Role of Artificial Intelligence (AI) art in care of ageing society:

Focus on dementia

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Abstract

Background: Art enhances both physical and mental health wellbeing. The health benefits include reduction in blood pressure, heart rate, pain perception and briefer inpatient stays, as well as improvement of communication skills and self-esteem. In addition to these, people living with dementia benefit from reduction of their non-cognitive, behavioural changes, enhancement of their cognitive capacities and being socially active.

Methods: The current study represents a narrative general literature review on available studies and knowledge about contribution of Artificial Intelligence (AI) in creative arts.

Results: We review AI visual arts technologies, and their potential for use among people with dementia and care, drawing on similar experiences to date from traditional art in dementia care.

Conclusion: The virtual reality, installations and the psychedelic properties of the AI created art provide a new venue for more detailed research about its therapeutic use in dementia.

Key words: Dementia, ageing, carers, technology, artificial intelligence, art

Introduction

There is growing evidence of arts as a tool for enhancing mental health wellbeing. Active engagement with arts enables people to demonstrate their creativity, engage in the direct process of art development, appreciation and interactions. In addition, a number of benefits in terms of reducing distress among children and adolescents [1], improving emotional state i.e., depression and anxiety in both younger [2, 3] and older adults [3-5], improvement in negative symptoms of schizophrenia [6], social cohesion in people with both psychotic and non-psychotic mental problems [7], enhancing sleep quality among older people [8], as well as improvement in interpersonal relatedness, hopefulness and gratification for adults with post-traumatic stress disorder [9] and self-esteem [3,10] have all been demonstrated.

Art therapy in dementia care

There is some research evidence for art therapy, efficacy and as such the uptake of art as a medium for care and self-care in dementia is discussed and put forward, not least because of its relative low cost and minimal risk [11]. Art appears to reduce anxiety and confusion, improves generation of old term memories and emotion regulation, explores cognitions, and increases the overall wellbeing of people with dementia [11]. It is, thus, not surprising that art therapy is now considered as one of the non-pharmacological treatments for dementia, and in some countries even prescribed under the National Health Service, as is the case in Canada.

Though the recent Cochrane review showed low efficacy of art therapy for people with dementia, this is because the findings were based on low quality studies [12], in contrast to high quality studies [i.e. Randomised Control Trials (RCT) and/or longitudinal studies using good psychometric measures] that show emerging efficacy. Thus, in two recent RCT studies, older people with mild cognitive impairment at risk to develop Alzheimer's disease who were allocated to creative expression therapy showed significantly higher performance in several cognitive domains than patients receiving standard cognitive training. These included general cognitive functioning, memory, executive function, functional status, and everyday living ability and these improvements were maintained at the 6-month [13] and 9-month [14] follow-up. Similar benefits in terms of improving vitality and quality of life were achieved in an earlier RCT trial of art therapy for people with mild Alzheimer's Disease [15]. In

another study, conducted among people with mild to severe dementia and living in both 24-hours (i.e., residential care homes and a county hospital) and community dwellings, Windle et al (2017) reported significant improvement in quality of life during the first 3-month follow-up, highlighting the benefits of art activities and the potential for creative aging within dementia care [16]. Similarly, multi-dimensional mental health benefits were described in a 13-week sculpture art-based therapy (2 hours/week) involving people with moderate to severe dementia [Mini Mental State Examination scores 0-18/30] who lived in nursing homes. In this study, remarkable improvements in mental state and concentration, self-reliance, self-esteem and physicality were seen in the sculptural activity dementia group (n=6), but not the control group (n=6) [17]. Larger studies on more divergent groups of people with memory problems are now needed to expand on these findings and validate them further prior routine use of art therapy in the treatment and management of people with dementia, both living independently and/or in 24-hours care.

Art-centred activities for dementia

Art museums have now opened their doors to people with dementia and provide art-centred activities for both people living with dementia and their carers. The positive experience of the offered art tours and classes appears to be dependent on the museum space itself, the facilitation process and socialization with other participants [18], with the well-being benefits experienced both by people with dementia and their carers equally from traditional and contemporary art gallery sites [16, 19-21], with carers reporting reduced carer's burden [19]. The investigation of museum/art stimulation programs for people with dementia requires a more rigorous validation of the assessment methods for them to be considered as a nonpharmacological intervention for this population, as suggested recently via the proposed 'Artwork effect' paradigm, which is in accordance to the personhood model [22].

Although subjective participants' experiences of these interventions are in the domains of positive emotional and cognitive experiences, reduced isolation and built social networks [23], only lately is there evidence from randomised control trials about objective benefits of such interventions among people with dementia. Thus, the ARTEMIS (ART Encounters: Museum Intervention Study), an art-based intervention consisting of a combination of museum visits and artistic activity for both people with

dementia and their carers/partners, reported improvements in participants' self-rated quality of life, and a significant positive change of emotional well-being immediately after each of the museum sessions. These improvements were also accompanied by decline in the Neuropsychiatric Inventory scores in several domains, including affective (depression and anxiety) and apathy subscales [24]. What is potentially important about these two findings is a revaluation of mental health themes identified. The above two studies [23, 24] present evidence of two powerful mental health outcomes around the way that mental health is conceptualised: hedonic and eudaimonic well-being [25]. Schall et al [24] identify depression and anxiety outcomes from interventions. These are popular assessments of well-being (such as those used in primary and secondary care situations), that fall into a hedonic well-being domain. This domain assesses specific positive and negative emotion within a particularly short timeframe. However, Flatt et al [23] in identifying concepts such as feelings of autonomy, mastery or control, having a sense of importance accepted, or acceptance, are finding evidence of effects of *eudaimonic well-being.* Eudaimonic well-being involves individual development through engagement with the challenges within life, concentrating on issues of meaning and self-reflection. This idea has huge pedigree in psychology and this type of well-being been singled out as a protective resilient factor for promoting positive health and life factors across the life-span and into old age [26].

Similarly, museum settings with historically authentic environments that recreated the material and cultural context of participants' youth provoked more autobiographical memories, and these memories were more elaborated, detailed and spontaneous, compared to the memories evoked in a control condition [27]. However, a cross-sectional observational Dutch study highlights that offered museum programmes need to be adapted to the degree of dementia, since art appreciation and responsiveness appears to be related to the severity of dementia, specific cognitive impairments and to the type of artworks [28]. Thus, people with more advanced dementia responded less to art than those with milder impairments, whereas people at early to middle stage dementia showed larger positive increases in wellbeing [29, 30].

