A History of Creativity for Future AI Research

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Abstract

We look at two traditions for talking about creative activity, one originating in the classical Latin use of the word "creare" as a natural process of bringing about change, the other in Jerome's later use in the Vulgate bible, referring to the Christian God's creation of the world from nothing but ideas. We aim to show that because the latter tradition has predominated recently in the fields of Psychology and Artificial Intelligence these academic fields have been limited in scope to the Western culture of individualism and progress. We argue that the former tradition is a more general and useful notion as it applies more readily to describing human experience and activity as well as applying equally to other non-western cultures. Furthermore, because both traditions are still alive, and since they are both referred to through the use of this word "creativity", there is chronic confusion in everyday modern discourse as well as in Psychology and Artificial Intelligence. We outline these two traditions in order to understand and unpick this confusion and discuss implications for future research.

Introduction

The modern science of creativity started in 1950 when JP Guilford published his paper "Creativity" which he had read that year as the presidential address to the American Psychological Association. This word soon replaced the established concept of "creative imagination" (Engell, 1981) which was studied by a wide range of Psychologists interested in creative activity. Guilford was an expert in Psychometrics, the measurement of mind, and he offered "creativity" as a measurable psychological power or propensity, distinct from the familiar "intelligence". It was presented as a power that would explain the products of "creative genius", of Einstein and Picasso, as well as more mundane inventions in industry and war, and the imaginative productions of children and adults. Guilford defined the word by explaining that "The creative person has novel ideas" (Guilford 1950:452), and "creativity refers to the abilities that are most characteristic of creative people".

It was soon recognised that it was not enough just to have new ideas; they have to result in something of value: "The creative work is a novel work that is accepted as tenable or useful or satisfying by [sic] a group in some point in time" (Stein, 1953: 311). This definition of creativity, involving novelty and value has dominated both Psychology and Artificial Intelligence (AI), as in Margaret Boden's "the ability to generate novel, and valuable, ideas" (Boden, 2009:24). The scope of this modern concept (from child art to Michelangelo) carried with it the old mystery of how the human mind, the product of evolution, could be behind the astonishing achievements of "creative genius" . The task of Psychology and AI therefore, has been to understand scientifically the mechanisms underlying these achievements.

Until around the 1920s the word "creativity" was rarely used, but when it did appear it did not refer to a psychological propensity, but to new productions and changes in a culture or an individual, as in "the cycle of creativity, in which the languages from which our present tongues are derived, were formed" (Stuart-Glennie, 1874). or "the period of Shakespeare's [sic] dramatic creativity which produced Cymbeline and The Tempest" (Ward, 1899: 240).

The word "creative" on the other hand was common during the early 20th century. "Creative imagination" had been around since the 18th century, and this was the name given to the process of thinking underlying creative activity, studied especially by Developmental Psychologists interested in the ability of children to think and act imaginatively (Ribot 2006). But "creative" was used in a different sense by John Dewey in the title of the book he edited in 1917 called "Creative Intelligence". Dewey, and the other authors of this book, used the word "creative" to express their belief that intelligence is inherently a process of inquiry and reflection that comes through a strong sense of "being in the world", in direct opposition to the more mechanical conception of intelligence contained in IQ tests. As a practical expression of this belief "Creative writing" was pioneered in schools that were based on Dewey's principles (Mearns, 1925), and several significant works on *creative activity* appeared, where the emphasis is on the ongoing experience of a human being in the world. These included Dewey's seminal Art and Experience (1934) and Wertheimer's Productive Thinking (1945), two of the most important psychological works on this topic that have ever been written. Wertheimer's chapter on Einstein succeeded in showing both Einstein's brilliance and the grounding of his thought in experience; without any of the mystery about it stirred up by treating creativity as a power in the mind

