgess & Shallice, 1997). The digit span task has three parts, which ask the participants to respond putting a sequence of digits into a specified order; forwards, i.e. in the order in which they were read out, which measures short term memory capacity; backwards, i.e. reversing the order in which they were read out, which measures working memory; and in sequence, i.e. reordering them into the correct numerical sequence, which measures the ability to manipulate information in working memory. Participants in cohorts 1 and 2 were asked to complete the forwards and backwards tasks, and participants in cohort 3 completed all three. The *longest digit span forwards* (LDSF) and the *longest digit* *span backwards* (LDSB) were calculated for all cohorts. The *longest digit span sequence* (LDSS) was calculated for cohort 3. The mean scores were higher than the UK norms for the LDSB scores, (Wechsler, 2010) which suggests that written rather than verbal responses may give some advantage (see supplemental material for cohort-specific information).

The Hayling Sentence Completion Test (Burgess & Shallice, 1997) is a response suppression test that has two parts, both containing 15 items. The first part is a sensible sentence completion task, in which participants must complete an incomplete sentence (e.g., The old house will be torn __.) with a word that fits (e.g., down). The second part is an unconnected sentence completion task, in which participants must complete the incomplete sentence with a word that is completely semantically unconnected (e.g., banana). The responses to part 2 were scored in line with the guidance (Burgess & Shallice, 1997) as falling within one of three categories: a correct response, when the word was completely unrelated to the sentence; a *category A error,* when the word completed the sentence in a sensible way (e.g. 'the dough was put in the hot *oven');* and a *category B error,* when the word was connected to the meaning of the sentence in some way (e.g. 'the dough was put in the hot *sink').* The number of category A and B errors was summed and the raw score was then translated to a scaled score (1-8, where 8 = *good* (no errors), and 1 = *impaired*). A very high percentage of the participants, 97.7%, achieved scores of 6-8, with 58% achieving the maximum score of 8. Owing to these ceiling effects, this error measure was not included in the data analyses.

Leisure Questionnaire. This questionnaire (included in supplemental material) was developed by the research team to find out how participants spent their spare time. 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). Participants were asked about four main areas: creative hobbies and interests, sports and physical activity, socialising, and relaxing. Participants were asked to indicate how often over the last month they had done each activity: from never, less than once a week, 1-2 days a week, 3-4 days a week, 5-6 days a week to every day. A score for engagement in creative hobbies was calculated based on the number of creative hobbies ticked by the participants, and how often they engaged in those hobbies (less than once a week = 0.5, 1-2 days a week = 1.5, 3-4 days a week = 3.5, 5-6 days a week = 5.5 and every day = 7). A score for engagement in sports and physical activity was calculated in the same way.

Procedure

Participants took part within group sessions in schools and colleges or at the university, between October 2016 and March 2017. Permission for the study was granted by the Local Research Ethics Committee at the lead author's institution. For the first two age groups, information sheets were provided both for the students, and for their parents or carers, so that they could discuss participating in the study, and were distributed by the teachers of each participating class a few days before the planned sessions. In cohort 1, as the participants were under 16 years old, parental consent was obtained and students gave their own assent in the data collection session. Participants in cohorts 2 and 3 were over 16 and gave their own informed consent. Most of the sessions for cohorts 1 and 2 took place during normal lesson time, and a few took place before lessons started, or at lunchtime. Cohort 3 participated in sessions outside their timetabled lectures and seminars.

All students were given a booklet in which to record their responses. The researcher gave the students the instructions for each task using PowerPoint slides and a standard script. All the stimuli, such as the SPM problems and the incomplete sentences, were included in the response booklets, apart from the three examples for the drawing task (which were presented on the slides) and the number sequences for the digit span task (which the researcher read aloud). The testing session was 1- 1¼ hours in duration. Due to timetabling constraints, it was not possible to have all students complete all of the tasks (Table 1 shows the sample size for each task). Students first provided some demographic information, and then their current studies and/or past school results, the wellbeing measures, the creativity measures, the SPM short form, the BFI-10, the Hayling Sentence Completion Task, the digit span task, and the leisure questionnaire[i]. Participants who had not been studying at an English-speaking school for five years or more were excluded from the sample. This was to ensure adequate language proficiency to be able to carry out the tasks and accurately understand task instructions.