The type of artwork also appears to have a different impact upon the enjoyment of artwork. Thus, artworks containing more natural elements revealed less interaction

with others, in contrast to artefacts i.e., objects not originally meant as artworks, evoking more reactions than the artworks *per* sé [28], suggesting that imaginary unreal art presentations are not only well received by people with dementia, but cause more curiosity and interactions than the traditional forms of art.

The above studies have provided valuable information about the appreciation of art by people with dementia. The data to date confirms that modern art is appreciated by people with dementia and, in fact, the art that stimulates creativity and fantasy seems to be much more appreciated and caused interest among people with dementia. In the era of digital technologies, the exposure to an algorithm-created digital art is becoming a reality. These digitally psychedelic and fantasmorganic images may well trigger unexpected emotional responses and interactions, and contribute to changing neuronal network dynamics, whilst enhancing fantasies, facilitating memories and communications.

What is Artificial Intelligence?

Automation and accompanying technologies have been embraced by artists throughout centuries. It is, thus, not surprising that most recent technological evolvements in the form of artificial intelligence have been added to the growing list of art-making techniques, enabling artists to combine creative processes with digital innovations.

Artificial Intelligence (AI) comprises an assemblage of technological advancements that appear to simulate human intelligence (figure 1). Most recent AI technology extends to machines having the capacity to learn [31], to sense, reason and take action to detect, deliberate and develop on its own to determine the attributes in a dataset that are predictive [32].

- Figure 1 here-

Whilst AIs are advancing at a rapid pace, it is the humanistic perspective of AI that enables researchers to ask questions of the ethical guidelines that shape its evolution. Common questions such as ‘how much autonomy should a machine have?’ and ‘what level of decision-making power should a machine have?’ are increasingly being asked. Organizations such as UNESCO are calling for policy and standards that put

human-centred design that addresses social value and inequalities in all forms at the heart of its development.

Expectations for adoption of AI are in a range of services including healthcare, public and consumer facing sectors [37]. Its impact is anticipated to be on all types of activities from information and operations management, research and development, supply chain management, marketing and customer services [38]. Incorporated into so-called smart environments, AIs uses data gathered from ambient technologies (such as sensors, telecoms networks) to provide sustainable resource efficiencies and provide new insight from complex datasets to stakeholders [39]. A smart context can be almost anything from a home to a service, a community, a neighbourhood or city. Configuration of an environment is unique to stakeholders and/or users - consumers build homes and install a range of physical devices that acquire data, service providers do likewise. AIs learn from datasets generated by the interactions between objects and agents (people, devices) operating within its system boundaries (see [40]). Of significance in a smart environment is for whom it is beneficial, thus the concept of ambient intelligence is a typical user-centric paradigm used to describe the adaptive nature of the context [41]. As computer processing and network capabilities increase, along with the growing number of objects recognized it an environment, so the potential for new services expands exponentially. Examples of smart service environments are in healthcare facilities such as hospital rooms that are being modelled with ambient technologies and assist both patients and medical staff through integrated sensor technologies [42].

AI technology and art

Tangential to this, an area of interesting application of AI technologies is that of cultural production, where artists use AIs (algorithms) to support collaborations with datasets that produce creative outcomes (table 1). The AIs are generally trained on some aesthetic data forms such as a corpus of music, painting, poetry or film. Artists use an algorithm to identify some interesting things about the dataset that in various ways they then employ to devise new creative forms. Some (e.g. [43, 44]) suggest that the use of AIs as a creative device facilitates a more humanistic approach to understanding the role of the technological advancement because it presents opportunities for a diverse skillset to be involved in new forms of cultural production.

Once the domain of trained artists, AI-art can be produced by coders and those without traditional talent in music notation, instrumentation, drawing or scriptwriting competencies to become creators. In effect, the AI becomes the paintbrush.

- Table 1 here-

By way of example, the image in figure 2 is a screen capture of an interactive moving art installation (exhibited during the Art AI Festival in Leicester, May 2019) that combines the viewer's facial characteristics with images from a vast database of historic European portraiture. The artist has trained an AI to match and create a unique image for each viewer using facial recognition technology, and each image created is also 'memorized' to inform subsequent viewers' experiences, thereby expanding the database. The image created, however, is never repeated.

- Figure 2 here -

In general, the artworks produced via AI appear to be neither aesthetically nor conceptually rich enough to hold the attention of art experts for long. In the words of Theo Triantafyllidis (an AI artist) '… (the) state-of-the-art AI today is somewhere between a really clumsy child and a really smart pet'. Even artwork produced with the generative Adversarial Networks software, known as GANs, share similar characteristics of surreal distortions that are now referred to as the 'Francis Bacon effect' (Barratt; Klingemann).

Interestingly, similar distortions in proportion and perspective, as well as defects in spatial organization, lack of individual characteristics in depicting subjects, as well as increasing trend in photographic realism are also noted in the work of artists with dementia [45], who had Alzheimer's disease [46-48 and Lewy Body, Fronto-temporal lobe and/or Vascular dementias [49]. In a recent pilot study conducted by our group (EBM-L and TH, unpublished data) people with dementia, their carers and professionals had very similar attitudes towards conventional and AI generated art. They recognised correctly the AI generated art in 90% of cases, with people with memory problems correctly identifying the AI generated art. Only two (0.125%) of the Memory Clinic Service users (≈ 1,600 in total over 3 weeks duration) complained

about distorted, static images (i.e. images resembling melting faces, joint faces showing 3 eyes), finding them distressing in relation to some of the artwork presented. An AI installation that showed different types of more abstract and psychedelic moving images (see figure 3) was received well, and kept the attention of viewers for longer, despite its repetitive nature (sequence repeated every 3 minutes throughout the day, 9am-5pm).

- Figure 3 here -

The relaxing, calming effects of the AI installation were highlighted by 35% (6 out of 17) of the service users and participants in the study. This is the first evidence that older people with and without memory problems respond well to new technological art advances. This *per sè* is encouraging enough to consider the possible therapeutic implications of these novel art forms for people with dementia.

