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The Language of the Creative Person: Validating the Use of Linguistic Analysis to Assess Creativity

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Validating the Use of Linguistic Analysis to Assess Creativity

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ABSTRACT

THE LANGUAGE OF THE CREATIVE PERSON:
VALIDATING THE USE OF LINGUISTIC ANALYSIS TO ASSESS CREATIVITY

by Sana Tariq Ahmed

Creativity is most commonly assessed through methods such as questionnaires and specific tasks, the validity of which can be weakened by scorer or experimenter error, subjective and response biases, and self-knowledge constraints. Linguistic analysis provides researchers with an automatic, objective method of assessing creativity, free from human error and bias. This study used 419 creativity text samples from a wide range of creative individuals (Big-C, Pro-C, and Small-c) to investigate whether linguistic analysis can, in fact, distinguish between creativity levels and creativity domains using creativity dictionaries and personality dimension language patterns in the Linguistic Inquiry and Word Count (LIWC) text analysis program. Creative individuals used more words on the creativity dictionaries as well as more Introversion and Openness to Experience Language Pattern words than less creative individuals. Regarding creativity domains, eminent artists used more Introversion and Openness to Experience Language Pattern words than eminent scientists. Text analysis through LIWC was able to successfully distinguish between the three creativity levels, in some cases, and the two creativity domains with statistical significance. These findings lend support to the use of linguistic analysis as a partially valid form of creativity assessment.

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

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The track record of our species is filled with a myriad of creative accomplishments, some as grand as the great pyramids of Egypt and others as simple, yet significant, as the wheel. Both survival and mundane obstacles have been overcome with creative solutions. As Edward de Bono said, "there is no doubt that *creativity is the most important human resource of all*. Without creativity, there would be no progress and we would be forever repeating the same patterns" (1992, p. 169, emphasis added). Our survival and progress as a species thus far are partly due to our ability to be creative.

Understanding the importance of creativity and humanity's dependence on it, researchers have been studying the creative person, process, and product. Traditionally, creativity is assessed through questionnaires and tasks, methods that require human raters; however, creativity has seldom been successfully assessed automatically through computerized programs. Linguistic analysis provides the opportunity to assess creativity both directly and through personality dimensions. If linguistic analysis proves to be a valid form of creativity assessment, linguistics and personality psychology will be able to make great strides in further creativity research. A major goal of the current study was to analyze the creative personality using linguistic analysis to determine if this approach provides a valid and relatively novel assessment tool for creativity researchers.

Defining Creativity

Most of the contemporary definitions of creativity have the same criteria and are therefore, similar to one another (Newell, 1962; Stein, 1974). Runco and Jaeger (2012) explain that for something to be creative, it requires two elements: originality, or what

some people might refer to as novelty or uniqueness, and effectiveness, which in creativity may go by another name, such as "usefulness, fit, or appropriateness" (Runco & Jaeger, 2012, p. 92). Elaborating on the element of usefulness, Stein (in Taylor, 1964) clarifies that something meets the criterion of being creative if, at some point in time, the product of the creative action or work results in something that is satisfying or useful to a group. However, Feist (2017) defines the second component of creativity not simply as usefulness, but rather meaningfulness: "to be classified as creative, thought or behavior must also have meaning to other people" (p. 186). This component of meaningfulness allows for a distinction between creativity and original nonsense (things that are simply novel but have no meaning).

More recently, a few other scholars have proposed a three-criterion definition. For example, Kaufman and Sternberg (2007) define creative ideas in terms of not only novelty and appropriateness but also quality. In a similar vein, Simonton (2016) also has three components for defining creative ideas: originality, utility, which "may indicate the idea's usefulness, effectiveness, value, appropriateness, meaningfulness, etc. depending on the specific task at hand" (p. 4), and surprisingness. Creative ideas are surprising or "nonobvious" and provide new knowledge (Simonton, 2013). Simonton's (2013, 2016) criteria for creativity of originality, utility, and surprisingness matches the United States Patent Office's patent criteria of new, useful, and nonobvious (Simonton, 2012).

Levels of Creativity

Initially, creativity was dichotomized into two levels: Big-C and little-c, which are eminent creativity and everyday creativity, respectively. This dichotomy, however, is

limited and does not illustrate the growth and progress of creative thinkers. Therefore, to create a more functional model of creativity, Kaufman and Beghetto (2009) expanded the dichotomy of Big-C and little-c creativity, to create the Four C Model of Creativity which includes mini-c, little-c, Pro-C, and Big-C.

Mini-c creativity is defined as the "novel and personally meaningful interpretation of experiences, actions, and events" (Beghetto & Kaufman, 2007, p. 73). This category encompasses personal, individual, expressive, and developmental creativity (Beghetto & Plucker, 2006; Cohen, 1989; Niu & Sternberg, 2006; Runco, 1996, 2004; Taylor, 1964). Unlike other categories of creativity, mini-c creativity does not focus on the creative product but rather on the process of creating itself, and the manner in which an individual personally and meaningfully grows through it (Helfand et al., 2017).

Little-c creativity is the creativity that is exhibited in everyday life (Kaufman & Beghetto, 2009). The difference between the levels of mini-c and little-c creativity is that the latter requires the abilities of creative self-efficacy and creative metacognition (Kaufman & Beghetto, 2009). Creative self-efficacy is an extension of the concept of self-efficacy and is the confidence individuals have in their ability to create new and meaningful ideas (Beghetto, 2006). In order to move into the category of little-c creativity, individuals must develop their creative self-efficacy and be confident and willing to have their personally meaningful insights and ideas subject to feedback (Beghetto, 2007; Beghetto & Kaufman, 2007). The second ability individuals must have to transition to little-c creativity is creative metacognition, which is the self and contextual knowledge necessary to know how to use creativity in a beneficial and

strategic manner in conjunction with classic metacognitive traits, such as self-regulation, self-monitoring, and self-reflection (Kaufman & Beghetto, 2013).

It is possible for an individual to, if desired, move from the little-c level to the Pro-C creativity level with practice, hard work, mentorship, and advanced training (Helfand et al., 2017). The Pro-C creativity category is for individuals who create professionally but have not reached eminent status (Kaufman & Beghetto, 2009). Examples of Pro-C creativity are the works of artists, writers, scientists, and craftspeople, individuals who create but whose impact and recognition are relatively narrow and limited.

The highest level of creativity is Big-C creativity, which describes eminent creativity. The individuals in this category are remembered for years and often have national or international reputations in their field (Helfand et al., 2017). This is the level of prominence that can lead to immortality (Kaufman & Beghetto, 2009), albeit symbolically. In short, these are the people whose creative work changes their field and/or opens new fields of study or art. Since this level of creativity is associated with expertise acquisition, some scholars have argued that ten years of domain-expertise preparation is required to reach world-class, expert-level status (Kaufman & Beghetto, 2009). Ten years is the time-frame because studies have shown that 10,000 hours roughly translates into 10 years of intensive preparation that is necessary for one to become an international performer in an extensive range of domains (Bloom, 1985; Ericsson, 1998; Hayes, 1989).

While there are four levels of creativity (Big, Pro, little, and mini), some researchers have talked about creativity as being either “big” or “small.” In 1998, Csikszentmihalyi

wrote about the distinction between the two, saying that small "c" is personal creativity while big "C" is cultural creativity. This distinction came from his research that highlighted individuals who should have been creative by their creativity tests but did not achieve anything creative or make novel contributions (Csikszentmihalyi, 1998). He said:

> Confronted with this kind of evidence, one can make one of two decisions. Either one says that it is the personal, subjective qualities that count as creativity, and success is irrelevant. Or one can say that it is not enough to show symptoms of creativity; one also has to be able to deliver… I eventually opted for [the following] solution: to think of creativity as a result of the interaction between a person, a social system, and a cultural system. All three of these components must be synchronized in order for real creativity – with a capital 'C' – to take place. When a person has all the traits that facilitate innovation, but the culture and the society are not cooperating, then we can only talk about originality, or personal creativity with a small 'c.' (Csikszentmihalyi, 1998, p. 80)

Small-c creativity can be considered as a combination of the two lower levels of creativity: mini-c and little-c, the personal and everyday creativity that everyone is capable of.

Domains of Creativity

Within creativity and creative individuals, there are notable differences that have allowed for a division to be recognized within creativity creating different domains, or cultures, if you will. In his book, the *Two Cultures*, published in 1959, C. P. Snow was among the first to describe the conflict that exists in academia between the "two cultures" – the humanities and the sciences. The conflict that arises from the divide between these two domains is a major obstacle for both "cultures" in solving the world's problems. Each culture holds specific views and impressions about the other: scientists believe that literary intellectuals have a complete lack of foresight and are unconcerned with their

fellow humans while non-scientists believe that scientists are "shallowly optimistic" and are unaware about humans' true condition. Snow (1959) maintained that while there does not appear to be a place where the cultures meet, "the clashing point of two subjects, two disciplines, two cultures – of two galaxies, so far as that goes – ought to produce creative chances" (p. 16). It is from these two cultures that great artists and scientists emerge and whose creativity and endeavors are "cornerstones of culture and provide mileposts of our cultural development and progress" (Feist, 2010, p. 113).