The reason that "creativity" started to become more popular seems to have been Alfred North Whitehead's use of the word for the process of generating novelty in the theory

of physical evolution that was the mainstay of his process metaphysics (Whitehead, 1976, first published 1929). After the publication of Whitehead's philosophy, the word "creativity" became more common in academia, and towards the end of the 1940's it turned up as a buzz word in the fields of marketing and self-help. It figured prominently in Alex Osborn's best seller, Your Creative Power, where it replaced his earlier use of "creative imagination" which was the standard term used by Psychologists investigating creative activity. Osborn was an advertising executive and the inventor of Brainstorming as a way of releasing creative power from social inhibitions. Guilford may well have been encouraged by this to develop his own version of "creativity" as a mental power, with its definition, essentially that of Alex Osborn, of creativity as the generation of valuable novelty. This definition certainly works well for Osborn's usage in marketing and it understandably thrives in a capitalist economy that depends upon the never-ending supply of new commodities. It works less well when the product is not a marketable commodity, but an activity like dance, or jazz improvisation, or the traditional painting of icons and illuminated manuscripts. For instance the Lindisfarne Gospels from the early 8th century were recently put on display in the Bishop Cosin library under the shadow of Durham Cathedral in the Northeast of England. The manuscripts were extraordinary and beautiful, high in quality and appropriate to their original purpose. It is, as the Exhibition Guide points out

. . . one of the greatest landmarks of human cultural achievement. Created by the community of St Cuthbert on Lindisfarne ? an outstanding example of creativity and craftsmanship from medieval times. [1]

Most people would agree that the author of the guide was right to consider them an example of creativity, and stretching a point we may say they were novel, nothing exactly like it had been done before. But this stretches too far since it is not "novelty" that the authors of the guide are referring to when they speak about creativity but something much deeper. The manuscripts are not so much novel as the high point of a tradition, like the Alhambra in Granada, a John Coltrane Solo, a Ming vase, or Bach's B minor Mass.

But in spite of these difficulties, the definition of creativity as novelty has stuck and, we believe, obscured the pioneering work of Dewey and colleagues starting with his concept of creative intelligence. This, we argue, deserves to play a much stronger role in thinking about our approach to designing novel computational systems. In this paper we try to show historically how and why creativity has become such an overloaded term, as a way of disambiguating two versions which provides us with a fuller understanding about how we approach the design of novel computational systems in general.

The profligacy of "creativity"

After 1950, the word became Protean in its scope. Astonishingly for a term of scientific enquiry, and following on directly from Guilford, the word took on a wide variety of

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[1]Exhibition Guide, Lindisfarne Gospels in Durham, 2013 p.3

meanings. It was at once a psychological power, and a process in the mind, as well as also being the product of that process (Eysenck, 1995). In addition, it has retained some of the pre-Guilford older meanings of an activity taking place in the world. With creativity it seemed there was room for everyone.

In a much quoted paper Rhodes (Rhodes, 1961) translated the 4 P's of successful marketing - "Price, Product, Promotion, and Place" - into the 4 P's of creativity, "Person, Process, Product and Press", where Press refers to the environmental determinants. Creativity is the result of the 4 P's. There is nothing special about this, since the same scheme of 4 P's could be used for "achievement" or "innovation" or "depression". What is odd and different in the case of "creativity" is that the word is not only the result of the 4 P's, but *can refer to each of the first three of the four P's, as well as to the system that incorporates all 4 of them.* Whilst it would be absurd to identify any of the 4 P's of marketing with successful marketing itself, this is what occurs in the case of "creativity". Creativity needs Creativity to explain itself. It is no surprise therefore to find that one leading Theologian has identified it with God. Gordon Kaufman, the late Mallinckrodt Professor of Divinity at Harvard Divinity School substituted "creativity" for "the word" in the opening verses of the Gospel of John: "in the beginning was creativity, and the creativity was with God, and the creativity was God." (Kaufman, 2004: ix).