Conclusions

The technological advances are redesigning modern healthcare: from AI algorithms able to mine medical records, design treatment plans, find novel therapies from a database of molecular structures and repositioning existing drugs, to generating virtual and augmented reality experiences. These advances have not bypassed the dementia healthcare: they have contributed to improving dementia diagnostic accuracy [50], estimate dementia risk factors [51], inform about dementia prognosis [52], as well as determine (non)pharmacological management [53] of people with dementia. However, the implementation of technology driven dementia care raises concerns, starting from ethical and regulatory frameworks, lack of clear guidance on development and use of AI applications, their integration in both clinical practice and training of healthcare professionals. Are the current clinical services under threat to be replaced by these novel technologies? What about responsibilities towards and supervision of service users and medical practitioners? What is the potential for misuse of technology if used to replace established services? Similarly, patients' autonomy and long-term effects of these applications on understanding illnesses and management remain areas of concern (reviewed in [54]).

Technological advances have contributed to a wide range of products and services available to people with dementia to live independently, including telecare and assistive technology. A recent study found that the acceptability, utility, usability and efficacy of the technology were evaluated as positive among people with dementia and their carers [55], improving their quality of life, reducing healthcare costs, premature institutional care [56] and augmenting and supporting their social interactions [57]. In addition, they also mitigate the mental and physical burden of dementia caregivers [58].

Many applications have been specifically designed for people with dementia and their carers in mind, such as games, digital photobooks, reminiscence aids. Virtual reality programmes and environments including avatars are the latest advances in this field, all providing easily accessible and cost-effective dementia management [59] and even diagnostic solutions [60]. Some of the virtual reality programmes contain creative activities that can be experienced in a 'real-time' context, for example, using one's fingers to sculpt an object, pottery and then paint objects with a selection of patterns [61].

Interestingly, older people with and without memory problems have not reported negative attitudes towards using technological advances, thus making their use in both clinical and home/community environments encouraging and acceptable. Art, being one of the essential forms of appreciation of beauty and a powerful tool to evoke old memories and enhance communication, is enjoyed by people with dementia, and the use of digital technology can not only enable continuation of this enjoyment, but also facilitate a person with dementia to be an integral figure in the process of interactive appreciation. This is particularly so with the creation of virtual galleries enhanced with digitally created AI art forms that enable a person to actively take part in the art presentation and be able to adapt the exhibits and display environment according to one's own interests, imagination, creativity, and/or interpretation of exhibits/events.

The role of culture and creative arts is recognized as being essential for social care of older people, particularly in care homes where people can become isolated and excluded from society [62]. The Mental Health Foundation (2011) [63] found that people who participated in visual arts, dance, theatre and drama, music and storytelling benefitted through improved wellbeing through increased self-confidence, sense of accomplishment, cognitive and physical function, enjoyment of life, memory and creative thinking. In extending the evidence base, Age Cymru (2017) [64] conducted an extensive evaluation of culture and arts related activities in 122 care homes across Wales involving residents, staff and artist practitioners. Their analysis found significant improvement in wellbeing and contributed to the inquiry report of the newly formed All Party Parliamentary Group on Arts, Health and Wellbeing (2017) [65].

The full potential of AI art in dementia care, in the light of its aesthetic diversity and conceptual richness, remains to be explored and determined. Although the above AI technologies provide a promising approach for the overall management of people with dementia, they also call for further research to address both their beneficial performance and potential harmful behaviours because of machine learning systems when wrong objective function(s) are specified (i.e. change and anomaly detection, hypothesis testing, transfer learning etc.) [reviewed in detail in 66]. This also raises broader ethical and societal concerns for their use among people who may have difficulties making some or all decisions about their lives The development of ethical guidance, thus, remain the high-priority area [54].

The novel opportunities of experiences with AI technologies are exciting regarding further stimulating senses, improving communication and overall enjoyment, besides being both educational and entertaining. In addition, the psychedelic experiences AI art technology offers may also have an additional impact on neuronal network dynamics of people with dementia, in terms of modifying their personality reducing anxiety and depression, as well as anti-inflammatory processes [67] and increasing functional connectivity in both subcortical [68] and cortical areas [69] as shown in studies using psychedelic drugs. If this is the case, AI art may provide an avenue for novel art-based neurobiological interventions for treatment and management of both

cognitive and behavioral symptoms in people with dementia. With advancements in the technology for creative interventions, such aesthetic creative technologies may even have potential to be customized in real-time, reflecting the hyper-personal needs and interests of individual people living with dementia, i.e. people with dementia and their carers creating their own AI art, based on familiar images, i.e. photos of familiar places and faces, as well as important events from one's life, as well as modifying the content. However, we should not forget the potential limitations of the AI technologies, including considerations/ethics of treatment/management and how these are managed in terms of direction/control of treatment that everyday practitioners need to be aware of, and how to install these sets of rules into AI technologies.

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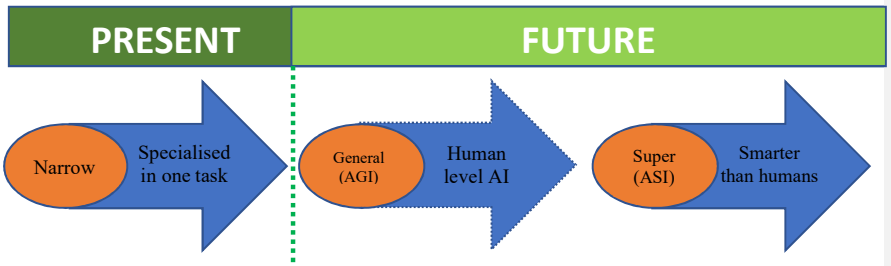

Figure 1: Types of Artificial Intelligence (AI) and their progression.

A narrow AI is used as decision-support tool with a focussed application, albeit a potentially broad range of operations that it may be applied to [i.e. workflow planning and optimization, fraud detection, error reduction, connected machines, automated (eg. vision-based) problem identification, cybersecurity, health diagnosis]. Within expert systems it may be used to support case-based reasoning, responding using speech synthesis, natural language generation, robot automation and systems control through computer apps (e.g. application interfaces).