Creativity and Personality

Feist (2019) proposed a functional model of personality and creativity that states that personality traits function to lower behavioral thresholds and thereby increase the likelihood of certain behaviors, such as creative behavior. His model poses that there is a causal sequence of six latent variables: genetic and epigenetic factors, brain qualities, and four categories of personality traits (cognitive, social, motivational-affective, and clinical) (Feist, 2019). Genetic and epigenetic factors influence chemical and structural brain qualities that affect the four categories of personality traits, which lower the behavioral threshold for creative thought and behavior (Feist, 2019). The lowered threshold makes creative thought and behavior more likely in individuals with those personality traits. The causal direction is not necessarily unidirectional; there are places where there can be bidirectionality (Feist, 2019). Personality can also be influenced by creative thought and behavior. The four personality traits, by shaping experience, can also affect brain qualities and, by means of epigenetics, gene expression.

The creative personality is comparably consistent over time (Helson, 1996). The personality traits associated with a high creativity index and high creative achievement are high exploratory excitability, low harm avoidance, high persistence, and high self-directedness and cooperativeness (Chávez-Eakle et al., 2006). In his meta-analysis of creativity in the scientific and artistic domains, Feist (1998) found that Openness to Experience is the largest and strongest consistent predictor of creativity. When looking at the relationship between Extraversion and creativity, Extraversion must be broken down into its two main components: Sociability and Dominance. Creative individuals are high in Dominance and low in Sociability. Feist also found that Agreeableness and Neuroticism have a negative relationship with creativity while also having the smallest effects. The relationship between Conscientiousness and creativity is moderate; yet, the direction of the relationship is domain-dependent. In the artistic domain, Conscientiousness is negatively related to creativity while in the scientific domain, Conscientiousness is positively related to creativity. Feist's work ultimately revealed that creative people tend to be more "autonomous, introverted, open to new experiences, norm-doubting, self-confident, self-accepting, driven, ambitious, dominant, hostile, and impulsive" (1998, p. 299) compared to less creative people.

The two personality dimensions from the Big Five model that are most associated with creativity are Openness to Experience and Extraversion. Openness to Experience consists of a willingness to explore and try new experiences and ideas in addition to the curiosity and desire to know. It is related to cognitive flexibility and divergent thinking and is also correlated with both artistic and scientific creativity (McCrae, 1987; O'Rourke

et al., 2017). Openness to Experience is followed by Extraversion, which is strongly positively correlated with creative achievement, dependent upon the type or level of creativity being measured (O'Rourke et al., 2017). Within Extraversion, creative individuals are high in the Dominance component of Extraversion and low in the Sociability component (Feist, 1998). Highly creative individuals, particularly in the arts and sciences, frequently demonstrate introverted behaviors, such as "a greater than normal desire to remove oneself from social interaction and being overstimulated by novel social situations (Feist, 1998). Götz and Götz (1979) also found that Neuroticism in the arts is positively related to creativity while Neuroticism in the sciences is negatively related to creativity.

When looking at personality differences between the two creative domains, Feist (1998) found that artists and scientists differ somewhat in their social, cognitive, motivational, and affective dispositions. Whereas both share the dispositional dimensions of Introversion and Openness and being driven, ambitious, and hostile, artists are also norm-doubting, nonconforming, independent, aloof, cold, imaginative, impulsive, anxious, emotional, and sensitive while scientists are dominant, arrogant, self-confident, autonomous, and flexible.

This review has only touched the surface, but it should be clear that there is a developed and rich empirical literature on creativity and personality. One topic, however, that has not been investigated is linguistic style and creativity – the main focus of the current study.

Linguistic Analysis

The basic words that are used in daily life can be extremely revealing of one's underlying psychology as there are connections between the style and content of an individual's language and how they feel, think, and behave (Boyd, 2017). Linguistic analysis provides researchers the opportunity to explore psychological properties using a reliable method.

Language Use

Freud argued that the words an individual uses can provide insight into hidden desires and motives, as well as emotions (Freud, 1891). In the mid-twentieth century, researchers began developing more empirical approaches to measure meaningful psychological processes and constructs by using word clusters called "dictionaries" (Boyd, 2017). Probably the most widely used linguistic analysis program in the social sciences is Linguistic Inquiry and Word Count (LIWC) (Pennebaker, Booth et al., 2015). LIWC was first developed in 1993 and is a computer-based text analysis program that analyzes texts into psychological categories using a dictionary-based approach (Pennebaker, Booth et al., 2015). More specifically, LIWC analyzes the cognitive, emotional, and structural elements present in individual text samples by processing target words and matching them to internal dictionary words that tap into particular domains or elements (Pennebaker, Boyd et al., 2015).

The creation of the LIWC dictionary was a rigorous process with multiple steps: word collection, judge ratings, base rate analyses, candidate word list generation, psychometric evaluation, refinement, and the addition of summary variables (Pennebaker, Boyd et al.,

2015). LIWC has an internal dictionary that consists of nearly 6,400 words, word stems, and select emoticons, as well as nearly 90 output variables (Pennebaker, Boyd et al., 2015). With LIWC, it is now possible for psychologists and researchers to quickly and accurately gain insight into individual differences, social processes, and mental health as well as understand individuals' preoccupations, motivations, and emotional states by using a word-counting approach from linguistic-style patterns (Boyd, 2017). LIWC provides users with frequencies in the output variables, which are simply percentages of total words in the text sample. For example, if a text sample is analyzed and researchers find that the Articles (or article) number was 13.87, this means that 13.87% of the words in that particular text sample are articles (Tausczik & Pennebaker, 2010).

LIWC analyzes both content words, which communicate some kind of meaning, like who, what, where, or why (nouns, regular verbs, adjectives, and adverbs), and function or style words (pronouns, prepositions, auxiliary verbs, conjugations, etc.) that are used to link meaningful words together, which are generated from a deep level of the mind and are often automatic and used unconsciously, consequently revealing an individual's psychological state (Boyd, 2017; Tausczik & Pennebaker, 2010). The advantage of LIWC's word-counting approach for exploring the psychological processes found in individuals' language is that the reliability of LIWC's results is never undermined by experimenter error or subjective bias (Ireland & Mehl, 2014).

LIWC, however has never been used to assess an individual's level of creativity or their creative ability; it has only been used with creativity in the sense that participants are asked to provide a creative writing sample that is used to assess other constructs, such

as work-life narrative and motivation (Djikic et al., 2006; Lengelle et al., 2013). The current study will examine whether or not linguistic style and content can differentiate creative from less creative people.

Language Use and Personality

It can be problematic to rely on self-report questionnaires as the "gold standard" scores for personality research because of potential response biases and self-knowledge constraints (Paulhus & Vazire, 2007). Linguistic analysis has become a technique for personality researchers to assess personality in a less biased and more reliable way (Ireland & Mehl, 2014; Kern et al., 2019; Obschonka et al., 2017; Yarkoni, 2010). A more "psychologically telling" and psychometrically parsimonious method of determining individual differences is language styles (an individual's use of function or "stop" words), *how* an individual says things, rather than differences in language content (an individual's use of nouns, verbs, adjectives, and most adverbs), *what* an individual says (Ireland & Mehl, 2014; Yarkoni, 2010).

Researchers have reported consistent relationships between linguistic style and the Big Five elements of personality (Iacobelli et al., 2011; Ireland & Mehl, 2014; Mairesse et al., 2015; Pennebaker & King, 1999; Walker et al., 2007; Yarkoni, 2010) (see Table 1). For example, individuals high in Extraversion, compared to individuals low in Extraversion, use more social words, more references to self and others, more positive emotion words, greater certainty (Oberlander & Gill, 2006; Pennebaker & King, 1999), greater complexity, conjunctions and adjectives (Oberlander & Gill, 2006), more present-tense verbs, and more references to communication (Iacobelli et al., 2011). Similarly,

Mairesse et al. (2007) found that compared to introverts, extraverts tend to use more social words, which are indicative of positive emotions, and language that represents an external focus (e.g., fewer first-person singular pronouns). Individuals low in Extraversion tend to use more negations and negative emotion expressions (ex: "hate," "worthless," "enemy"), exclusive words (ex: "but," "without," "exclude"), inclusive words (ex: "and," "with," "include"), causation words (ex: "because," "effect," "hence"), articles, greater tentativeness (ex: "maybe," "perhaps," "guess"), achievement words (ex: "try," "goal," "win"), and discrepancies (ex: "should," "would," "could") (Nowson, 2006; Oberlander & Gill, 2006; Pennebaker & King, 199).