Data was collected from 437 participants. Fifteen participants were excluded from cohort 2 as they were older than 18, so that cohort 2 and cohort 3 did not overlap in age. A further 10 participants were excluded as their SPM scores were below the range that could be translated to IQ using Jensen et al.'s (1988) table (cohort 1= 6, cohort 2=3, cohort 3=1), and a further 3 were excluded as they generated an average of less than one response for each item in the AUT (cohort 1=2, cohort 3=1). The final sample consisted of 409 participants (cohort 1 = 134, cohort 2 = 204, cohort 3 = 71). See Table 1 for the descriptive statistics of the variables.

Approach to statistical analysis

Data analysis was carried out using IBM SPSS Statistics version 24, and the JASP software version 0.8.6.0 (JASP Team, 2018). Interpretation of *p*-values within a traditional frequentist framework does not allow researchers to determine the relative strength of the evidence for a null or alternate hypothesis, or whether a non-significant *p* value represents a null effect or insensitive data (Kruschke & Liddell, 2018; Lakens, McLatchie, Isager, Scheel, & Dienes, 2018; Quintana & Williams, 2018). Bayesian hypothesis testing offers a useful

Table 1

Summary of sample sizes, means and SDs of the creativity variables, individual differences and contextual factors, and wellbeing variables

Variable	Whole dataset			Cohort 1 (age: 14-15)			Cohort 2 (age: 16-17)			Cohort 3 (age: 18-20)		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
AUT Fluency	407	4.36	1.67	132	4.09	1.73	204	4.43	1.71	71	4.64	1.36
AUT Overall originality	407	6.42	2.08	132	6.55	2.40	204	6.21	1.88	71	6.79	1.94
AUT Peak originality	407	6.01	3.64	132	5.86	3.71	204	5.89	3.64	71	6.65	3.51
OKC	390	1.23	0.95	129	1.26	0.97	195	1.31	0.92	66	0.97	0.96
Openness	409	6.56	2.07	134	6.75	1.91	204	6.44	2.23	71	6.51	1.89
IQ	381	105.48	7.88	114	104.37	8.33	196	105.76	7.62	71	106.48	7.75
LDSF	344	6.88	1.34	79	7.03	1.44	196	6.79	1.27	69	6.99	1.40
LDSB	267	6.22	1.47	34	6.76	1.30	167	6.08	1.53	66	6.30	1.34
LDSS	-	-	-	-	-	-	-	-	-	68	6.24	1.27
Creative hobbies	281	5.74	6.51	60	7.38	7.97	150	5.87	6.34	71	4.08	5.03

alternative, particularly when it comes to interpreting the relative support for a null model against an alternative model (Lakens et al., 2018; Quintana & Williams, 2018). The JASP software package (JASP Team, 2018) offers Bayesian alternatives to many of the most commonly used inferential tests. In this results section, we have compared the results of the frequentist statistical test with the Bayesian alternative, when there was a Bayesian alternative available within JASP.

The data were analysed using linear regression, logistic regression, and ANOVA. For the regressions, we have compared the frequentist models to the Bayesian regression analysis which presents the results of all possible combinations of the covariates. For the Bayesian regression models, we used a Jeffreys-Zellner-Siow prior with a r scale of 0.354. For the comparisons between the age groups, frequentist and Bayesian ANOVAs were used to compare the creative potential and predictor variables across the cohorts. The Bayesian ANOVA used the JASP default r scale fixed effects prior width of 0.5 for the prior distribution. We selected a Bayes factor threshold of 3 (and its inverse), as this closely corresponds to a *p* value of .05 (Wetzels et al., 2011). A Bayes factor of 3 suggests that an alternative model is 3 times more favoured than a null model, given the data[ii].