General and Super AIs are many years from application, sometimes referred to as 'theory of mind' and 'self-aware' AIs [33]. A general AI (Artificial General Intelligence or AGI) can perform at the same level as a human and is the goal of AI development. AGIs should also have the abilities to acquire knowledge in real time, understand language, remember interactions and relate them to context, use knowledge to accelerate learning, manage conflicting goals and priorities, respond to human emotion, and do all this in a context with limited knowledge such as may reflect real world problems [34-36]. Super AIs (Artificial Super Intelligence or ASI) extend beyond this to achieve what is not humanly possible. These AIs and the 'intelligences' implied by the descriptions represent a broad evolution of the computer science discipline. Modified after Girardi E, in http://www.girablog.com/artificial-intelligence-art-ai/.

Figure 2. Interstitial Space 2019 at Art AI Festival, Leicester (Klingemann). Image used with permission, copyright retained by the artist.

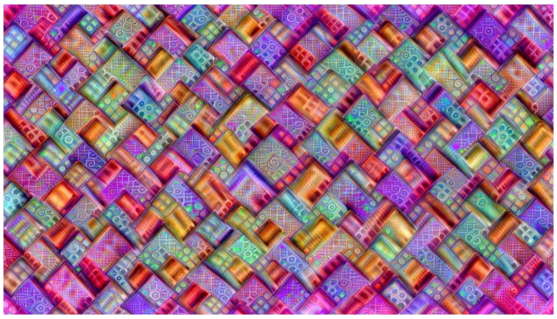

Figure 3. Neural Synthesis, exhibited at Art AI Festival 2019, Leicester (Kogan). Image used with permission, copyright retained by the artist.

Table 1: Examples of computational creativity

Creative software	How it works
AARON (a computer program that creates original artistic images)	Robotic system that can pick up a paintbrush with its robotic arm and paint on canvas on its own, with knowledge about body postures and plants by means of rules.
The Painting Fool software (a piece of software that produces its own artwork)	This software needs minimal direction and can use own concepts by going online for source material. It runs its own web searches through social media websites. The idea is that it may produce meaningful art since it is drawing on the human experiences.
Generative Adversarial Networks, or GANs (a class of machine learning systems: two neural networks contest with each other in a game. Given a training set, this technique learns to generate new data with the same statistics as the training set.)	Images are generated based on information contained within a database of more than 200,000 photographs. Alternatively, artists generate their own data sets to train the software rather than use existing images. DeepFake software is a GAN technique that combines and superimposes existing images and videos onto source images or videos. Google Tilt Brush tool is software based on the same principles, with images resembling contemporary abstract paintings.
Convolutional Neural Networks, or CNNs (a class of deep neural networks, usually applied to analysing visual images)	The neural networks five modern machine-learning systems the ability to perceive the world through vision, filtering e.g. obscene images or using psychedelic filters from web search(es). The machines are trained on a set of images of real-life objects and create abstract representational prints until the created forms register as a specific object confirmed by AI systems.
Google's TensorFlow (a software library for dataflow and differentiable programming library for dataflow and differentiable across a range of tasks. It represents a symbolic mathematical library. Also used for machine learning applications such as neural networks.)	This is an open-source software library used for machine learning, to classify archives of artist's own drawings. Its algorithms have contributed to a new form of psychedelic and abstract art.

Google's Deep Dream (a software designed to detect faces and other patterns in images, with the aim of automatically classifying images)	This program uses a convolutional neural network to find and enhance patterns in images via algorithmic pareidolia (is the tendency to interpret a vague stimulus as something known to the observer, such as seeing shapes in clouds, seeing faces in inanimate objects or abstract pattern), creating a dream-like hallucinogenic appearance in over-processed images.
RePaint technology (3D design and/or printing technology)	This system uses a neural network to identify a layout of a painting and predict the exact colour combination to recreate it. The neural network is trained to accurately predict colours using a dataset of 18,878 samples. The AI-based 3-D printing technology chooses from 10 different coloured transparent inks, stacking them in thin layers in a 3-D printer. The ink is applied using tiny ink dots instead of a continuous field of colour. The look of the final piece resembles a classic oil painting, but the created images lack surface texture The software can currently create prints the size of postcards.
SENSORY4™ (media platform that creates an engaging, multisensory environment)	Combines multichannel motion graphics, cinema quality surround sound and up to forty high-definition projectors to provide multiscreen environments.

Role of Artificial Intelligence (AI) art in care of ageing society: Focus on dementia

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Abstract

Background: Art enhances both physical and mental health wellbeing. The health benefits include reduction in blood pressure, heart rate, pain perception and briefer inpatient stays, as well as improvement of communication skills and self-esteem. In addition to these, people living with dementia benefit from reduction of their non-cognitive, behavioural changes, enhancement of their cognitive capacities and being socially active.

Methods: The current study represents a narrative general literature review on available studies and knowledge about contribution of Artificial Intelligence (AI) in creative arts.

Results: We review AI visual arts technologies, and their potential for use among people with dementia and care, drawing on similar experiences to date from traditional art in dementia care.

Conclusion: The virtual reality, installations and the psychedelic properties of the AI created art provide a new venue for more detailed research about its therapeutic use in dementia.

Key words: Dementia, ageing, carers, technology, artificial intelligence, art

Introduction

There is growing evidence of arts as a tool for enhancing mental health wellbeing. Active engagement with arts enables people to demonstrate their creativity, engage in the direct process of art development, appreciation and interactions. In addition, a number of benefits in terms of reducing distress among children and adolescents [1], improving emotional state i.e., depression and anxiety in both younger [2, 3] and older adults [3-5, 4, add Rawtaer er al, reference], anxiety in adults [4], improvement in- negative symptoms of schizophrenia [65], social cohesion in people with both psychotic and non-psychotic mental problems [76], enhancing sleep quality among older people [8], as well as and improvement in interpersonal relatedness, hopefulness and gratification for adults with post-traumatic stress disorder [97]- and self-esteem [3,10 ref] have all been demonstrated.

Arts therapy in dementia care

There is some research evidence for arts therapy, efficacy and as such the uptake of arts as a medium for care and self-care in dementia is discussed and put forward, not least because of its relative low cost and minimal risk [118], Art appears to reduce anxiety and confusion, improve generation of old term memories and emotion regulation, explore cognitions, and increase the overall wellbeing of people with dementia [118]. It is, thus, not surprising that art therapy is now considered as one of the non-pharmacological treatments for dementia, and in some countries even prescribed under the National Health Service, as is the case in Canada.