It is important to note that as of the 2015 version of LIWC, the Exclusive and Inclusive word categories have been changed to the Differentiation and Conjunction categories, respectively, due to "weak" and "terrible" psychometrics (Pennebaker, Booth et al., 2015). Extraverts are active social explorers; therefore, it makes sense that Extraversion is associated with words that are associated with humans, family, and social processes (Hirsh & Peterson, 2009). Furthermore, researchers have found that introverts use more articles, exclusive words, negations, and tentative words – categories that result in a more concrete and descriptive language style that is careful, precise, and focused, compared to extraverts who have a more abstract and interpretive language style (Beukeboom et al., 2012).

Individuals high in Openness to Experience, compared to those low in Openness, tend to express positive feelings and use articles, longer words, insight words, and inclusive words (Nowson, 2006; Pennebaker & King, 1999). Those with low Openness to

Experience scores tend to use first-person singular words, present tense words, causation words, negations, and references to school as well as more articles and prepositions and fewer personal pronouns (Ireland & Mehl, 2014; Nowson, 2006; Pennebaker & King, 1999). Openness is strongly related to greater use of perceptual processes, which include words related to seeing and hearing (Hirsh & Peterson, 2009).

Table 1

Personality Dimension Language Use Patterns

Personality Dimension	LIWC Categories	Examples
Introversion	Articles	a, an, the
	Negations	no, never, not
	Negative Emotions	hate, worthless, enemy
	Causation	because, effect, hence
	Discrepancy	should, would, could
	Tentative	maybe, perhaps, guess
	Differentiation	but, except, without
	Body	ache, heart, cough
	Achievement	try, goal, win
	Fillers	blah, you know, I mean
Openness to Experience	Articles	a, an, the
	Past Tense	walked, were, had
	Prepositions	with, above
	Positive Emotions	happy, pretty, good
	Social Processes	talk, us, friend
	Tentative	maybe, perhaps, guess
	Conjunction	with, and, include
	Seeing	view, saw, look
	Sexuality	horny, love, incest
	Leisure	house, TV, music
	Religion	altar, church, mosque
	Death	bury, coffin, kill
	Swear Words	*****

Language Use and Creativity

There has not been much research examining language use and creativity, specifically the language used in describing creative work and the language used by highly creative individuals. Four exceptions to this trend are research by Pennebaker and Stone (2003), Borowiecki (2017), Kelley and Ireland (2017), and Kelley et al. (2019). Pennebaker and Stone (2003) used LIWC to explore the relationship between aging and language use for over 3,000 research subjects from 45 different studies as well as the collected works of 10 eminent poets, novelists, and playwrights from the last 500 years. They found that as individuals age, they use fewer self-reference, past-tense, and negative affect words and more future-tense and positive affect words, all while exhibiting a pattern of increasing cognitive complexity. Borowiecki (2017) explored the relationship between negative emotions and creativity using LIWC to analyze 1,400 letters written by three eminent composers: Wolfgang Amadeus Mozart, Ludwig van Beethoven, and Franz Liszt. He explored the association between negative emotions and outstanding creative achievements and found that creativity is causally attributed to negative states, particularly sadness. Kelley and Ireland (2017) used LIWC to explore nearly 1,500 artists' potential motivations for writing from the artists' writings on art practice, artwork, art movement, artists, curators, patrons, and critics. They found that artists use words higher in cognitive complexity and meaning-making while having a high drive for achievement and low social affiliation and connectivity (Kelley & Ireland, 2017). Finally, Kelley et al. (2019) also used LIWC to explore whether or not Intellect can predict high achievement of visual artists using over 2,000 writing samples of visual

artists and scientists. There were no meaningful differences across the linguistic categories associated with Intellect between eminent artists and scientists; therefore, Intellect is equally associated with eminent creative achievements in the arts and the sciences.

LIWC dictionaries can be used to identify creativity language use patterns. Toward this end, a Creativity and Innovation Dictionary for LIWC was created by Neufeld and Gaucher in 2017 (see Table 2).

Table 2

Creativity & Innovation LIWC Dictionary (Neufeld & Gaucher, 2017)

Actualiz*	Expand*	Innovate*	Radical
Adapt*	Device*	Inspire*	Resourceful*
Advanc*	Devis*	Introduce*	Revolution*
Artistic	Differ*	Invent*	Set Up
Avant-garde	Discover*	Lead*	Shift*
Best-in-class	Experiment*	Leading-edge	Solv*
Brainstorm*	Forge	Metamorphosis	Spawn*
Build*	Form*	Modern*	State-of-the-art
Change*	Found*	Modif*	Surpris*
Clever*	Fresh*	New*	Trailblaz*
Conceiv*	Future	Novel*	Transform*
Contemporary	Generat*	Odd*	Uncommon
Craz*	Ground-breaking	Offbeat	Unfamiliar*
Create*	Grow*	Open-mind*	Unique*
Cutting-edge	Hatch*	Opportunity*	Unprecedent*
Depart*	Imagin*	Origin*	Unusual*
Design*	Improv*	Peculiar	Unveil*
Develop*	Individual*	Pioneer*	Upheav*
Enhanc*	Industry-leading	Problem-solv*	Vicissitude*
Enterprising	Ingen*	Produc*	Vision*
Efficien*	Initiat*	Prolific	Wild

The Creativity and Innovation LIWC Dictionary was created through multiple rounds of synonym collection for the words “creativity” and “innovation” from dictionaries and

thesauri. Each word was assessed to determine if it was a conceptual match to the original words and if it had any other non-creativity or non-innovation synonyms. The words that were a conceptual match and did not have any undesirable synonyms were included in the Creativity and Innovation Dictionary resulting in the final dictionary consisting of 86 words (Neufeld & Gaucher, 2017).

Jordanous (2012) created a list of the "Top 100 Creativity Corpus Keywords," which is a list of keywords for creativity (see Table 3). Although the list is not an explicit creativity dictionary, like Neufeld and Gaucher's (2017), the list Jordanous created is valuable for evaluating creative practices and exploring the nature of creativity. To create the list, she used the most frequently used words in 30 academic papers (selected by influence of document through number of citations, year of publication, academic discipline, and author(s)), spanning 60 years of research. Jordanous (2012) explored the relationship between creativity words and general academic words used in written English (found in the Academic Word List and the University Word List) and was left with a list of 694 words (389 nouns, 205 adjectives, 72 verbs, and 28 adverbs). These words were then considered keywords for creativity.

The 694 words were analyzed for context and 16 categories of creativity emerged: cognitive processes, originality, the creative individual, ability, influences, divergence, autonomy, discovery, dimensions, association, product, value, replicating creativity, and the study, measures, and evolution of creativity (Jordanous, 2012). Furthermore, from the linguistic analysis conducted, 14 themes (or components) of creativity were identified that added to the comprehensive meaning of creativity: active involvement and

persistence, dealing with uncertainty, domain competence, general intellect, generation of results, independence and freedom, intention and emotional involvement, originality, progression and development, social interaction and communication, spontaneity/subconscious processing, thinking and evaluation, value, and variety, divergence, and experimentation. The top 100 words in the list are valuable for linguistically assessing creativity as they are the "keywords that highlight key components of creativity" (Jordanous, 2010, p. 279).

Table 3

Top 100 Creativity Corpus Keywords (Jordanous, 2012)

Creative	Artistic	Unconscious
Creativity	Evolutionary	Probability
Cognition	Correlated	Self
Domain	Ability	Knowledge
Innovation	Programs	Variables
Openness	Intelligence	Primitive
Because	Cannot	Novelty
Divergent	Facilitate	Subjects
Process	Toward	Retention
Motivation	Correlation	Dimensions
Domains	Basis	Hypotheses
Found	Computational	Innovative
Abilities	Extrinsic	Ideas
Thinking	Selective	Related
Scores	Cognition	Dimension
Solving	Hypothesis	Validation
Individuals	Interactions	Attributes
Personality	Criterion	Research
Scales	Validity	IQ
Processes	According	Artifacts
Empirical	Measures	Combinations
Ratings	Tests	Predictions
Correlations	Verbal	Heuristic
Originality	Investigations	Factors
Traits	Heuristics	These
Associative	Fluency	Psychology
Influences	Rated	Barren
Primary	Psychologists	Positively
Conceptual	Complexity	Investigators
Instance	Discoveries	Perceptual
Developmental	Semantic	Example
Individual	Discovery	Elements
Problem	Schema	
Intrinsic	Rat	

Current Study

The purpose of this study was to be among the first to examine the idea that linguistic analysis can provide validation for distinguishing individuals high in creativity from those lower in it, as well as for understanding the personality-related language use patterns of Big-C, Pro-C, and Small-c individuals. Because there is very little research examining the direct relationship between creativity and language use patterns, this study used personality-related language use patterns to examine the relationship between creativity and linguistic style.

