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The recent report published by the Australian Productivity Commission states:

Taxpayers should spend \$975 million a year to hire a “wellbeing leader” for every school, to spot students with mental health problems and send them to psychologists.

One in seven Australian children has a mental illness, which can range from anxiety and depression to attention deficit hyperactivity and conduct disorders.

At school, one in 20 kids needs extra help in class due to “social and emotional disability”.

The Commission says half of all Australians will suffer a mental illness at some time in their life costing the nation \$500 million a day in treatment and lost productivity.

Despite \$18 billion a year spent on mental health, the commission found that one million Australians are failing to get treatment for illnesses including anxiety and depression.

A quarter of 16 to 24-year-olds have an anxiety, mood or substance use disorder, the report says, and three-quarters of Australians with a mental illness will first experience symptoms before they turn 25.

#1 Understanding Stress Effects

‘Some people thrive on stress and even need it to get things done. When the term ‘stress’ is used in a clinical sense, it refers to a situation that causes discomfort and distress for a person and can lead to other mental health problems, such as anxiety and depression.

Stress affects us in many ways, including:

- a. Emotionally - anxiety, depression, tension, anger
- b. The way we think - poor concentration, forgetfulness, indecisiveness, apathy, hopelessness
- c. Behaviourally - increased drinking and smoking, insomnia, accident proneness, weight problems, obsessive-compulsive behaviour, nervousness, gambling.’ (Better Health Channel, Victoria State Government).

#2: Prevention and Early Intervention

Psychological and physiological benefits of viewing nature have been extensively studied and it has been recently suggested that a positive effect can be explained by nature’s fractal properties (Hägerhäll, Laike, Kuller, Marcheschi & Taylor, 2015). The visual connection with nature patterns has evolved from research on visual preference and responses to views of nature showing reduced stress, more positive emotional functioning, and improved concentration and recovery rates (2014 Terrapin Bright Green, llc p25, Appendix End Notes (P1) p53). In general, stress recovery from visual connections with nature have reportedly been realised through lowered blood pressure and heart rate; reduced attentional fatigue, sadness, anger, and aggression; improved mental engagement/attentiveness, attitude and overall happiness. There is also evidence for stress reduction related to both experiencing real nature and seeing images of nature (2014 Terrapin Bright Green, llc p24, Appendix End Notes (P1) p53).

‘In such fractal environments, our body automatically dampens its response to stress induced by intensive tasks and reaction to external forces. This implies that

particular fractal environments are healing, or at least buffer us from life's stresses. The remarkable fact is that this response is independent of what the fractal designs around us actually look like: they can be either representational or abstract. Altogether, we have here the beginnings of a new way of interpreting how the visual environment affects our health.

Further, seeing images of nature elicits a positive impact on mood and self-esteem. Just being in nature for ten minutes prior to experiencing a mental stressor has shown to stimulate heart rate variability and parasympathetic activity (i.e., regulation of internal organs and glands that support digestion and other activities that occur when the body is at rest) (Brown, Barton & Gladwell, 2013). Whilst viewing a forest scene for 20 minutes after a mental stressor shows cerebral blood flow and brain activity returning to a natural relaxed state (Tsunetsugu & Miyazaki, 2005, Terrapin Bright Green LLC, 2014).'

The psychological benefits of viewing natural scenery has generated great interest both theoretically and empirically. Much of the psychology studies on the topic refer to nature in broad terms but less research has been directed to elaborating on the concept of nature and what makes its visual pattern unique for psychological benefits.

#3 Physiological Response to Fractals

'Visual perception studies reveal human preferences for fractal landscapes and structures. I review material here from Richard Taylor and Janes Wise (Taylor 2006: Wise, Rosenberg 1986; Wise, Taylor 202). They found that people feel more comfortable with fractal images showing nature, over non-fractal images such as non-fractal abstract art. The first point to emphasize is that those research studies used physiological measures and did not depend upon responses giving the subject's preference, because that could be, and usually is, influenced by learned biases. Instead, the body's automatic responses were rated by measuring skin conductance. It is known in medical profession that raised skin conductance (electrodermal response)

correlates very well with increased bodily stress. Therefore, the sink conductance will peak in a stress-inducing environment, and will be reduced in a low-stress environment' (Salingaros, N (2012), p14).

Fractals in nature consist of pattern that recur on finer and finer scales, building scale-invariant shapes of immense complexity i.e. shells, river paths, coastlines, mountain ranges, clouds, waves, vegetable like broccoli, trees, some flowers, froth bubbles and some plants such as ferns.

Even though there are currently a limited number of studies on the subject (see list below), this paper comes to support the fact that fractals do reduce stress by their presence and 'can even do more if used as a therapeutic instrument in psychologist's offices' (Simion, MR., 2016).