The analysis reported in this paper was run for all ages 14-20 years. Analysis by each age cohort separately is reported in the supplemental materials in Tables S5-7. [iii]

Results

The aim of the study was to explore the predictors of creative potential in young people aged 14-20. It included both individual factors, specifically intelligence, personality and executive functions, and contextual factors, specifically leisure activities such as engagement in creative hobbies, and sports. The results of the whole cohort analysis are presented in the first section. The second section explores whether creative potential varied across the three age groups included in the study.

Predictors of creativity in young people

In order to identify predictors for the multiple regressions, simple linear regressions were run for each of the predictor variables and outcome variables, and *p*-values were adjusted to correct for multiple tests using a Bonferroni correction (see Table 2 for a summary). Based on the results, two significant predictors were identified: openness to aesthetic and imaginative experience (individual factor; hereafter referred to as openness) and engagement in creative hobbies (contextual factor). A third predictor, IQ (individual factor), was not significant after adjusting for multiple tests, but was retained because much previous research has supported a positive relationship between creativity and intelligence, although effect sizes have varied depending on the statistical and scoring methods (Benedek et al., 2014; Jauk et al., 2014; Silvia, 2008a, 2008b). Multiple regressions were run to examine the effect of these predictors on creative potential (see Table 3 for a summary of the frequentist multiple regressions and Table 4 for a summary of the Bayesian multiple regressions).

To summarise the results of the frequentist analysis, all the predictor variables had an influence on divergent thinking scores, but to a different extent for different outcome variables (see Table 3). The analysis showed that openness predicted creative potential when measured by fluency and overall originality, and most strongly when measured by peak originality (or the propensity to generate highly unusual responses), but only at the level of a trend for OKC. Moreover, IQ and creative hobbies contributed to the prediction of peak originality.

Table 2

Summary of Simple Regressions to Identify Predictors of Creativity Variables, p values

Variable	Fluency	Originality	Peak Originality	OKC
Openness	.000[a]	.000[a]	.000[a]	.004[a]
IQ	.165	.393	.012	.766
LDSF	.918	.655	.550	.440
LDSB	.149	.936	.684	.629
Creative hobbies	.002[a]	.190	.000[a]	.287
Sports	.107	.637	.225	.653

Note: *p* values are uncorrected. [a] indicates *p* values that remain significant following correction for multiple tests.

Results from the Bayesian analysis allow us to examine the effect of these predictors further. Bayesian regression analysis in JASP shows the regression models with all possible combinations of the predictors. The results presented in Table 4 show that multiple models are noteworthy predictors of the three AUT variables [iv]. For overall originality, the only noteworthy predictor was openness. For fluency and peak originality, multiple models involving both individual and contextual variables were good predictors of these aspects of creative potential. For fluency, the strongest model was that which included only openness as a predictor, whereas for peak originality, the strongest model was one which included all three predictors, openness, IQ, and creative hobbies.

Differences between the Age Cohorts in Creativity and its Predictors

Looking first at the measures of creative potential, there were no differences between the cohorts in overall originality or peak originality, and this was supported by both the

Table 3

Summary of the Frequentist Multiple Regressions Predicting Creativity from Openness, IQ, and Engagement in Creative Hobbies

	Fluency		Overall Originality		Peak Originality		OKC	
Predictor	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Openness	0.19***	[0.09, 0.29]	0.15*	[0.02, 0.28]	0.39**	[0.17, 0.61]	1.14†	[1.00, 1.30]
IQ	0.01	[-0.02, 0.03]	0.02	[-0.01, 0.05]	0.06*	[0.00, 0.11]	.99	[0.96, 1.02]
Creative hobbies	0.02	[-0.01, 0.06]	0.01	[-0.03, 0.05]	0.08*	[0.01, 0.15]	1.00	[0.96, 1.05]
R^2	.09		.03		.11		.03	
F	8.93		3.02		10.98			
p	< .001		.030		< .001		.165	

Note: The table reports the results of linear regressions for fluency, overall originality and peak originality, N = 271. For OKC the results of logistic regression are reported with Nagelkerke's R^2, $N = 262$, $\chi^2 = 5.10$.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 4