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Though the recent Cochrane review showed low efficacy of art therapy for people with dementia, this is because the findings were based on low quality studies [129], in contrast to high quality studies [i.e. Randomised Control Trials (RCT) and/or longitudinal studies using good psychometric measures) that show emerging efficacy. Thus, in twoa recent randomised control (RCT) studiesy, older people with mild cognitive impairment at risk to develop Alzheimer's disease who were allocated to creative expression therapy showed significantly higher performance in several cognitive domains than patients receiving standard cognitive training. These included general cognitive functioning, memory, executive function, functional status, and everyday living ability and these improvements were maintained at the 6-month [130] and 9- month [14] ref] follow-up [10]. Similar benefits in terms of improving vitality

and quality of life were achieved in an earlier RCT trial of art therapy for people with mild Alzheimer's Disease [151]. In another study, conducted among people with mild to severe dementia and living in both 24-hours (i.e., residential care homes and a county hospital) and community dwellings, Windle et al (2017) reported significant improvement in quality of life during the first 3-month follow-up, highlighting the benefits of art activities and the potential for creative aging within dementia care [162]. Similarly, multi-dimensional mental health benefits were described in a 13-week sculpture art-based therapy (2 hours/week) involving people with moderate to severe dementia [Mini Mental State Examination (MMSE) scores 0-18/30] who lived in nursing homes. In this study, remarkable improvements in mental state and concentration, self-reliance, self-esteem and physicality were seen in the sculptural activity dementia group (*n*=6), but not the control group (*n*=6) [173]. Larger studies on more divergent groups of people with memory problems are now needed to expand on these findings and validate them further prior routine use of art therapy in the treatment and management of people with dementia, both living independently and/or in 24-hours care.

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Art-centred activities for dementia

Art museums have now opened their doors to people with dementia and provide art-centred activities for both people living with dementia and their carers. The positive experience of the offered art tours and classes appear to be dependent on the museum space itself, the facilitation process, and socialization with other participants [184], with the well-being benefits experienced both by people with dementia and their carers equally from traditional and contemporary art gallery sites [19-2115, 16, ref], with carers reporting reduced carer's burden [1915]. The iInvestigation of ing this museum/art stimulation programs for people with dementia facesrequires a more rigorous validation of the assessment methods for them to be considered as a nonpharmacological intervention for this population, as suggested recently via the proposed 'Artwork effect' paradigm, which is in accordance to the personhood model [22ref].

Although subjective participants' experiences of these interventions are in the domains of positive emotional and cognitive experiences, reduced isolation and built social networks [2317] only lately is there evidence from randomised control trials

about objective benefits of such interventions among people with dementia. Thus, the ARTEMIS (ART Encounters: Museum Intervention Study), an art-based intervention consisting of a combination of museum visits and artistic activity for both people with dementia and their carers/partners, reported improvements in participants' self-rated quality of life, and a significant positive change of emotional well-being immediately after each of the museum sessions. These improvements were also accompanied by decline in the Neuropsychiatric Inventory (NPI) scores in several domains, including affective (depression and anxiety) and apathy subscales [24~~18~~]. What is potentially important about these two findings is a revaluation of mental health themes identified. the above two studies [23, 24~~17, 18~~] present evidence of two powerful mental health outcomes around the way that mental health is conceptualised; hedonic and eudaimonic well-being [25~~19~~]. Schall et al [24~~18~~] identify depression and anxiety outcomes from interventions. These are popular assessments of well-being (such as those used in primary and secondary care situations), that fall into a hedonic well-being domain. This domain assesses specific positive and negative emotion within a particularly short timeframe. However, Flatt et al [23~~17~~] in identifying concepts such as feelings of autonomy, mastery or control, having a sense of importance accepted, or acceptance, are finding evidence of effects of ~~*Eudaimonic*~~ *eudaimonic well-being.* Eudaimonic well-being involves individual development through engagement with the challenges within life, concentrating on issues of meaning and self-reflection. This idea has huge pedigree in psychology and this type of well-being been singled out as a protective resilient factor for promoting positive health and life factors across the life-span and into old age [26~~0~~].

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Similarly, museum settings with historically authentic environments that recreated the material and cultural context of participants' youth provoked more autobiographical memories, and these memories were more elaborated, detailed and spontaneous, compared to the memories evoked in a control condition [27~~1~~]. However, a cross-sectional observational Dutch study highlights that offered museum programmes need to be adapted to the degree of dementia, since art appreciation and responsiveness appears to be related to the severity of dementia, specific cognitive impairments and also to the type of artworks [28~~2~~]. Thus, people with more advanced dementia responded less to art than those with milder impairments, whereas people at early to middle stage dementia showed larger positive increases in wellbeing [29~~3~~, 30~~24~~].

The type of artwork also appears to have a different impact upon the enjoyment of artwork. Thus, artworks containing more natural elements revealed less interaction with others, in contrast to artefacts i.e., objects not originally meant as artworks, evoking more reactions than the artworks *per* sé [282], suggesting that imaginary unreal art presentations are not only well received by people with dementia, but cause more curiosity and interactions than the traditional forms of art.

The above studies have provided valuable information about the appreciation of art by people with dementia. The data to date confirms that modern art is appreciated by people with dementia and, in fact, the art that stimulates creativity and fantasy seems to be much more appreciated and caused interest among people with dementia. In the era of digital technologies, the exposure to an algorithm-created digital art is becoming a reality. These digitally psychedelic and fantasmorganic images may well trigger unexpected emotional responses and interactions, and contribute to changing neuronal network dynamics, whilst enhancing fantasies, facilitating memories and communications.

What is Artificial Intelligence?

~~Mechanization~~Automation and ~~its~~ accompanying technologies have been embraced by artists throughout centuries. It is, thus, not surprising~~,~~ that most recent technological evolvements in the form of artificial intelligence have been added to the growing list of art-making techniques, enabling artists ~~face new challenges in~~to combin~~e~~ing creative processes with digital innovations.