Linguistic analyses were conducted using the Linguistic Inquiry and Word Count (LIWC) program and statistical analyses were conducting using SPSS-26. Interviews from Gregory Feist's dissertation (1991) and Lisl Marburg-Goodman's book *Death and the Creative Life* (1981) as well as lectures of selected Nobel Laureates and selected blogs were analyzed using LIWC. The hypotheses of the current study were:

1. Individuals in the Big-C creativity level will use more words from the Creativity and Innovation LIWC Dictionary (Neufeld & Gaucher, 2017) than subjects in the Pro-C and Small-c creativity levels after controlling for gender, nationality, and mode of language.
2. Individuals in the Big-C creativity level will use more words from the Creativity Corpus keywords (Jordanous, 2012) than subjects in the Pro-C and Small-c creativity levels after controlling for mode of language.

3. Individuals in the Big-C creativity level will use more Introversion Language Pattern words than those in the Pro-C and Small-c creativity levels after controlling for nationality and mode of language.
4. Individuals in the Big-C creativity level will use more Openness to Experience Language Pattern words than those in the Pro-C and Small-c creativity levels after controlling for nationality and mode of language.
5. Big-C artists will use more Introversion Language Pattern words than Big-C scientists after controlling for nationality and mode of language.
6. Big-C artists will use more Openness to Experience Language Pattern words than Big-C scientists after controlling for nationality and mode of language.

In sum, this study examined whether linguistic analysis is a valid or invalid form of assessing creativity levels and domains. By using interviews and lectures, I hoped to validate linguistic analysis as a method of creativity assessment. Blog entries and interviews of less-creative individuals served as the comparison to more-creative individuals and to further validate the linguistic analysis. If the results suggest that linguistic analysis is a valid form of assessment, then it will be a relatively novel and efficient method of assessing creativity as it will eliminate the need for human involvement in the scoring process.

Method

The current study was archival and involved analyzing texts written and spoken by a range of creative levels and domains. The texts analyzed in this study came from four different sources: *Death and the Creative Life* (Marburg-Goodman, 1981), Gregory Feist's dissertation interviews (1991), Nobel Laureate Lectures, and blogs from the internet. A total of 419 text samples across all sources were used in this study (see Table 4). Demographics from individuals whose language samples were used were collected and compiled. The demographics collected were gender and nationality. However, demographics were not available for all subjects. Gender was coded as either male or female, nationality was coded as either single, dual, or multiple nationality, and mode of language was coded as either written or spoken.

The Small-c creativity level consisted of individuals in the mini-c or little-c creativity level. This included career fields that did not require creativity. The Pro-C creativity level consisted of individuals whose careers required creativity. The Big-C creativity level consisted of individuals who have reached eminent creative status, whether by accomplishment or recognition.

Sources of Texts

Big-C Sample

Twenty-two interviews from Marburg-Goodman's book *Death and the Creative Life* (1981) were taken to be a part of the Big-C sample for the study. The Big-C sample from this source consisted of eminent creatives from two domains, art (N = 11) and science (N = 11). Thirty-one interviews of scientists from Feist's dissertation (1991) were taken to

be a part of the Big-C sample for the study. To qualify as part of the Big-C sample, the criteria of eminence for the scientists in Feist's sample was that they must be members of the National Academy of Sciences. The Big-C sample from this source consisted of scientists from the three major scientific disciplines: biology (N = 10), physics (N = 9), and chemistry (N = 12).

The third source of the Big-C sample came from Nobel Laureates. Nobel Lectures were taken from each of the five categories of Nobel Prizes: physics, chemistry, medicine, literature, and economic sciences. The lectures were taken from the Nobel Prize website (https://www.nobelprize.org/) and were chosen based on their content and whether or not they were told in a story-like fashion and from a first-person perspective. The Nobel Prize and the Prize in Economic Sciences have been awarded 597 times. This was the initial subject pool. However, because there were laureates who had not given a lecture or had not presented it from a first-person perspective in a story-like manner, the number of Nobel Lectures used in this study was 248. Fifty-five Nobel Laureates' lectures were chosen from Physics Prize winners, 60 Nobel Laureates' lectures were chosen from the Chemistry Prize winners, 58 Nobel Laureates' lectures were chosen from the Medicine Prize winners, 42 Nobel Laureates' lectures were chosen from the Literature Prize winners, and 34 Nobel Laureates' lectures were chosen from the winners of the Prize in Economic Sciences.

Pro-C Sample

The Pro-C sample consisted of individuals whose profession required creativity, but who had not yet reached internationally eminent status through their work. One

interview of an "Unfulfilled" individual from Marburg-Goodman's book was taken to be a part of the study in the Pro-C sample. This particular interviewee had a career that fell under engineering.

Sixty-eight scientists' interviews from Feist's dissertation (1991) were taken to be a part of the Pro-C sample of the study. The scientists in the Pro-C sample are creative but not eminently (as defined by being members of the National Academy of Sciences). The Pro-C sample from this source consisted of scientists from the three major scientific disciplines: biology (N = 18), physics (N = 20), and chemistry (N = 30).

The third source of the Pro-C sample came from bloggers. A list of professions was created after searching for different types of professions on Google.com. With a compiled list of professions, blogs were then found by searching "diary of a [profession]" and "[profession] blogs" on Google.com for each profession from the list. The selection criteria for the blogs were that they must be told from a first-person point of view rather than a third-person point of view and be about the blogger's profession. The blogger's follower-base size was not considered or used in the selection process because the blog's impact or influence on others was not a criterion as the blogs were meant to be the less-creative Small-c sample. Using this selection criteria, 43 blogs, and subsequently 43 blog posts, were selected to serve as text samples for this study. Thirty-two bloggers fell under the criteria of being in the Pro-C creativity level in that they were earning money from their profession. The career fields represented in the Pro-C blog samples were biological sciences (N = 16), psychology (N = 1), engineering (N = 3), art (N = 3), literature (N = 4), architecture (N = 2), and culinary (N = 3).

Table 4

Subjects

Group	*n*	Gender		Creativity Level			Nationality		
		Male	Female	Big-C	Pro-C	Small-c	Single	Dual	Multi
Nobel Laureate	249	239	10	249	0	0	187	57	5
Physics	55	55	0	55	0	0	42	10	3
Chemistry	60	59	1	60	0	0	45	14	1
Medicine	58	57	1	58	0	0	43	14	1
Literature	42	35	7	42	0	0	30	12	0
Economic Sciences	34	33	1	34	0	0	27	7	0
Marburg-Goodman	28	27	1	22	2	4	11	9	1
Scientists	11	11	0	11	0	0	6	2	1
Artists	11	10	1	11	0	0	4	7	0
Unfulfilled	6	6	0	0	2	4	1	0	0
Feist	99	99	0	31	68	0			
Physics	29	29	0	9	20	0			
Biology	28	28	0	10	18	0			
Chemistry	42	42	0	12	30	0			
Blog	43	20	21	0	32	11			

Note. $N = 419$

Small-c Sample

As a comparison group for the more creative samples, Marburg-Goodman's (1981) interviews of the "Unfulfilled" and blogs from everyday professions were used for the Small-c sample. Five interviewees from the "Unfulfilled" group from Marburg-Goodman's book were taken to be a part of the study in the Small-c sample. The career fields represented by the five interviewees were banking (N = 1), stocks (N = 1), teaching (N = 1), and unemployed or unknown (N = 2).

The search for blogs of Small-c individuals followed the same method as the Pro-C blogs. From the list of 43 blogs, 11 belonged to Small-c individuals. The career fields represented in the Small-c blog samples were public service (N = 6), trade (N = 1), agriculture (N = 2), and beauty (N = 2). The interviews of Marburg-Goodman's "Unfulfilled" (1981), along with the blog posts and LIWC norms from the literature, served as comparison groups against the Big-C and Pro-C creativity samples.

Text Cleaning

All texts were cleaned so that only what the interviewees, Nobel Laureates, and bloggers said or wrote were left in the text files. Texts from the interviewers as well as quotes, poems, charts, graphs, images, and equations, were scratched from each text sample file. A folder containing all 419 text samples was uploaded into LIWC and run through each category of the 2015 LIWC dictionary, excluding the punctuation and net speak categories.

Creativity and Personality Dictionaries

The text files were run through the Creativity and Innovation Dictionary (Neufeld & Gaucher, 2017), the LIWC dictionary that was made from the top 100 creativity key words compiled by Jordanous (2010) in her Creativity Corpus (also called the Creativity Corpus Keywords Dictionary in this study), and the personality language use dictionaries. The personality language use dictionaries for Introversion and Openness to Experience were made from words that represented language in a personality space (Schwartz et al., 2013), and the words that fell under the LIWC categories correlated with Introversion and Openness to Experience (see Table 1) (Iacobelli et al., 2011; Ireland & Mehl, 2014; Mairesse et al., 2007; Yarkoni, 2010). These dictionaries have validated the LIWC dimensions with the Big Five dimensions of personality. After running all samples through LIWC with the aforementioned categories and dictionaries, the results were exported to SPSS-26 so that the planned analyses could be performed.