Summary of the Bayesian Multiple Regressions Predicting Creative Potential from Openness, IQ, and Engagement in Creative Hobbies

Fluency			Overall Originality			Peak Originality		
Model predictors	BF_{10}	R^2	Model predictors	BF_{10}	R^2	Model predictors	BF_{10}	R^2
Null model	1.00	.00	Null model	1.00	.00	Null model	1.00	.00
Openness	8575.61	.08	Openness	4.85	.03	Openness + IQ + Creative hobbies	13513.90	.11
Openness + Creative hobbies	3845.16	.09	Openness + IQ	1.62	.03	Openness + Creative hobbies	9901.73	.10
Openness + IQ	1733.28	.08	Openness + Creative hobbies	1.00	.03	Openness	8406.81	.08
Openness + IQ + Creative hobbies	1000.70	.09	Openness + IQ + Creative hobbies	0.42	.03	Openness + IQ	7982.03	.10
Creative hobbies	15.04	.04	Creative hobbies	0.37	.01	IQ + Creative hobbies	233.52	.07
IQ + Creative hobbies	5.37	.04	IQ	0.34	.01	Creative hobbies	83.09	.05
IQ	0.26	.01	IQ + Creative hobbies	0.18	.02	IQ	2.02	.02

Table 5

Differences between the three cohorts for creative potential and predictor variables using null hypothesis significant testing (NHST) and Bayesian analyses

Variable	NHST	Bayes Factors (BF_{10})	
Average fluency	Non-significant ($F(2, 404) = 2.92$, $p = .055$)	0.44	Anecdotal support for the null hypothesis
Overall originality	Non-significant ($F(2, 180.67) = 2.69$, $p = .070$)*	0.28	Moderate support for the null hypothesis
Peak originality	Non-significant ($F(2, 404) = 1.31$, $p = .270$)	0.10	Moderate support for the null hypothesis
Raw OKC	**Significant ($F(2, 387) = 3.22$, $p = .041$)**	0.58	Anecdotal support for the null hypothesis
Openness	Non-significant ($F(2, 195.44) = 1.00$, $p = .370$)*	0.07	Strong support for the null hypothesis
IQ	Non-significant ($F(2, 378) = 1.84$, $p = .161$)	0.17	Moderate support for the null hypothesis
LDSF	Non-significant ($F(2, 341) = 1.12$, $p = .329$)	0.10	Moderate support for the null hypothesis
LDSB	**Significant ($F(2, 264) = 3.21$, $p = .042$)**	0.83	Anecdotal support for the null hypothesis
Creative hobbies	**Significant ($F(2, 278) = 4.35$, $p = .014$)**	1.91	**Anecdotal support for the alternate hypothesis**

Note: * Welch's *F*.

frequentist and Bayesian analysis (all $p > .05$, $BF_{10} < 0.33$, see Table 5). For fluency, there was no support for cohort-based differences as the frequentist analysis suggested that there was no significant difference between the cohorts ($p = .055$) and the results of the Bayesian analysis provided anecdotal support for the null hypothesis ($BF_{10} = 0.44$). A comparison of raw OKC scores across the cohorts produced mixed results and was inconclusive: the frequentist analysis indicated that there was a significant difference between the cohorts (F (2, 387) = 3.22, $p = .041$)[v] but the results of the Bayesian analysis provided anecdotal support for the null hypothesis ($BF_{10} = 0.58$). In summary, the three cohorts were not found to be consistently and significantly different in any aspect of creative ideation.