Major contradictions are not hard to find. It is uniquely human ("the distinctively human capacity to generate new ideas, new approaches, and new solutions" (Hennessey and Amabile, 2010: 570)), but it also occurs in animals (Bateson and Martin, 2013); and it is an unmitigated good ("positive value is a crucial part of the definition of creativity"; (Boden, 1994: 558)) but takes on a malevolent form in the hands of bad people like terrorists (Cropley et al, 2010). No one takes much notice of such anomalies since the word is so malleable that it can readily be shaped to fit every situation.

Given all this, it is not surprising that early on in the modern career of "creativity" Liam Hudson could write:

This odd word ['Creativity'] . . . applies to all those qualities of which psychologists approve. And like so many other virtues . . . it is as difficult to disapprove of as to say what it means. As a topic for research, "creativity" is a bandwagon; one which all of us sufficiently hale and healthy have leapt athletically abroad. (Hudson 1966: 100-101).

and little has changed since hudson wrote this

The word ["creativity"] has, historically, undergone several shifts in meaning, and it continues to mean different things to different people. (Cardosa et al 2009: 21).

and such a word, vague but redolent with promise and progress, is a gift to politicians, for Kennedy in 1962

. . . we are coming to understand that the arts incarnate the creativity of a free society. We know that a totalitarian society can promote the arts in its own way–that it can arrange for splendid productions of opera and

ballet, as it can arrange for the restoration of ancient and historic buildings. But art means more than the resuscitation of the past: it means the free and unconfined search for new ways of expressing the experience of the present and the vision of the future. When the creative impulse cannot flourish freely, when it cannot freely select its methods and objects, when it is deprived of spontaneity, then society severs the root of art. [2]
(Kennedy, 1962)

and President Obama in his 2011 State of the Union address

What we can do - what America does better than anyone else - is spark the creativity and imagination of our people (quoted in Bateson and Mason, 2013: 85)

Scientists themselves have been eager to lend support to this patriotic mission. As Guilford declared soon after the launch of Sputnik by the USSR, when the anxiety about "Falling Behind" [3] was at its height:

The preservation of our way of life and our future security depend upon our most important national resources: our intellectual abilities and, more particularly, our creative abilities. It is time, then, that we learn all we can about those resources (Guilford, 1959: 469).

And 50 years later, when the clash of civilizations had replaced that of political ideologies, Hennessey and Amabile wrote, in the 2010 Annual Review of Psychology:

If we are to make real strides in boosting the creativity of scientists, mathematicians, artists, and all upon whom civilization depends, we must arrive at a far more detailed understanding of the creative process, its antecedents, and its inhibitors. The study of creativity must be seen as a basic necessity. (Hennessey and Amabile, 2010:570)

In the past, the beginning of a new science has always been marked by a new precision in the use of key concepts, a process analysed in detail by the French historian of science Gaston Bachelard (Tiles, 1984). But precisely the opposite has happened in the case of creativity. We have seen a reasonably precise and developing discourse on creativity and creative activity before 1950 turn into semantic chaos. The earlier science of Dewey and Wertheimer was ignored, or even denied after Guilford had led the way by declaring himself "appalled" at the historical neglect of creativity. But we are not here to blame Guilford. What happened goes deeper. He unwittingly amalgamated two very powerful traditions in thinking about creative activity, and much of our present

confusion about creativity follows from their unmarked mingling in both everyday talk and academic discourse.

Here we illustrate this by outlining the history of these two traditions, and end by using the distinction between them to point towards a possible way forward for Computational Creativity.

The history of two traditions

In the classical Latin of Cicero and Lucretius, "creare" had meant bringing about or having an impact through natural forces. In Lucretius' first century poem On the Nature of Things (Lucretius, 1992), where he described a version of evolution which was materialistic but not strictly mechanistic, because his atoms were liable to chance "swerves". Creare was part of the natural (including human) world of creation and dissolution, as in the birth of a child (the father being the creator, mother creatrix), or the growth of plants. A little earlier Cicero had used creare to refer to the founding of Rome by Romulus and the appointment of a consul. Creare was different from "facere", to make out of available materials, as in the world-making of the old creator Gods described in Plato's Timaeus (Plato, 1977), and facere was used in early Latin versions of the Bible.