-Artificial Intelligence (AI) comprises an assemblage of technological advancements that appear to simulate human intelligence (figure 1).~~.~~ Most recent ~~Minsky (1967) [3125] defined~~ AI ~~as a~~ technology ~~or machine that would perform a task which if conducted by a human would require intelligence to complete. Another definition describes AI as~~extends to machines -having the capacity to learn [31~~22~~6], to sense, reason and take action to detect, deliberate and develop on its own to ~~devise~~ determine the attributes in a dataset that are predictive [323~~27~~]. ~~There are, broadly, three types of AI: narrow, general and super-AIs (figure 1). A narrow AI is used as decision-support tool with a focussed application, albeit a potentially broad range of~~

~~operations that it may be applied to. This may include workflow planning and optimization, fraud detection, error reduction, connected machines, automated (eg. vision-based) problem identification, cybersecurity, health diagnosis. Narrow AIs increasingly use natural language processing for such things as machine translation and sentiment analysis, where it may be employed within recommender systems, data mining and learning including reinforced, supervised and unsupervised learning contexts. Within expert systems it may be used to support case-based reasoning, as well as in responding using speech synthesis, natural language generation, robot automation and systems control through computer apps (e.g. application interfaces).~~

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~~General and Super AIs are, arguably, many years from application, sometimes referred to as 'theory of mind' and 'self-aware' AIs [3428]. A general AI (Artificial General Intelligence or AGI) can perform at the same level as a human and is broadly acknowledged as the goal of AI development. As well as being able to acquire and apply knowledge in a defined way, AGIs must also encompass abilities such as to acquire knowledge in real time, understand language, remember interactions and relate them to context including other actors, use knowledge to accelerate learning, abstract and generalize knowledge acquired, manage conflicting goals and priorities, respond to human emotion, and do all this in a context with limited knowledge such as may reflect real-world problems [3529-371]. Super AIs (Artificial Super Intelligence or ASI) extend beyond this to achieve what is not humanly possible. These AIs and the 'intelligences' implied by the descriptions represent a broad evolution of the computer science discipline.~~

Whilst AIs are advancing at a rapid pace, it is the humanistic perspective of AI that enables researchers to ask questions of the ethical guidelines that shape its evolution. Common questions such as 'how much autonomy should a machine have?' and 'what level of decision-making power should a machine have?' are increasingly being asked. Organizations such as UNESCO are calling for policy and standards that put human-centred design that addresses social value and inequalities in all forms at the heart of its development.

Expectations for adoption of AI are in a range of services including healthcare, public and consumer facing sectors [3782] and its impact is anticipated to be on all types of activities from information and operations management, research and development, supply chain management, marketing and customer services [3893].

Incorporated into so-called smart environments, AIs use data gathered from ambient technologies (such as sensors, telecoms networks) to provide sustainable resource efficiencies and provide new insight from complex datasets to stakeholders [394034]. A smart context can be almost anything from a home to a service, a community, a neighbourhood or city. Configuration of an environment is unique to stakeholders and/or users - consumers build homes and install a range of physical devices that acquire data, service providers do likewise. AIs learn from datasets generated by the interactions between objects and agents (people, devices) operating within its system boundaries (see [40135]). Of significance in a smart environment is for whom it is 'smartified'is beneficial, thus the concept of ambient intelligence is a typical user-centric paradigm used to describe the adaptive nature of the context [41236]. As computer processing and network capabilities increase, along with the growing number of objects recognized it an environment, so the potential for new services expands exponentially. Examples of smart service environments are in healthcare facilities such as hospital rooms that are being modelled with ambient technologies that assist both patients and medical staff through integrated sensor technologies [42337].

AI technology and art

Tangential to this, another an area of interesting application of AI technologies is that of cultural production, where artists use AIs (algorithms) to support collaborations with datasets that produce creative outcomes (table 1). The AIs are generally trained on some visualaesthetic , artistic data forms such as a corpus of music, painting, or poetry or film. It Artists uses an algorithm to learn identify some interesting things about the dataset that it in various ways they then employs to devise new creative forms. Some (e.g.,[43438, 44539]) suggest that its the use of AIsuse as a creative device facilitates a more humanistic approach to understanding the role of the technological advancement because it presents opportunities for a diverse skillset to

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be involved in new forms of cultural production. Once the domain of trained artists, AI-art can be produced by coders and those without traditional talent in music notation, instrumentation, ~~or~~ drawing or scriptwriting competencies to become creators. In effect, the AI becomes the paintbrush.

- Table 1 here-

By way of example, the image in figure 2 is a screen capture of an interactive moving art installation (exhibited during the Art AI Festival in Leicester, May 2019) that combines the viewer's facial characteristics with images from a vast database of historic European portraiture. The artist has trained an AI to match and create a unique image for each viewer using facial recognition technology, and each image created is also 'memorized' to inform subsequent viewers' experiences, thereby expanding the database. The image created, however, is never repeated.

- Figure 2 here -

~~Figure 2 Interstitial Space 2019 at Art AI Festival, Leicester (Klingemann)~~

~~image used with permission, copyright retained by the artist~~

In general, the artworks produced via AI appear to be neither aesthetically nor conceptually rich enough to hold the attention of art experts for long. In the words of Theo Triantafyllidis (an AI artist) '… (the) state-of-the-art AI today is somewhere between a really clumsy child and a really smart pet'. Even artwork produced with the generative Adversarial Networks software, known as GANs, share similar characteristics of surreal distortions that are now referred to as the 'Francis Bacon effect' (Barratt; Klingemann).

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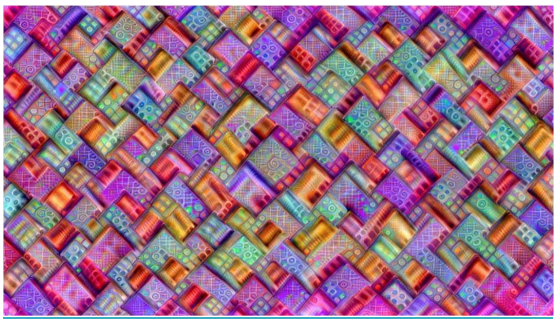
Interestingly, similar distortions in proportion and perspective, as well as defects in spatial organization, lack of individual characteristics in depicting subjects, as well as increasing trend in photographic realism are also noted in the work of artists with dementia [456], ~~including who had~~who had Alzheimer's disease [4~~0~~]~~67-489~~ and Lewy Body, Fronto-temporal lobe and/or Vascular dementias [495~~0~~].~~-~~

~~-~~In a recent pilot study conducted by our group (EBM-L and TH, unpublished data) people with dementia, their carers and professionals had very similar attitudes towards conventional and AI generated art. They recognised correctly the ~~machine~~AI generated art in 90% of cases, with people with memory problems correctly identifying the ~~machine~~AI generated art. Only two (0.125%) of the Memory Clinic Service users (≈ 1,600 in total over 3 weeks duration) complained about distorted, static images (i.e. images resembling melting faces, joint faces showing 3 eyes), finding them distressing in relation to some of the artwork presented. ~~, whereas~~A ~~a~~n AI installation that showed different types of more abstract and psychedelic moving images (see figure 3) was received well, and kept the attention of viewers for longer, despite its repetitive nature (sequence repeated every 3 minutes throughout the day, 9am-5pm).