Looking next at the individual predictors of creative potential, there were no differences between the cohorts in openness, IQ and longest digit span forwards score (LDSF) which measured short term memory, and this was supported by both the frequentist and Bayesian analysis (all $p > .05$, $BF_{10} < 0.33$, see Table 5). The evidence was inconclusive as to whether there was a difference in longest digit span backwards (LDSB) scores, a measure of working memory, between the cohorts: it was supported by the frequentist analysis ($p = .042$)[vi], but the Bayes factor was inconclusive, as it was close to 1 ($BF_{10} = 0.83$). Looking at the contextual predictor, engagement in creative hobbies, the finding that participation declined with age was significantly supported by the frequentist analysis ($p = .014$)[vii], and there was a significant linear trend (F (1, 278) = 8.68, $p = .003$, $\eta^2 = .03$) which indicated that engagement in creative hobbies declined across the age groups, but there was only anecdotal evidence for the same from the Bayesian analysis ($BF_{10} = 1.91$). To summarise, there were no differences between the cohorts in openness, IQ, and the digit span scores, but engagement in creative hobbies declined across the cohorts (see Figure 1).

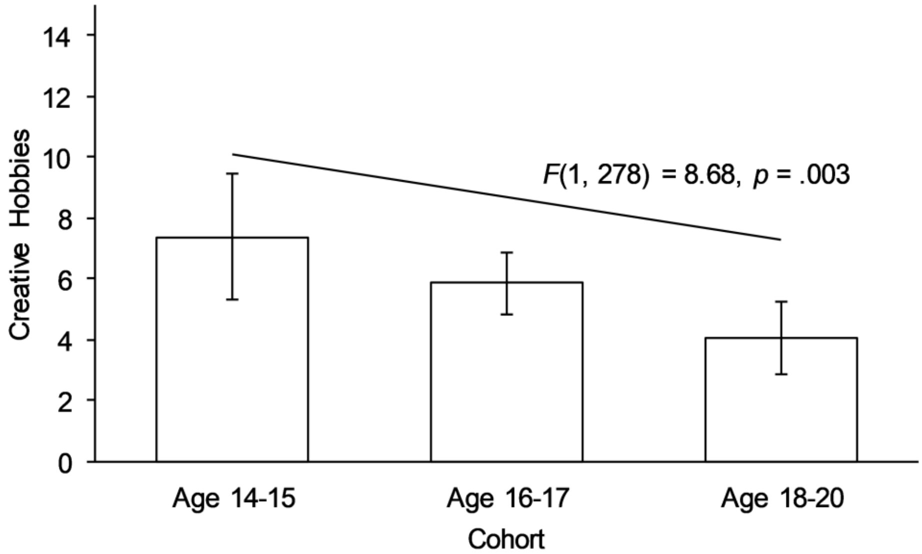

Figure 1: Mean weekly engagement in creative hobbies by cohort (number of days per week). Error bars represent the 95% confidence interval.

Discussion

This study examined predictors of creativity, specifically personality traits in the form of openness to aesthetic and imaginative experience and contextual factors in the form of engagement in creative hobbies, in young people aged 14-20. To summarise the results of the regression analysis, openness consistently predicted creative potential as measured by fluency, overall originality and peak originality. The role of openness in predicting such aspects of divergent thinking is in line with the results from several other studies on adult populations (Jauk et al., 2014; McCrae, 1987; Puryear et al., 2017). Only a few studies have examined the same in populations below university age (Niu, 2007; Shi, Dao & Lu, 2016). McCrae (1987) proposed three possible explanations for the relationship between openness and divergent thinking: first, that people high in openness may be more engaged by divergent thinking tasks; second, that they may develop divergent thinking skills through practice, and third, that divergent thinking may facilitate interests in varied experience.

The present findings add to the debate on the association between intelligence and creative potential. IQ did not predict fluency or overall originality, but the Bayesian regressions suggested that it did notably contribute to the prediction of peak originality, or the generation of highly original responses. This contrasts with other research that found a relationship between intelligence and fluency and originality (Furnham, 2015; Kandler et al., 2016; Karwowski et al., 2016) but is in line with the findings of Jauk et al.'s (2013) study which found a relationship between intelligence and creative potential, when specifically taking into consideration the number of creative ideas that were generated. Jauk et al.'s study also found a threshold IQ score of 120 for this relationship and a lower threshold of 85 for the relationship between intelligence and fluency. The present study employed a short form SPM and translated the results to IQ scores (Jensen et al., 1988), which limited IQ scores to a range from 85 to 117. This may explain why IQ did not predict fluency in this study as other studies that have found that intelligence predicted divergent thinking scores have used full form tests of IQ (Furnham, 2015; Runco & Albert, 1986; Silvia, 2008a).