But in St Jerome's 4th century version, known as the Vulgate Bible, the word creare was used instead of facere, and this was taken to mean creation out of nothing but ideas in God's mind. Once done the creation was distinct from Himself but what He actually did to bring it about was a matter of debate. William Harvey, who discovered the circulation of the blood, suggested that the Creation came into being with a nod from God, giving the matter some scientific credibility, since Harvey falsely believed that the words 'nod' and 'neurone' were etymologically connected (Kassler,1991).

This new Christian meaning of creare was a mixture of the old creare and facere, so that the word "create" means to *bring about* by *making*. But it has never succeeded in obliterating the older Pagan meanings, in which creare (to bring about) is distinct from facere (to make). Both meanings of create, Christian and Pagan, often occur together in English. For instance, both senses occur in Mary Shelley's 1818 novel on the scientific creation of a human being, Frankenstein. Dr Frankenstein writes (drawing on the Christian sense) "I began the creation of a human being" (Shelley, 1985: 52). Later in the book, having murdered Frankenstein's child, the monster uses the Pagan meaning:

I too can create desolation; my enemy is not invulnerable; this death will carry despair to him, and a thousand other miseries shall torment and destroy him. (Shelley 1985: 138).

Both meanings are present 200 years later:

Reggae-Jazz crossover SKAMEL arrived, almost unanimously, with spectacular facial hair creations . . . they were impressive but in no way prepared us for the musical spectacular with which they laid waste to an excellent, enthusiastic and appreciative audience, thereby creating a long-memorable evening of superb jazz. [4].

To distinguish these two meanings we will call Jerome's (Christian) meaning of "creare" G-creative (where G stands for God, but could also be linked to Genius or Guilford). And the older (Pagan) meaning of "creare" N-Creative, where N stands for nature, as for Lucretius creare was the unfolding of natural processes. In this scheme SKAMEL's hair creations were G-creative and creating a long-memorable evening N-creative.

The cognates "create", "creation", and "creative" have become increasingly popular over the centuries. "Creativity", on the other hand remained rare until the 20th century. In the 13th century Duns Scotus used it as though it were a kind of power possessed by God. William of Ockham ridiculed Scotus for this (Leff, 1975: 148), as though you were to take the general word (collective noun) for horses, "equinity", and treat it as an independent entity with causal powers over and above individual horses, and say "equinity enables us to travel faster than walking". If God created the world (which Ockham didn't doubt) it was because that is what God did, not because of some mysterious power called "creativity".

G-Creative

During the Renaissance the biblical sense of God's Creation, the inventing of a world out of nothing but ideas, was taken as analogous to artistic productions, and the analogy was common in discussions of art and poetry in Italy in the 15th and 16th centuries (Charlton, 1913; Panofsky, 1968), and in later discussions of "creative genius" (Abrams 1953: 381), a notion that became common during the 18th century. This analogy with God applied to "high art", great paintings, poetry and music, and it led to a contrast with crafts or low art made out of given materials, and relying only on skill rather than ideas.

The analogy was in the background when modern Psychology arose from the problem of accounting for mental processes in the mechanistic world of 17th century Physics. The most pressing problem was to explain how works of creative genius (by definition original and non-mechanical) can emerge from the association of ideas, in the mechanistic systems put forward by the two great English philosophers of the 17th century, Hobbes and Locke. Their associationist theories formed a closed system in that outputs are explained by lawful processes that occur within a mind that is separate from the world, from which it passively receives inputs, like messages. This creates a mystery, sometimes explained by inspiration, and this pattern of thought has continued to this day. As Herb Simon wrote over three centuries later:

The notion that creativity requires inspiration derives from puzzlement about how a mechanism (even a biological mechanism like the brain), if it proceeds in its lawful mechanistic way, can ever produce novelty (Simon 1995: 945).