- Figure 3 here -

~~Figure 3 Neural Synthesis, exhibited at Art AI Festival 2019, Leicester (Kogan)~~



~~image used with permission, copyright retained by the artist~~

The relaxing, calming effects of the AI installation were highlighted by 35% (6 out of 17) of the service users and participants in the study. This is the first evidence that older people with and without memory problems respond well to new technological

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art advances. This *per sè* ~~is~~è is encouraging enough to consider the possible therapeutic implications of these novel art forms for people with dementia.

Conclusions

The technological advances are redesigning modern healthcare: from AI algorithms able to mine medical records, design treatment plans, find novel therapies from a database of molecular structures and repositioning existing drugs, to generating virtual and augmented reality experiences. These advances have not bypassed the dementia healthcare: they have contributed to improving dementia diagnostic accuracy [50], estimate dementia risk factors [51], inform about dementia prognosis [52], as well as determine (non)pharmacological management [53] of people with dementia. However, the implementation of technology driven dementia care raises concerns, starting from ethical and regulatory frameworks, lack of clear guidance on development and use of AI applications, their integration in both clinical practice and training of healthcare professionals. Are the current clinical services under threat to be replaced by these novel technologies? What about responsibilities towards and supervision of service users and medical practitioners? What is the potential for misuse of technology if used to replace established services? Similarly, patients' autonomy and long-term effects of these applications on understanding illnesses and management remain areas of concern (reviewed in [54]).

Technological advances have contributed to a wide range of products and services available to people with dementia to live independently, including telecare and assistive technology. A recent study found that the acceptability, utility, usability, and efficacy of the technology were evaluated as positive among people with dementia and their carers [55~~0~~141], improving their quality of life, reducing healthcare costs, ~~and~~ premature institutional care [56~~1~~42] and augmenting and support their social interactions [57~~2~~3]. ~~-~~In addition, they also mitigate the mental and physical burden of dementia caregivers [58~~3~~4~~1~~3].

~~, improve diagnostic accuracy for both dementia [2] and depression/anxiety [4] for older adults. .~~Many applications have been specifically designed for people with dementia and their carers in mind, such as games, digital photobooks, reminiscence

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aids. Virtual reality programmes and environments including avatars are the latest advances in this field, all providing easily accessible and cost-effective dementia management [595~~644~~] and even diagnostic solutions [606~~745~~]. Some of the virtual reality programmes contain creative activities that can be experienced in a 'real-time' ~~gaming~~ context, for example, using one's fingers to sculpt an object, pottery and then paint objects with a selection of patterns [617~~846~~].

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Interestingly, older people with and without memory problems have not reported negative attitudes towards using technological advances, thus making their use in both clinical and home/community environments encouraging and acceptable. Art being one of the essential forms of appreciation of beauty, and a powerful tool to evoke old memories and enhance communication is enjoyed by people with dementia, and the use of digital technology can not only enable continuation of this enjoyment, but also facilitate a person with dementia to be an integral figure in the process of interactive appreciation. This is particularly so with the creation of virtual galleries enhanced with digitally created AI art forms that enable a person ~~can~~ to actively take part in the art presentation and be able to adapt the exhibits and display environment according to one's own interests, imagination, creativity, and/or interpretation of exhibits/events.

The role of culture and creative arts is recognized as being essential for social care of older people, particularly in care homes where people can become isolated and excluded from society [628~~947~~]. The Mental Health Foundation (2011) [635~~96048~~] found that people who participated in visual arts, dance, theatre and drama, music and storytelling benefitted through improved wellbeing through increased self-confidence, sense of accomplishment, cognitive and physical function, enjoyment of life, memory and creative thinking. In extending the evidence base, Age Cymru (2017) [640~~149~~] conducted an extensive evaluation of culture and arts related activities in 122 care homes across Wales involving residents, staff and artist practitioners. Their analysis found significant improvement in wellbeing and contributed to the inquiry report of the newly formed All Party Parliamentary Group on Arts, Health and Wellbeing (2017) [651~~250~~].

The full potential of AI art in dementia care, in the light of its aesthetic diversity and conceptual richness, remains to be explored and determined. Although the above AI technologies provide a promising approach for the overall management of people with dementia, they also call for further research to address both their beneficial performance and potential harmful behaviours as a result of machine learning systems when wrong objective function(s) are specified (i.e. change and anomaly detection, hypothesis testing, transfer learning etc.) [reviewed in detail in 66]. This also calls for broader ethical and societal concerns for their use among people who may have difficulties making some or all decisions about their lives. The development of ethical guidance, thus, remain the high-priority area [54].

The novel opportunities of ~~3D~~ experiences with ~~the~~ AI technologies ~~y offers~~ are exciting regarding further stimulating senses, improving communication and overall enjoyment, besides being both educational and entertaining. ~~.~~ In addition, the psychedelic experiences AI art technology offers may also have an additional impact on neuronal network dynamics of people with dementia, in terms of modifying their personality reducing anxiety and depression, as well as anti-inflammatory processes [67~~23~~~~51~~] and increasing functional connectivity in both subcortical [68~~34~~~~52~~], and cortical areas [69~~45~~~~53~~] as shown in studies using psychedelic drugs. If this is the case, AI ~~visual~~ art may provide an a~~n a~~venue for novel art-based neurobiological interventions for treatment and management of both cognitive and behavioral symptoms in people with dementia. With advancements in the technology for creative interventions, such ~~visual~~ aesthetic creative technologies ~~art~~ may even have potential to be customized in real-time, reflecting the hyper-personal needs and interests of individual people living with dementia, i.e. people with dementia and their carers creating their own AI art, based on familiar images, i.e. photos of familiar places and faces, as well as important events from one's life, as well as modifying the content. However, we should not forget the potential limitations of the AI technologies, including considerations/ethics of treatment/management and how these are managed in terms of direction/control of treatment that everyday practitioners need to be aware of, and how to install these sets of rules into AI technologies.