In our study, we did not investigate an interaction between openness and intelligence, but recent research suggests a role for the interaction in predicting creative achievement, such that the relationship between intelligence and creative achievement is stronger in those who are higher in openness (Harris et al., 2019). Although that study only investigated creative achievement, the authors suggested that their conditional threshold hypothesis may also apply to measures of creative potential, which would be an interesting question for future research.

There was also support for engagement in creative hobbies as a predictor of one of the measures of creative potential, peak originality. The effect of engagement in creative hobbies on creative potential has not been studied extensively. Cotter et al. (2016) studied the relationship between extracurricular activities and creativity in college students and found that involvement in arts clubs did not predict divergent thinking although it did predict some forms of creativity, such as caption and performance creativity. There is some overlap between the creative hobbies included in the leisure questionnaire and the way in which everyday creativity and creative activity has been measured in adult samples. A positive relationship has been found between openness and creative activity (Jauk et al., 2014; Wolfradt & Pretz, 2001) as well as between openness and everyday creative engagement (Conner & Silvia, 2015; Silvia et al., 2014). Engagement in creative hobbies in this study was also positively correlated with openness (see Table S8 in the supplemental material). This may explain why creative hobbies were not a stronger predictor of creative potential in addition to openness.

To sum up, the influence of the individual and contextual predictors differed for the various measures of creative potential. Openness was the most consistent predictor, but there was also support for intelligence and engagement in creative hobbies as noteworthy additional predictors of peak originality (or the generation of highly original responses) in particular. It should be noted that the BFI-10 (Rammstedt & John, 2007) contains only two items for the two aspects of the personality trait of openness. The item '…has lots of artistic interests' captures the 'openness' aspect of openness to experience, which reflects engagement with aesthetics, perception and fantasy. The item '…has an active imagination' correlates almost equally with both the 'openness' aspect, and the 'intellect' aspect of engagement with abstract and semantic information (DeYoung, Quilty & Peterson, 2007). Openness to experience as operationalised in this study may therefore be considered to focus on the aesthetic and imaginative aspects and underrepresent the 'intellect' aspect of the trait. Intellect is associated with non-verbal intelligence (DeYoung, Quilty, Peterson & Gray, 2014) and with working memory (DeYoung, Shamosh, Green, Braver & Gray, 2009) which were represented by IQ and digit span tasks in this study. Note that we found some support for IQ as a predictor of creative potential in the form of peak originality, but none for working memory.

The study also examined differences in creativity and individual and contextual factors. There were no differences in creative ideation between the three age groups, and these findings are consistent with the work of Wu, Cheng, Ip, and McBride-Chang (2005) who found no differences in tests of verbal divergent thinking between two age groups, grade 6 and university students aged 19-22. It is also broadly consistent with the work of Kleibeuker et al. (2013) who found no differences in fluency across four age groups, 12/13, 15/16, 18/19 and 25-30, although they did find a difference in originality between their 12/13 and 15/16 groups and the young adult 25-30 group. Other studies which used the Test for Creative Thinking - Drawing Production (TCT-DP; Urban, 2005) found a dip in creativity during adolescence (Gralewski et al., 2016; Jastrzębska & Limont, 2017), which was not seen here in the verbal divergent thinking task. Wu et al. (2005) suggested that the level of knowledge and language ability required for the AUT may not differentiate the two groups in their study, and Kleibeuker et al. (2013) suggested that the ability to generate multiple ideas is fully developed by early adolescence. The greater originality that they found in the young adult age group, older than the oldest age group in this study, may be due to access to more diverse experiences, and to a greater ability to flex between analytical and associative processing (Kleibeuker et al., 2013).