Both Hobbes and Locke had recognised the problem, and neither were inclined to appeal to supernatural inspiration. Hobbes suggested what we might refer to as the "Spaniel Search Metaphor" as a solution. In this account, the inventive mind searches through ideas in imagination and memory like a spaniel that "ranges the field, till he finds a scent"

(Hobbes, 1962: 22). This search metaphor was used to account for creation by the poet and playwright John Dryden, and in outline has remained the preferred cognitive process account for invention of all kinds. In the 18th century the answer to the problem of invention in art and science became "creative imagination", starting with Addison's Pleasures of the Imagination, where he wrote that imagination "has something in it like creation ... it makes additions to nature" (Engell, 1981: 36-37) and the analogies of God and spaniel remained in the background as the issue of creative genius merged into the beginnings of psychology.

Leibniz used a more complex version of this to explain theodicy, which was his attempt to reconcile evil with the goodness of God. His argument started from the premise that a world in which everything was perfect would be static and boring, and therefore unsatisfactory. To make it better God was obliged (given his good intentions) to bring in variation and change, which precludes a steady state of perfection. So God could not make it perfect, only as good as possible, and to achieve this Leibniz envisaged a combinatorial process in which God arrives at the best of all combinations. In 1740 Leibniz's model of God's creation was used by the Swiss writers Johann Bodmer and Johann Breitinger to account for poetic creation within the framework set up by Addison (Abrams 1953:276).

Work on creative imagination continued during the 19th century, and in France Alfred Binet and Theodor Ribot began experimental studies, especially in children. This cognitive work based on the association of ideas continued in Britain during the 20th century after the publication in 1906 of Ribot's Creative Imagination. Osborn's "Your Creative Power" in 1948 referred to this work, but began to use "creativity" in place of "creative imagination" (although this was not the meaning given it by Whitehead), and this opened the way for Guilford's use in 1950. Osborn had seen it as a mystery beyond scientific explanation. Guilford agreed that it was a mystery, but one that will be cleared up by science, presumably like the mystery of Life, or the Universe. Creating an extraordinary mystery that only science can solve is a smart tactic to start a bandwagon.

N-Creative

At the end of the 18th century another theoretical approach emerged, an alternative to the tacit analogy with God's creation and this new theory followed from a return to the older pagan, materialist meaning of creare, N-creative rather than G-creative. Instead of treating the mind as a closed system, isolated from the world of nature, but adding to nature by a God-like process of creation, it began to treat mind and nature as inseparable parts of an open system, drawing on earlier work by Shaftesbury and Leibniz (in his philosophy of nature rather than his theodicy). There were two aspects of this, one very sober, starting with Hume, and the other more revolutionary. The revolution came from German philosophy and then philosopher-poets, such as Schiller, Novalis and Goethe; it was brought to Britain and taken further by Coleridge and Wordsworth and their circle. For these writers human creating is like the growth of a plant, flourishing in its special environment, rather than caused by the operations

of an associative mechanism.

In a version of Hobbes' spaniel metaphor, Hume in 1739 described how "the imagination suggests its ideas, and presents them at the very instant, in which they become necessary or useful". It is as though "the whole intellectual world of ideas was at once subjected to our view" and we just pick out what is needed. But this is not what happens since only the needed ideas are present which "are thus collected by a kind of magical faculty in the soul, which, tho' it always be most perfect in the greatest geniuses . . . is however inexplicable by the utmost efforts of human understanding" (Hume,1978:24). Hume did not believe in magic, and "a kind of magical faculty" is a way of expressing his recognition that the steps of a mechanistic account using association of ideas will not explain creative thinking, even when the spaniel metaphor is added.