Results

Four analyses were conducted in this study using SPSS-26. The purpose of the first two analyses was to validate the Creativity and Innovation LIWC Dictionary (Neufeld & Gaucher, 2017) and the Creativity Corpus Keywords Dictionary (the top 100 creativity keywords from the Creativity Corpus) (Jordanous, 2012). The purpose of the third analysis was to explore personality language patterns and creativity. The purpose of the fourth analysis was to explore personality language pattern differences between Big-C artists and scientists.

Descriptive statistics of the different creativity levels and domains on the output variables are presented in Tables 5 – 7. Raincloud frequency plots made using the statistical computing language R for the output variables are presented in Figures 1 – 6.

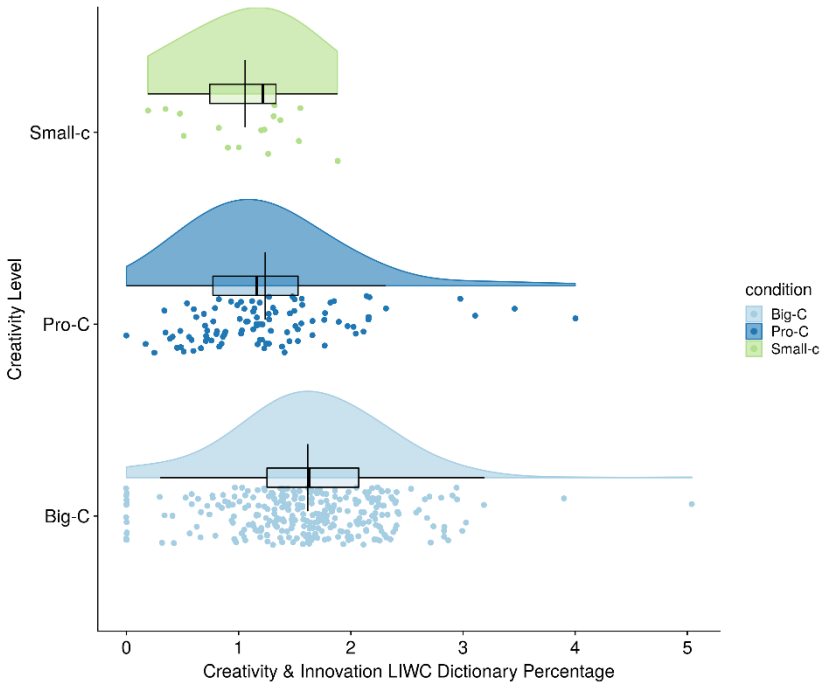
Hypothesis 1 was that individuals in the Big-C creativity level would use more words from the Creativity and Innovation LIWC Dictionary than subjects in the Pro-C and Small-C creativity levels after controlling for gender, nationality, and mode of language. In order to test Hypothesis 1, a one-way between-subjects analysis of covariance (ANCOVA) was conducted to compare creativity level on Creativity and Innovation LIWC Dictionary percentages (see Table 5). The predictor variable was creativity level, defined categorically as Small-c, Pro-C, and Big-C. The outcome variable was the percentage on the Creativity and Innovation LIWC Dictionary. In this analysis, nationality was held constant as a covariate.

Results of the evaluation for normality and homogeneity of variance assumptions were satisfactory. There were only three univariate outliers from the Nobel Laureate and

Marburg-Goodman groups (see Figure 1). After adjusting for gender and nationality, there were no significant differences between the three levels of creativity. Only .5% of adjusted Creativity and Innovation Dictionary percentages were explained by creativity level.

Figure 1

Creativity Level Differences on Creativity & Innovation LIWC Dictionary



Hypothesis 2 was that individuals in the Big-C creativity level would use more words from the Creativity Corpus keywords than subjects in the Pro-C and Small-c creativity levels after controlling for mode of language. Hypothesis 2 was tested with a one-way between-subjects ANCOVA that compared creativity level on the Creativity Corpus Keywords Dictionary percentages (see Table 5). The predictor variable was creativity level, defined categorically as Small-c, Pro-C, and Big-C. The outcome variable was the

percentage on the Creativity Corpus Keywords Dictionary. In this analysis, mode of language was held constant as a covariate.

Table 5

Means, Standard Deviations, and One-Way ANCOVA Statistics for Study Variables

Variable	Big-C		Pro-C		Small-c		ANCOVA		
	M	*SD*	*M*	*SD*	*M*	*SD*	*F* ratio	*df*	η^2
Creativity & Innovation LIWC	1.61	.69	1.24	.67	1.06	.48	1.08	2, 414	.01
Creativity Corpus Keywords	1.21	.56	1.35	.73	.65	.38	9.99*	2, 415	.05

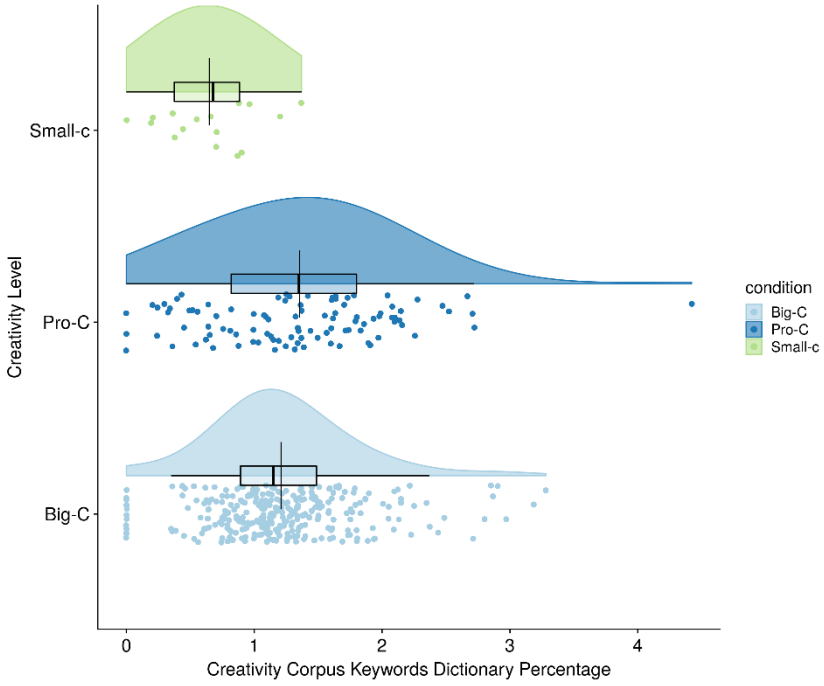
Note. $N = 419$.
*$p < .001$

Results of the evaluation for normality and homogeneity of variance assumptions were satisfactory. There were only three univariate outliers from the Nobel Laureate and Marburg-Goodman groups. After adjusting for mode of language, there was a significant difference among the three levels of creativity. Creativity level explained 4.6% of the variance in Creativity Corpus Keywords Dictionary percentage.

The adjusted marginal means showed that when mode of language was held constant, the creativity level with the statistically highest Creativity Corpus Keywords Dictionary percentages was the Pro-C creativity level, followed by the Big-C creativity level and the Small-c creativity level (see Figure 2). Overall, the ANCOVA value was significant, and simple pairwise comparisons found that the Pro-C and Big-C creativity levels had statistically higher percentages on the Creativity Corpus Keywords Dictionary than the Small-c creativity level. However, the Pro-C and Big-C creativity levels differed without statistical significance.

Figure 2

Creativity Level Differences on Creativity Corpus Keywords Dictionary



Hypotheses 3 and 4 were that individuals in the Big-C creativity level would use more Introversion Language Pattern and Openness to Experience Language Pattern words, respectively, than those in the Pro-C and Small-c creativity levels after controlling for nationality and mode of language. Hypotheses 3 and 4 were tested with a one-way multivariate analysis of covariance (MANCOVA) to investigate personality language use pattern differences between creativity levels (see Table 6). The predictor variable was creativity level, defined categorically as Small-c, Pro-C, and Big-C. The two outcome variables were Introversion Language Patterns and Openness to Experience Language Patterns. In this analysis, nationality and mode of language were held constant as covariates.

Results of the evaluation of the homogeneity of regression slopes and equality of covariance matrices assumptions were satisfactory. However, the homogeneity of variances assumption was violated for the Openness to Experience Language Patterns variable; therefore, an adjusted alpha level was used. Fourteen multivariate outliers from the Nobel Laureate, Marburg-Goodman, and blog groups were found by evaluating Mahalanobis distances (cases having a critical value over 13.82 were considered multivariate outliers). These outlier cases were removed for the analysis. After the removal of the 14 outlier cases, neither output variable, Introversion Language Patterns or Openness to Experience Language Patterns, was skewed.