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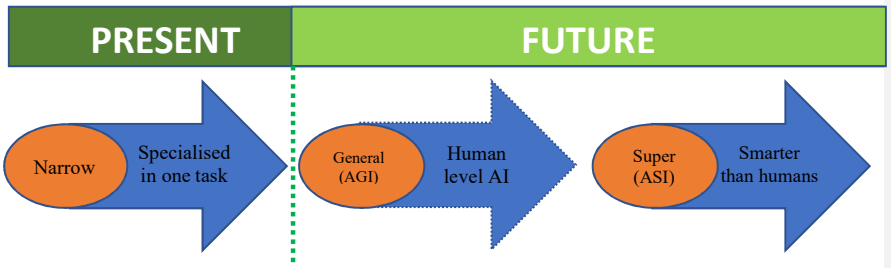

Figure 1: Types of Artificial Intelligence (AI) and their progression.

A narrow AI is used as decision-support tool with a focussed application, albeit a potentially broad range of operations that it may be applied to [i.e, workflow planning and optimization, fraud detection, error reduction, connected machines, automated (eg. vision-based) problem identification, cybersecurity, health diagnosis]. Within expert systems it may be used to support case-based reasoning, responding using speech synthesis, natural language generation, robot automation and systems control through computer apps (e.g. application interfaces). ~~More detailed explanation is contained within the text.~~

General and Super AIs are many years from application, sometimes referred to as 'theory of mind' and 'self-aware' AIs [33]. A general AI (Artificial General Intelligence or AGI) can perform at the same level as a human and is the goal of AI development. AGIs should also have the abilities to acquire knowledge in real time, understand language, remember interactions and relate them to context, use knowledge to accelerate learning, manage conflicting goals and priorities, respond to human emotion, and do all this in a context with limited knowledge such as may reflect real world problems [34-36]. Super AIs (Artificial Super Intelligence or ASI) extend beyond this to achieve what is not humanly possible. These AIs and the 'intelligences' implied by the descriptions represent a broad evolution of the computer science discipline. Modified after Girardi E, in http://www.girablog.com/artificial-intelligence-art-ai/.

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Figure 2. Interstitial Space 2019 at Art AI Festival, Leicester (Klingemann). Image used with permission, copyright retained by the artist.

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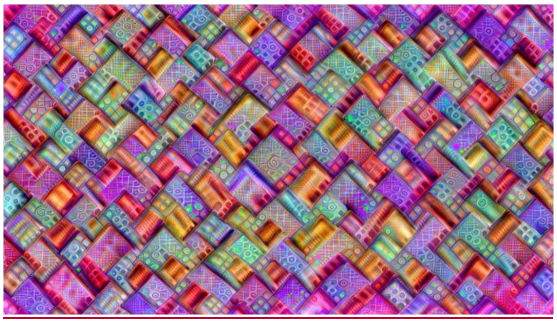

Figure 3. Neural Synthesis, exhibited at Art AI Festival 2019, Leicester (Kogan). Image used with permission, copyright retained by the artist.

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Table 1: Examples of computational ~~visual~~ creativity

Creative software	How it works
AARON (a computer program that creates original artistic images)	Robotic system that can pick up a paintbrush with its robotic arm and paint on canvas on its own, with knowledge about body postures and plants by means of rules.
The Painting Fool software (a piece of software that produces its own artwork)	This software needs minimal direction and can use own concepts by going online for source material. It runs its own web searches through social media websites. The idea is that it may produce meaningful art since it is drawing on the human experiences.
Generative Adversarial Networks, or GANs (a class of machine learning systems: two neural networks contest with each other in a game. Given a training set, this technique learns to generate new data with the same statistics as the training set.)	Images are generated based on information contained within a database of more than 200,000 photographs. Alternatively, artists generate their own data sets to train the software rather than use existing images. DeepFake software is a GAN technique that combines and superimposes existing images and videos onto source images or videos. Google Tilt Brush tool is software based on the same principles, with images resembling contemporary abstract paintings.
Convolutional Neural Networks, or CNNs (a class of deep neural networks, usually applied to analysing visual images)	The neural networks five modern machine-learning systems the ability to perceive the world through vision, filtering e.g. obscene images or using psychedelic filters from web search(es). The machines are trained on a set of images of real-life objects and create abstract representational prints until the created forms register as a specific object confirmed by AI systems.
Google's TensorFlow (a software library for dataflow and differentiable programming library for dataflow and differentiable across a range of tasks. It represents a symbolic mathematical library. Also used for machine learning applications such as neural networks.)	This is an open-source software library used for machine learning, to classify archives of artist's own drawings. Its algorithms have contributed to a new form of psychedelic and abstract art.

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Google's Deep Dream (a software designed to detect faces and other patterns in images, with the aim of automatically classifying images)	This ~~computer vision~~ program uses a convolutional neural network to find and enhance patterns in images via algorithmic pareidolia ~~(is the tendency to interpret a vague stimulus as something known to the observer, such as seeing shapes in clouds, seeing faces in inanimate objects or abstract pattern)~~, creating a dream-like hallucinogenic appearance in over-processed images.
RePaint technology (3-D design and/or printing technology)	~~AI-based 3_d printing technology chooses from 10 different coloured transparent inks, stacking them in thin layers in a 3-d printer. The ink is applied via half-toning, a method that uses tiny ink dots instead of a continuous field of colour.~~ This system uses a neural network to identify a layout of a painting and predict the exact colour combination to recreate it. The ~~researchers~~ neural network is trained to accurately predict colours using a dataset of 18,878 samples. The AI-based 3-D printing technology chooses from 10 different coloured transparent inks, stacking them in thin layers in a 3-D printer. The ink is applied using tiny ink dots instead of a continuous field of colour. The look of the final piece resembles a classic oil painting, but the created images lack surface texture The software can currently create prints the size of postcards.
SENSORY4™ (media platform that creates an engaging, multisensory environment)	Combines multichannel motion graphics, cinema quality surround sound and up to forty high-definition projectors to provide multiscreen environments.

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