The way forward was to make human invention a product, not of human mind alone, but of human mind acting on the environment, and this insight proved one of the great achievements of the Scottish Enlightenment following Hume. In 1774 in Aberdeen, Alexander Gerard described invention as the result of conjecture and experimentation, and 75 years later another Aberdonian, Alexander Bain, refined this by introducing "trial and error" (Bain, 1855). The answer to the psychological problem had begun to change, and this became a revolution in the hands of poet-philosophers in Germany and Britain around 1800. Instead of asking "How can a mechanistic mind generate new ideas?", the question became "How does a person engage with her physical and social surroundings in order to create her own world, which is a pre-requisite to human creation and invention?". This goes beyond the concept of mind as isolated mechanism, and invites a systemic approach involving organism and environment. In accord with this, the metaphor of mechanism was replaced with one of growth, and this was to some extent a return to the earlier meaning of create as creare in Lucretius (Nisbet, 1986; Bell, 1994). Creare was to bring about or have an impact through facere, doing or making, and the two process are typically linked in movement or flow, exemplified by growth.

This was expressed by a number of important writers in Germany and Britain, and drew explicitly on their own experience. Amongst writers in English the most important were Wordsworth and Coleridge in Britain, who were followed by Emerson and Thoreau in the States. Coleridge provided the philosophy, struggling for an organic metaphor to replace Locke's psychic mechanism, and finding it in his account of poetry. Writing of his friend Wordsworth's poetry in their Lyrical Ballads he describes it as aiming:

to give the charm of novelty to things of every day . . . by awakening the mind's attention from the lethargy of custom, and directing it to the loveliness and the wonders of the world before us (Coleridge, 1983: 7)

And in a later work he wrote that in poetry "Nature [is] idealized through the creative power of a profound yet observant meditation", and through science poetry is "substantiated and realised" (quoted in Corrigan, 1982: 131). In the Idiot Boy, for instance, the "lethargy of custom" led many to report disgust at Wordsworth's portrayal of a mother's love of her son, but Wordsworth's "observant meditation" went much deeper than the lethargy of custom to a human reality, the mother's love. Both poetry and science reveal reality through the power of "observant meditation", exemplified for science in Coleridge's's friend Humphrey Davy. In his poetry Wordsworth began to use "creative" for a way of living in the world. In the 1805-6 edition of his long autobiographical poem, The Prelude, Wordsworth wrote:

The exercise and produce of a toil,
Than analytic industry to me
More pleasing, and whose character I deem
Is more poetic as resembling more
Creative agency.

In these ways "creative" began to refer to a particular way of acting in the world, mindful and inquiring, rather than being defined in terms of a product, the "Creation". It involved an immersion in the life around in order to bring about the world from which art and science could emerge. As Wordsworth's younger contemporary John Keats wrote in 1817, "That which is creative must create itself" (White, 2012:73) . It can occur in nature herself, as when Thoreau wrote on the shape of snow crystals: "How full of the creative genius is the air in which these are generated?" (Searls, 2009: 354). But it usually referred to immersion in an activity, as in Emerson's "creative reading" in 1837 (Emerson, 1975), and Matthew Arnold's "creative criticism" of 1865 (Arnold, 1914).

This newer meaning of "creative" (N-creative) did not replace the older G-creative (which entails a specific product), and they existed alongside each other, as in "creative genius" or "creative invention" (e.g. Ward, 1899). But it is the newer conception of N-creative that led directly to the work of John Dewey and G.H. Mead in the early 20th century. Dewey wrote on both Arnold and Emerson, and is known to have been strongly influenced by Wordsworth (Gale, 2010). His reflex arc paper of 1896 (Dewey, 1896), in which stimulus and response form a feedback loop inseparable from ongoing activity (instead of a link in causal chain), provides an organic unit of the kind Coleridge struggled to find. His friend and colleague the social psychologist G.H. Mead, had contributed one of the chapters in Dewey's Creative Intelligence of 1917 where he had written, echoing Keats, "The individual in his experiences is continuously creating a world which becomes real through his discovery". (Mead 1964).