Table 6

Means, Standard Deviations, and One-Way MANCOVA Statistics for Study Variables

Variable	Big-C		Pro-C		Small-c		MANCOVA		
	M	*SD*	*M*	*SD*	*M*	*SD*	*F* ratio	*df*	η^2
ILP	22.13	3.25	23.71	3.47	23.67	4.06	5.66*	2, 400	.03
OLP	44.25	5.36	49.58	3.15	46.40	5.57	4.00	2, 400	.02

Note. ILP = Introversion Language Patterns; OLP = Openness to Experience Language Patterns
$N = 405$.
*$p < .01$

There was a statistically significant difference between the creativity levels on the multivariate combined dependent variables of Introversion Language Patterns and Openness to Experience Language Patterns, $F(4, 800) = 6.58$, $p < .001$; Pillai's Trace = .06; partial $\eta^2 = .03$. In other words, 3% of adjusted personality language pattern percentages were attributable to creativity level. When the results for the dependent

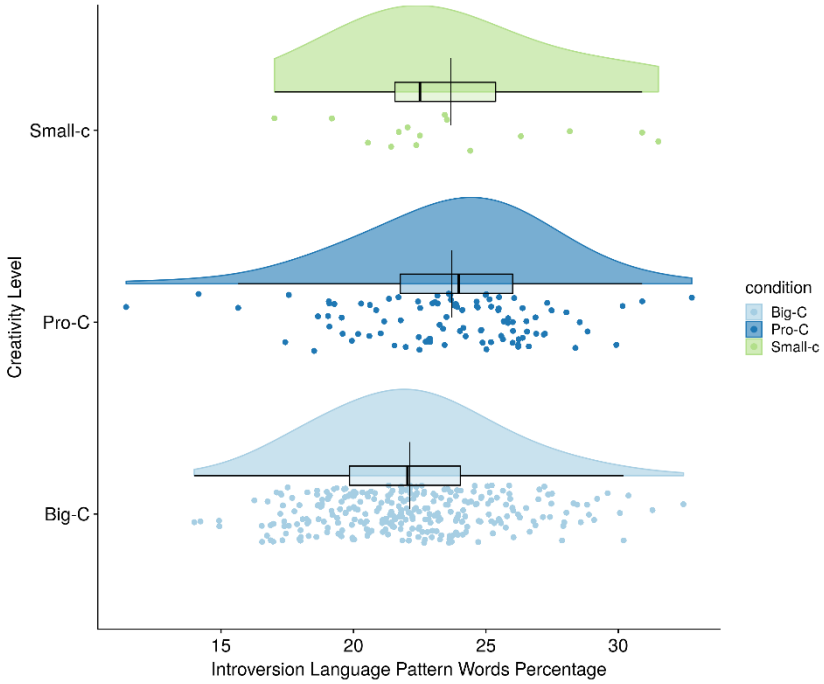
variables were considered separately, only Introversion Language Patterns reached statistical significance.

An inspection of the mean scores for Introversion Language Patterns indicated that the Pro-C creativity level had statistically higher percentages of Introversion Language Patterns than the Small-c creativity level and the Big-C creativity level (see Figure 3). Overall, the MANCOVA value was significant, and simple pairwise comparisons found that the Small-c creativity level had the statistically highest percentage on Introversion Language Pattern words compared to the Pro-C and Big-C creativity levels. Comparing the more creative levels, the Pro-C creativity level had statistically higher percentages on Introversion Language Pattern words than the Big-C creativity level. However, Openness to Experience Language Patterns did not reach statistical significance using a Bonferroni adjusted alpha level of .017 (see Figure 4).

Hypotheses 5 and 6 were that Big-C artists would use more Introversion Language Pattern and Openness to Experience Language Pattern words, respectively, than Big-C scientists after controlling for nationality and mode of language. Hypotheses 5 and 6 were tested with a one-way MANCOVA to investigate personality language pattern differences between Big-C artists and scientists (see Table 7). The predictor variables were creative domain, defined categorically as Art and Science, and Eminence, defined categorically as Big-C or Other. The two outcome variables were Introversion Language Patterns and Openness to Experience Language Patterns. In this analysis, nationality and mode of language were held constant as covariates.

Figure 3

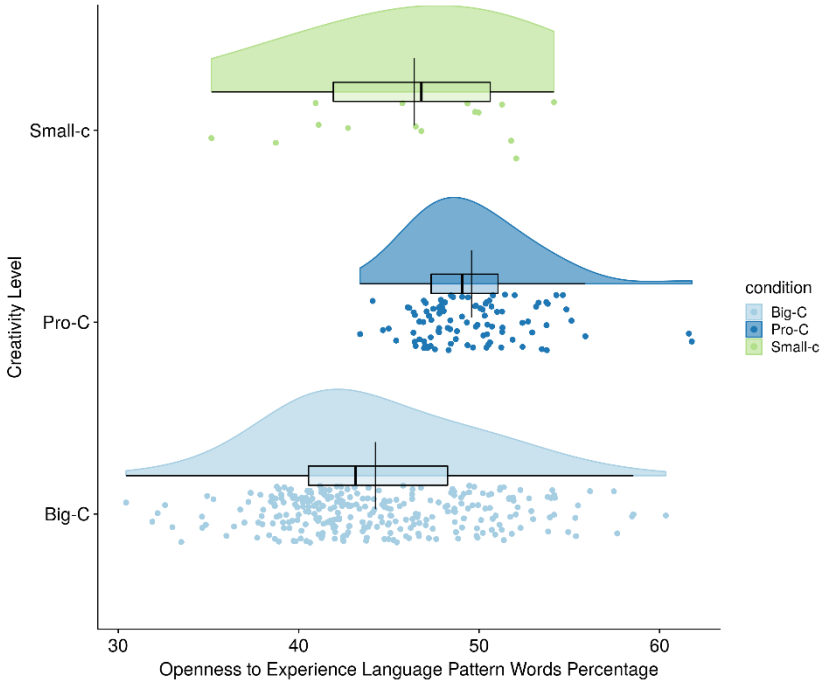
Creativity Level Differences on Introversion Language Patterns



Results of the evaluation of the equality of covariance matrices and homogeneity of variances assumptions were satisfactory. However, the homogeneity of regression slopes assumption was violated for the Openness to Experience Language Patterns variable; therefore, an adjusted alpha level was used. Fourteen multivariate outliers from the Nobel Laureate, Marburg-Goodman, and blog groups were found by evaluating Mahalanobis distances (cases having a critical value over 13.82 were considered multivariate outliers). These cases were removed from the analysis. After the removal of the 14 outlier cases, neither output variable, Introversion Language Patterns or Openness to Experience Language Patterns, was skewed.

Figure 4

Creativity Level Differences on Openness to Experience Language Patterns



There was a statistically significant difference between the Big-C Art and Science domains on the multivariate combined dependent variables of Introversion Language Patterns and Openness to Experience Language Patterns, $F(4, 794) = 12.07$, $p < .001$, Pillai's Trace = .12; partial η^2 =.06. When the creativity level and domain interaction results for the dependent variables were considered separately, Introversion Language Patterns reached statistical significance. Openness to Experience Language Patterns also reached statistical significance using a Bonferroni adjusted alpha level of .017.

An inspection of the interaction's mean scores for Introversion Language Patterns indicated that the Big-C Art domain group had statistically significant higher percentages

of Introversion Language Patterns compared to the Big-C Science domain group (see Figure 5).