We found no differences between the cohorts in the individual predictors of creativity, openness, IQ, and the digit span tasks, but we did find a difference in the contextual predictor, engagement in creative hobbies. We did not explore further in this study why this might be the case. One possible explanation is that the decline in engagement in creative hobbies reflects a difference in the samples, as the older age group was made up of university students, and not all of the 14-15- and 16-17-year olds may go on to university. However, other factors may be relevant in these age groups. For example, increasing academic pressure, work, and living away from home for the first time may affect both the time and resources available for such hobbies, and provide alternative explanations.

Although a lot of research has looked at profiles of engagement in extracurricular activities and leisure interests such as physical activity and sedentary behaviour in adolescents and young people, only a limited amount of research has examined participation in the arts or creative hobbies (Auhuber, Vogel, Grafe, Kiess, & Poulain, 2019). It would be informative to see whether engagement in creative hobbies changes with age, particularly if it is associated with differences in creative potential. This is planned for the second phase of the current study where participants from the first phase will be followed up after 18-24 months for retesting.

Limitations of the study

The data were collected in a group setting with written responses, as this was practical for recruiting participants from schools and colleges without disrupting the students' timetables over a long period. It also enabled collection of a larger sample size than would have been possible with one-to-one data collection. It may however have affected the sensitivity of the measures of executive functions. The Hayling Sentence Completion Task is usually administered on a one to one basis with verbal responses. The results were higher than the published norms (Burgess & Shallice, 1997) and did not discriminate, and so they were excluded from further analysis. The digit span task was selected to measure working memory, as it could be administered in a group setting, but it is possible that the use of written rather than verbal responses affected the sensitivity of the scores. In terms of sampling, cohort 3 was recruited from higher education students at a single university. Although we did not expect any differences in creative potential in relation to the destination after age 18, it should be borne in mind that only 51% of young people go to university after leaving school or college in the UK (Department for Education, 2018). The second phase of this study will follow up with participants from phase 1 after 18-24 months. We expect that the participants from cohort 2 will access a wider set of destinations, so it will be possible to investigate this within the second phase. The sample was predominantly female, particularly in cohort 3, and although we did not expect to find any differences in relation to gender it is possible that there may have been some differences to explore in the results had there been a greater proportion of male participants.

Conclusions

The study has employed a cross-sectional design to examine the predictors of creative potential in young people aged 14-20 and has evaluated the relative influence of both individual factors, specifically intelligence, personality, and executive functions, and contextual factors, specifically leisure activities such as engagement in creative hobbies and sports. It has used a combination of frequentist and Bayesian approaches to understand the influence of these factors. The results showed that specific individual factors (in the form of openness and IQ) and specific contextual factors (in the form of engagement in creative hobbies) all had an influence on divergent thinking, but to a different extent for different outcome variables. There were no differences in the three age groups in creative potential, openness or IQ, but engagement in creative hobbies was lower in the 18-20 age group than the 14-15 age group. By identifying the differential impact of individual and environmental factors on different facets of creative potential during development, the insights from this novel study using an original data-analytic approach constitute a foundational step for future explorations of how to optimally nurture creativity over the lifespan.

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Footnotes

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[i] Thirty-one students from cohort 2 completed the leisure questionnaire online.

[ii] 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).

[iii] Please note that when reviewing the cohort level results, it may be important to consider the sample size for cohort 1 (all participants did not complete all of the tasks) and cohort 3 (the smallest cohort), as the sample may be too small for the number of predictors, and this may lead to inflated Rs (Field, 2013).

[iv] SPSS was used for logistic regression as this was not possible in JASP 0.8.6.0.

[v] Post-hoc tests showed cohort 3 achieving a lower raw OKC score than cohort 2 (p = .036), with a small to medium effect size (Hedge's g = 0.36). The differences between cohorts 1 and 2 as well as cohorts 1 and 3 were not significant.

[vi] Post-hoc tests showed cohort 2 achieving a lower LDSB score than cohort 1 (p = .040), with a small to medium effect size (Hedge's g = 0.47). The differences between cohorts 1 and 3 as well as cohorts 2 and 3 were not significant.

[vii] Post-hoc tests showed that cohort 1 engaged more in creative hobbies than cohort 3, p = .018, with a medium effect size (Hedge's g = 0.51).