This word "creativity"

It was soon after Dewey's publication of Creative Intelligence that Whitehead used the word "creativity" in his philosophical writings while at Harvard in the 1920's, in which he attempted to replace the old clockwork mechanism of Laplace with a universe (like that of Lucretius) incorporating chance. He used the word "creativity" in his own special way, as change or "passing on" that is inherent in the world, and which he referred to as "the principle of novelty" (Whitehead, 1976: 21). He wrote that he meant it in the dictionary sense of the verb creare, "to bring forth, beget, produce" (Whitehead, 1976: 213), which we have glossed in

our account of N-creative as 'bring about' in nature, rather than through the power of a mind, though this is one form of it. According to Whitehead, "originality" emerges out of this; it belongs to life, as living organisms act on their environments and break away from the "line of their ancestry" (Whitehead, 1976: 104).

Whitehead's lectures at Harvard soon appeared in print. They were closely argued and difficult, but had an immediate impact, especially in the States. Dewey discussed them with Mead (Cook, 1979) and the word "Creativity" appeared in section headings in the latter's best known book (Mead 1934). Even though these headings were added by the editor (Meyer, 2005), they reflect Mead's intentions, and probably played their part in the burgeoning familiarity of the word, since the book was widely read amongst Psychologists and Sociologists. Dewey himself wrote on Whitehead (Dewey, 1937) and later started to use the word "creativity" in a way that draws on both Whitehead and William James.

In 1948 he wrote of "the life factor that varies from the previously given order, and that in varying transforms in some measure that from which it departs, even in the very act of receiving and using it. This creativity is the meaning of artistic activity - which is manifested not just in what are regarded as the fine arts, but in all forms of life that are not tied down to what is established by custom and convention. In re-creating them in its own way it brings refreshment, growth, and satisfying joy to one who participates." (Dewey, 1948). This N-Creative activity is activity that can have an impact by sustaining or changing the established order that has guided the individual and the society to which she belongs; and it is present in everyday activities, such as gardening or cooking, where there is a state of creative intelligence and a readiness for inquiry. He had already spelt this theory out in Art as Experience (1934).

At the same time, 1948, Alex Osborn was using "creativity" in a very different way to mean the power released by brainstorming, and two years later Guilford introduced his own G-creative version of this as the essence of creativity.

What does this mean for future research?

These two strands in history, G-creative and N-creative, define two distinct theories of creative activity that stem from two distinct meanings of "creative". N-creative is a way of living and acting in the world and it is inherent in all activity unless constrained by authority, or by self-imposed routine. It goes with a concept of intelligence based on attentive inquiry, rather than a mental power. G-creative is based on the power to generate valuable novelty, and it is distinct from intelligence, which in the IQ testing tradition is a relatively mechanical process of knowledge and problem solving.

These two theories have been living alongside each other for 75 years. They have shared the same name, and accordingly have been treated as the same. G-creative has fitted most readily into Psychology and AI, with several dissenting voices (Howe, 2001; Sawyer, 2006). N-creative has been more at home in Humanistic Psychology (Maslow, 1968; Rogers, 1954) and Education (Holbrook, 1964; Woods and Jeffrey, 1996). But there has been much mingling and overlap and this is what has caused much of the confusion. Ani-

mals are N-creative but not G-creative, so if we have only the one term "creativity" they both do and do not show creativity. Can we prise the two theories apart and decide between them as the basis for future research, or do we need both?

One important criterion is range. We have seen that G-creative is aimed at art works and inventions in the Western world, that exist, like God's creation, independently of the creator. But this is limited since "valuable novelty" and the focus on products belong to a world of profit and economic growth, to museums and concert halls. It does not readily include improvised dance, music and story-telling that plays a predominant part in earlier or non-Western traditions, and there is a kind of missionary zeal in the spread of G-creative around the world. It is clearly on the side of progress, whereas N-creative is more universal, and involves change within a tradition. Traditions themselves may be worth preserving, especially if they are necessary for creative activity to take place (Hallam and Ingold, 2007: 48, 113). But unlike G-creative there has been little attempt to formalise the assumptions underlying N-creative. How could we do this?