Figure 5

Creativity Domain Differences on Introversion Language Patterns

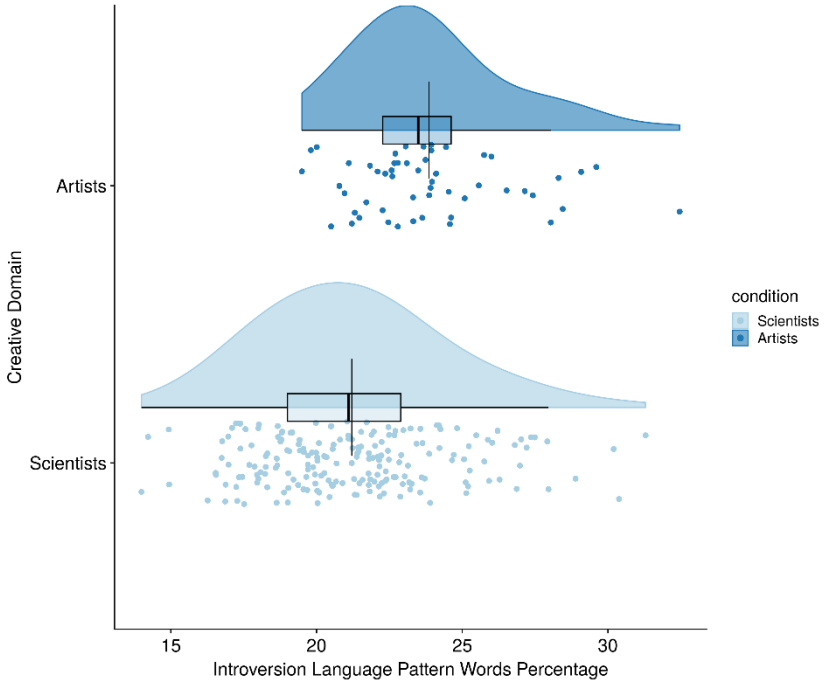


Table 7

Means, Standard Deviations, and One-Way MANCOVA Statistics for Study Variables

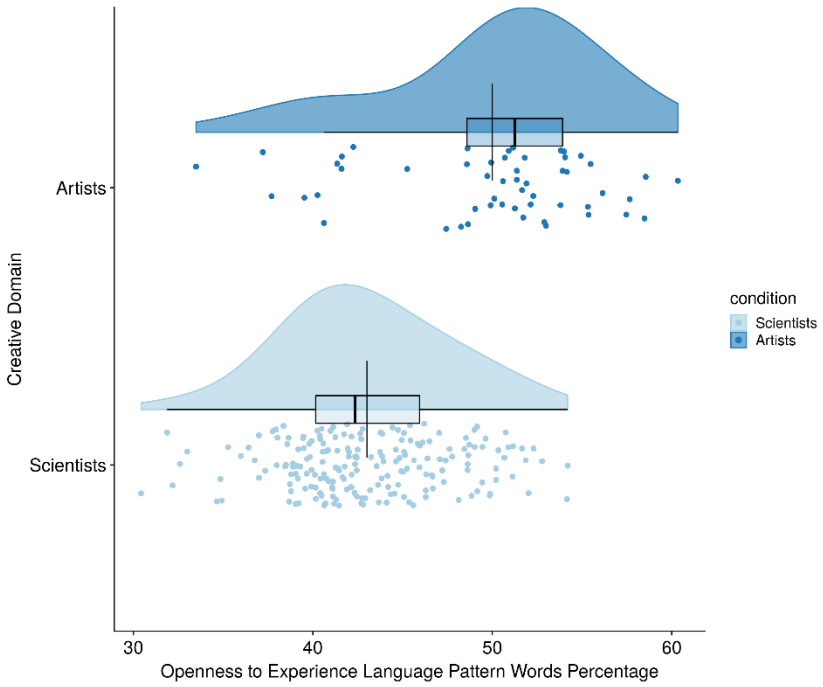
Variable	Art		Sciences		MANCOVA		
	M	*SD*	*M*	*SD*	*F* ratio	*df*	η^2
ILP	23.85	2.68	21.21	3.12	4.67*	2, 397	.02
OLP	50.00	5.97	43.01	4.47	24.74**	2, 397	.11

Note. ILP = Introversion Language Patterns; OLP = Openness to Experience Language Patterns
N = 405.
*p = .01. **p < .01

Similarly, the mean scores for Openness to Experience Language Patterns indicated that the Big-C Art domain group also had statistically significant higher percentages of Openness to Experience Language Patterns compared to the Big-C Science domain group (see Figure 6).

Figure 6

Creativity Domain Differences on Openness to Experience Language Patterns



Discussion

The purpose of this study was to be among the first to examine the validation of linguistic analysis as a method of creativity assessment and differentiation between individuals in varying creativity levels using creativity and personality dimension language pattern words. Linguistic differences between creativity levels were explored using the Creativity and Innovation LIWC Dictionary, Creativity Corpus Keywords dictionary, and Introversion and Openness to Experience Language Patterns to determine whether or not linguistic analysis could successfully distinguish between Big-C, Pro-C, and Small-c creativity levels. To explore the differences between eminent artists and scientists, linguistic analysis was conducted using Introversion and Openness to Experience Language Patterns.

As predicted, creative individuals used more creative language dictionary words and Introversion and Openness to Experience Language Pattern words in some situations. When creativity levels were compared on Creativity and Innovation LIWC Dictionary percentages, Big-C individuals had a higher percentage of Creativity and Innovation LIWC Dictionary words in their text samples compared to Pro-C and Small-c individuals. However, despite the differences between the creativity levels on the Creativity and Innovation LIWC Dictionary, these findings were not statistically significant. Since the findings were not significant, Hypothesis 1 was not supported. The results of the analysis suggest that this particular dictionary is not a valid assessment of creativity. This may be because the Creativity and Innovation LIWC Dictionary was created from synonyms of "creativity" and "innovation," which may not be the language style of creative

individuals. This particular dictionary also primarily consisted of content words rather than style words, which are more psychologically telling and more associated with personality.

When creativity levels were compared on Creativity Corpus Keywords Dictionary percentages, however, Pro-C individuals had a significantly higher percentage of Creativity Corpus Keywords Dictionary words in their text samples compared to Big-C and Small-c individuals. This shows that there were statistically significant differences between the creativity levels when compared on this dictionary. Despite the findings being significant, Hypothesis 2 was not supported because the Pro-C creativity level, not Big-C, had the highest percentages. The results of the analysis demonstrate that the Creativity Corpus Keywords Dictionary is at least a partially valid assessment of creativity because of the statistically significant differences between the creativity levels. This may be because the Creativity Corpus Keywords Dictionary contained more academic- and research-related words which may not be used by all creative individuals and consisted primarily of content words rather than style words which are more psychologically telling and more associated with personality.

When creativity levels were compared on personality language pattern differences, specifically Introversion Language Patterns, Pro-C individuals had a significantly higher percentage of Introversion Language Pattern words in their text samples compared to Small-c and Big-C individuals. This demonstrates that there are statistically significant differences between the creativity levels when compared on Introversion Language Patterns. Hypothesis 3, however, was not supported because the Pro-C creativity level,

not Big-C, had the highest percentages. These findings demonstrate that Introversion Language Patterns are a partially valid method of distinguishing between the creativity levels.

When creativity levels were compared on personality language pattern differences, specifically Openness to Experience Language Patterns, individuals in the Pro-C creativity level had a non-significant higher percentage of Openness to Experience Language Pattern words followed by Small-c individuals and then Big-C individuals. However, these percentage differences were not statistically significant. Hypothesis 4, therefore, was not supported because the Pro-C creativity level, not the Big-C, had the highest percentages. Despite the non-significance, it is interesting to find that individuals in the Pro-C level had higher percentages of Openness to Experience Language Pattern words when the literature says that Openness to Experience is the greatest predictor of creativity (Feist, 1998). These findings demonstrate that Openness to Experience Language Patterns are not a valid method of distinguishing between the creativity levels.

When creative domains, specifically Big-C scientists and artists, were compared on personality language pattern differences, specifically Introversion Language Patterns, Big-C artists had a significantly higher percentage of Introversion Language Pattern words in their text samples compared to Big-C scientists. Hypothesis 5 was supported because Big-C artists had the higher percentages compared to Big-C scientists. This demonstrates that there are statistically significant differences between the creative domains when compared on Introversion Language Patterns. These findings demonstrate that Introversion Language Patterns are a valid method of distinguishing between the

creative domains of art and science.

When creative domains, specifically Big-C artists and scientists, were compared on personality language pattern differences, specifically Openness to Experience Language Patterns, Big-C artists had a significantly higher percentage of Openness to Experience Language Pattern words in their text samples compared to Big-C scientists. Hypothesis 6 was supported because Big-C artists had the higher percentages compared to Big-C scientists. This demonstrated that there are statistically significant differences between the creative domains when compared on Openness to Experience Language Patterns. These findings demonstrate that Openness to Experience Language Patterns are a valid method of distinguishing between the creative domains of art and science.

In sum, there were consistent linguistic differences between the creativity levels, but more often than not, and contrary to prediction, the Pro-C creativity level used more creative words than the Big-C creativity level. This may be due to individuals in the Big-C creativity level using more field-specific and technical language while individuals in the Pro-C creativity level used more common language, which was present in the dictionaries used for linguistic analysis. However, it may be that the distinction between Big-C and Pro-C individuals was arbitrary and that they belonged grouped together rather than separately.

In order to address this issue of the Big-C and Pro-C difference, post-hoc analyses were run with these two creative groups combined, knowing that there are unequal sample sizes. A new variable was created with two levels: high creativity (Big-C and Pro-C combined) (n = 404) and low creativity (Small-c) (n = 15). The results of the first

post-hoc ANCOVA, comparing the two new creativity groupings on Creativity and Innovation LIWC Dictionary percentages, were not statistically significant, just as they were not when three creativity levels were used. The results of the second post-hoc ANCOVA, comparing the two new creativity groupings on Creativity Corpus Keywords Dictionary percentage, were statistically significant just as they were in the original analysis with the high creativity group having a statistically higher percentage on the dictionary than the low creativity group. The results of the first post-hoc MANCOVA, comparing the two new creativity groupings on both Introversion and Openness to Experience Language Patterns, were statistically significant. For Introversion, the low creativity group had a statistically higher percentage on Introversion Language Patterns than the high creativity group. For Openness, the high creativity group had a statistically higher percentage on Openness to Experience Language Patterns than the low creativity group. The results of the second post-hoc MANCOVA, comparing highly creative (now Big-C and Pro-C) artists and scientists on Introversion and Openness to Experience Language Patterns, were statistically significant just as they were in the original analysis. For Introversion, highly creative artists had a statistically higher percentage on Introversion Language Patterns than highly creative scientists. For Openness, highly creative artists had a statistically higher percentage on Openness to Experience Language Patterns than highly creative scientists. The results of these post-hoc analyses support the notion that the Big-C and Pro-C creativity levels belong grouped together and that the distinction between Big-C and Pro-C creative individuals is arbitrary.

Implications

This study has demonstrated that creativity can indeed be assessed by means of linguistic analysis, specifically through LIWC. However, this is dependent on what is being linguistically analyzed and through what means (dictionaries and language patterns). The Creativity Corpus Keywords Dictionary acted as a partially valid measure that distinguished between the three creativity levels, Big-C, Pro-C, and Small-c, with statistical significance. LIWC has also demonstrated the ability to be used in distinguishing between the artistic and scientific domains of creativity and not just the levels of creativity. The study used personality dimension language patterns associated with highly creative individuals to assess creativity through linguistic analysis, making it apparent that personality can be used to examine the relationship between creativity and language. Furthermore, Introversion and Openness to Experience are linguistic personality indicators of creativity, at least in some circumstances. More specifically, only Introversion Language Patterns can be used to successfully distinguish between different creativity levels with statistical significance while Openness to Experience Language Patterns cannot. The use of these two personality dimension language patterns in creativity needs to be explored further to better understand language use differences between creativity levels. In a similar vein, both Introversion and Openness to Experience Language Patterns were able to successfully distinguish between the creative domains of art and science with statistical significance, making it apparent that personality can be used to examine language use between creative domains. The advantage that comes with LIWC's partial-validity method for creativity assessment is

that researchers will no longer need to rely solely on previous measures of creativity, such as self-report questionnaires and tasks that are subject to scorer error, biases, and self-knowledge constraints.

Limitations

As is true for all studies, this study is not without its limitations. Perhaps the most obvious limitation is the uneven sample sizes for the sample groups, creativity levels, and creativity domains. By having unequal sample sizes, the distribution of the variables being compared was different because of the different standard deviations. One of the assumptions of analysis of variance is equality of variance, and a violation of that assumption decreases power and increases the likelihood of a Type I error. Since there were unequal sample sizes that resulted in some unequal variances, Bonferroni adjustments had to be used.

Furthermore, there were fewer female subjects (N = 32) compared to male subjects (N = 385); a ratio of nearly 12 to 1. More specifically, the ratio of Big-C male (n = 290) to Big-C female (n = 11) subjects was nearly 26 to 1 while the ratio of Pro-C male (n = 82) to Pro-C female (n = 18) subjects was nearly 5 to 1. In the domain of science, the ratio of Big-C male (n = 210) to Big-C female (n = 2) subjects was nearly 105 to 1 and the ratio of Pro-C male (n = 77) to Pro-C female (n = 12) subjects was nearly 7 to 1. With more male subjects in every category, the gender differences in the population of both Big-C and Pro-C are great and highly skewed. These ratios are relatively representative of population differences. The question is, then, why are the population differences between genders so skewed? Perhaps these differences are due to the historical lack of

female representation in highly creative fields, specifically in the sciences. This heavily male-dominated sample contributes to the lack of generalizability of these results since the results can only be generalized to creative male individuals and not the entire population of creative individuals.

Another limitation is that linguistic analysis was conducted using English language dictionaries, either from or uploaded to LIWC, on text samples taken from some subjects whose primary language was not English. Also, some of the Nobel Laureate lectures were written in different languages and then translated into English for accessibility. Having subjects whose primary language was not English and whose original words have been translated from another language can lead to a loss in meaning and words, weakening the validity of the linguistic analysis.

The two creativity language dictionaries used, the Creativity and Innovation LIWC Dictionary and the Creativity Corpus Keywords Dictionary, were mostly "creativity" and "innovation" synonyms as well as words related to research. Creative individuals do not speak saying "creative" or "innovative." Rather they use words that demonstrate greater conceptual distances, reflecting their cognitive flexibility and divergent thinking. The words in these two dictionaries may not fully capture how creative individuals talk compared to less creative individuals, decreasing the internal validity of these dictionaries as methods to assess creativity linguistically.

In addition, LIWC, the linguistic analysis program used, is rigid in that it strictly understands only words and not context. This can lead to phrases being interpreted differently by the program from how the subject had intended his or her words to be

interpreted. LIWC uses a closed approach using closed-vocabulary and word counting to analyze language. Perhaps a better method to analyze language is an open approach, which extracts comprehensive language features from text rather than relying on a priority word or category judgments (Park et al., 2015). The comprehensive collection of language features used in an open approach are single, uncategorized words, nonword symbols, multiword phrases, and clusters of semantically related words (Blei et al., 2003). Open approaches to language analysis have an advantage over closed approaches in that open approaches are able to accommodate neologisms and unconventional language use as well as extract many more and richer features from language samples (Park et al., 2015). A related limitation is that the only measure of personality used to distinguish between creativity levels and domains was Introversion and Openness to Experience language patterns from the literature; no other measure of personality was used. Also, only two dimensions of personality were explored in this study, leaving out the other personality dimensions as well as drives and motives, which can be present in language and provide great insight into creativity and the creative process.

Method differences regarding the original setting and context of the text samples could be a potential confound with the results. Nobel Lectures are meant to be extremely formal, interviews are slightly less formal, and blogs are a very casual medium. Formality differences in the method of text samples pose as a possible confound because these differences in formality, rather than creativity level, may have resulted in differences in word usage and linguistic styles.

A limitation regarding language is that changes in the English language were not considered when linguistically analyzing the text samples. English, like all languages, evolves and adapts to meet the needs of its users and is subject to "continuous and inevitable" change because language is culturally transmitted (Algeo & Butcher, 2014). There are many reasons for changes in language: syntagmatic (words and sounds affect neighboring words and sounds), paradigmatic or associative (words and sounds are affected by other words and sounds with which they are associated), and social change (language is changed because of the influence of world events) (Algeo & Butcher, 2014). The twentieth century saw less rigidity in adherence to Standard English and saw the manifestation of colloquialization while the twenty-first century is seeing a greater acceptance of both lexical and syntactic colloquial usages in English (Ayto, 2012). During the end of the twentieth, and into the beginning of the twenty-first century, English was observed as operating in a more relaxed and tolerant environment, indicating a shift in linguistic style over the decade. With text samples that range from 1901 to as recent as 2020, the language used in the text samples will have demonstrated the changes of the English language over the years, which the 2015 version of LIWC may not have been able to capture.

Another limitation regarding language are the three concentric circles of English that all the subjects fall under: the "inner" circle, the "outer" circle, and the "expanding" circle. The inner circle is where native speakers belong, the outer circle is for those who have learned English and use it as a second language, and the expanding circle is for those who learn and use English as a foreign language with a vast degree of expertise

(Ayto, 2012). The subjects in the study come from a wide variety of nationalities and many are not native English speakers. With these varying backgrounds, the subjects fall into all three circles of English and, as such, have different language use, which could present as a potential confound to the results.

Another limitation is that this study categorized creativity into three levels when creativity exists on a continuum and is not normally distributed. This categorization and use of univariate and multivariate analyses of covariance may have resulted in the specific findings we obtained rather than a true linguistic assessment of creativity. The categorization of data can often lead to a loss of meaning and information; therefore, the analyses conducted in this study are themselves a limitation. In a similar vein, this study distinguished between Big-C and Pro-C, and as the post-hoc analyses demonstrated, this distinction is arbitrary and had an effect on the results.

Despite the potential limitations noted, this study succeeded in its aim to investigate whether or not linguistic style can differentiate creative from less creative people and provide validation for distinguishing between creativity levels as well as creativity domains.

Future Research

Future research should further explore the use of Introversion and Openness to Experience language patterns by creative individuals to better understand personality-specific linguistic styles. Similarly, affect, drives, and motivations should also be linguistically explored to gain more insight into the creative process. Future research can also explore linguistic differences between different fields within the creativity domains

of art and science. Linguistic analyses should also be conducted in other languages, specifically the original language of texts, so that findings will have greater validity.

A better method of linguistic analysis for assessing creativity might be semantic distance. Semantic distance is a concept from psycholinguistic research and is essentially the number of steps that are between two concepts or words in semantic memory (Kenett, 2018). The Associative Theory of Creativity is the main theory that connects semantic distance to creative thinking. In the Associative Theory of Creativity, creativity is characterized by the association of weakly related and remote concepts into original and appropriate concepts (Kenett & Faust, 2019). The more creative a new combination of concepts is, the farther apart they are. Future studies should assess creativity using semantic distance to explore whether or not more creative individuals have greater semantic distance because their thoughts are more complex and more semantically distanced than those of less creative individuals.

Linguistic analysis is a newer, more efficient method of assessing creativity that is both automatic and objective, eliminating the need for human involvement in the scoring process. Even more importantly, linguistic analysis offers the possibility of being a fully valid form of creativity assessment, allowing for a new, more naturalistic assessment of human creativity.

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