According to G-creative theory, the mind, like that of God, generates novel ideas which result in valuable products. In the field of AI (and explicitly its subfield computational creativity) this has been explored by trying to simulate creativity using criteria similar to those of the Turing test (Turing, 1950; Boden, 1994). More recently there have been questions raised about the feasibility of the Turing test in relation to creativity (Bedworth and Norwood 1999), and Negrotti (1991) has suggested that AI (and by extension CC) can treat the intelligence and creativity of machines as of interest in themselves, rather than as a way of understanding human intelligence or creative activity. The Turing test would then become superfluous, except as entertainment, but it would mean dropping the "value" requirement for creativity, insofar as this is measured against the evaluation of human products. Recognising this, Dorin and Korb have proposed "creativity that is independent of notions of value or appropriateness" (Dorin and Korb, 2012), and Colton and Wiggins suggest replacing "value" in the definition of creativity with "impact" (Colton and Wiggins, 2012).

This use of "impact" makes it similar to the creare of N-creative and the historical distinction between N and G-creative could be used to define this concept. We can take this definition further in terms of the "social interactions between self-motivated autonomous agents" (d'Inverno and Luck, 2013), and the proposal for "artificial creative systems composed of intrinsically motivated agents engaging in language games to interact with a shared social and cultural environment" (Saunders (2012:216). We would then be close to modelling precisely the structures implied in John Dewey's N-creative theory of art and invention. The N-creative theory is made up of two components. An autonomous agent acts on its social world by constructing, making, talking, playing music, telling jokes, inquiring, etc. These are facere, and facere brings about change or has an impact (creare), to a varying degree, on the world, other agents, or itself. Put together, this system, as a formal statement of Dewey's definition of creativity in 1948, would embody N-creative.

If we are right in the arguments of this paper, it is history that will have helped us to see that there are alternative ways of conceptualising what is nowadays included under the blanket term "creativity", a term that has become so embedded in our language that even-handed debate on the matter may have become impossible.

That is why, to go further, we need to formalise the language of both theories, G-creative and N-creative, in order to prise them apart and to decide which version of creativity is most useful to us. This attempt may point the way to the design of new technologies, though it may well turn out that it will be the success or failure of such new technologies that will enable us to decide between the theories. But crucially we will have a concept of "creativity" that starts with Whitehead's theory of creativity and change, which as Bown puts it "forces us to think about creativity as a general process that can be applied wherever new things come into existence (Bown 2012:361). This is remarkably close to what Whitehead had in mind when he introduced the word "creativity" in the 1920's. At a more complex level, it gives rise to biological and social models of creativity as living organisms act on their environments and break away from the "line of their ancestry" (Whitehead, 1976: 104). Based on this, Dewey was working on the psychological theory of creative activity we have described shortly before he died in 1952. This would have been an extension to Psychology of the "general process" suggested by both Whitehead and Bown. But Dewey's pioneering work was forgotten in the excitement around Guilford's (in our view muddled and backward-looking) definition of creativity as an inner process and a measurable propensity in 1950. We end with six specific points for the future of AI research

1. Develop a profound skepticism of "creativity" as a mental entity.

2. Question why we would ever want to build artificial G-creative systems.

3. Increase our shared awareness of the N-creative work of Dewey and Whitehead that has been overshadowed by Guilford and his concept of creativity.

4. Build formal, computational models of N-creative systems and use them to build software that can support and refute these models.

5. Adopt an N-creative approach to designing systems supporting *being* in the world; enhancing and supporting human creative activity in all of its forms. (d'Inverno and McCormack, 2015).

6. Use human experience as the starting point for future system design. (Yee-King and d'Inverno, 2016)

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