Research including the work of many scientists (i.e. Salingaros, Taylor, Vogel, Williams etc.) supports measurable, positive impacts of a particular natural fractal dimension range on health. These efforts prove relevant to strengthening the empirical evidence for the human-nature connection and raising its priority level in everyday life.

Over the past decade, health psychologists have begun looking at how the arts might be used in a variety of ways to reduce symptoms, and alter behaviors and thinking patterns (Camic, 2008). Put together, art combined with fractals in nature may have great implications for well-being, such as the findings seen in Taylor's recent study (2017).

Salingaros N,(2012) a seasoned mathematician and educator the University of Texas in San Antonio, suggests in his work that fractal environments may be healing and could help the viewer to feel less stressed by tasks, deadlines and other stimuli. He also indicates that fractals with the right dimensions and those, which are not too complex and intricate, have positive effects no matter if abstract or representational. Further he suggests that as long as the size is right, the schools can

use any kind of fractal images regardless of colour or size (Salingaros, N., 2012, Simion, MR, 2016). Instead, offices, schools and homes are continually being built with a business criterion; only to see the same stress-raising environments reproduced in work environments of all types (Salingaros, N, 2012). It is well known that stress is the precursor to a plethora of mental health concerns.

Salingaros N (2012) ‘argues that fractal images reduce stress in the workplace and living environment, and digs deeper into results that certain fractals are better than others in accomplishing this task. Experimental evidence suggests that there is an optimal fractal dimension required to reduce stress, and that being exposed to plain non-fractal shapes increases a person’s stress levels. These results explain why we naturally prefer fractal images in our environment, and consequently, why humankind has produced intrinsically fractal traditional art, artifacts, and architecture. We know that we enjoy the complex patterns of woodland scenes, which are shown to be fractal. Going beyond simple enjoyment, people consider exposure to natural scenery to be restorative; it is good for our health.’ (Salingaros, N (2012), p13).

#4 FracArt Contribution

FracART was developed due to the research in this area. FracArt is a company that develops images with specific quantifiable qualities. These quality parameters have been found to have positive effects. In the science based studies (see Reference List) suggest that human exposure to fractals are responsible for lower level or perceived stress and cortisol (stress hormone) concentration in their blood more than the aesthetics of nature itself. In particular, these studies relate to a mathematical property called fractal dimension.

FracArt is devoted to articulate the relationships between nature, science and health. FracArt patterns are reflective of associations that are known to enhance our lives through a connection with nature. FracArt present mind benefits by incorporating real nature images processed to a specific-fractal dimension range and art

arrangement. These images incorporate effects extracted from science studies to achieve FracArt patterns. Micro-restorative real nature patterns by FracArt might include moments of visual contact with real nature through a wall hanging poster.

As shown in recent research studies with regards to fractals and their ability to reduce stress levels (Taylor, 2017), we expect FracArt patterns will be useful in classrooms rather than photos of natural elements. In this connection, FracArt patterns, in principle, promise an efficient way to improve educational workspaces and to contribute to a healthy education based on empirical evidence of fractal ability to subtly reduce stress. FracArt real nature patterns have been developed through extensive interdisciplinary collaboration and based on the findings of scientific research of fractal dimensions.

We hope this submission presents a contribution to thinking more critically about the human connection with nature. We believe FracArt's use of real nature patterns can be used as a tool for improving health and well-being in environments where stress and anxiety may be induced or prevail (i.e. school settings, childcare settings and mental health care settings).

#5 FracART Pattern Applications:

The intended recipients and users of FracArt real nature patterns are education systems, corporate employers and health professionals, workplaces, and public place administrators. Benefits of FracArt patterns could be categorized in two distinct areas of our well-being:

a. Enhancement of daily functions

Fractals would ideally be present in every workspace. Impact on reducing stress, would guide us to preferably think in different environments. FracArt real nature patterns have a wide range of applications for both interior and exterior environments, and are meant to be flexible and adaptive, allowing for project-appropriate implementation.

b. Improve learning potentials

It is expected that FracART patterns will help children and teachers cope with school demands such as competition, deadlines, evaluation, and comparison (Torsheim & World, 2001; Crnic & Low, 2002; Brooks, 2005). A calmed atmosphere, due to the products of FracART, especially at school, would offer children a proper setting to facilitate and develop knowledge acquisition, a reduction of stress and increase in concentration may result.

The objective of the visual connection with a FracArt real 'nature pattern is to provide an environment that helps the individual shift focus to relax the eye muscles and temper cognitive fatigue' (Terrapin Bright Green LLC (2014), p25). When in built environments and nature is not evident 'simulated or constructed nature is measurably better at engendering stress reduction than having no visual connection at all' (Terrapin Bright Green LLC (2014), p25)

#6 Human Health and FracART

The benefits of viewing real nature may be enhanced by a FracArt real nature pattern. They will certainly be of greatest value to spaces that, due to the nature of its function cannot easily incorporate real nature or views to the outdoors i.e. school corridors, school classrooms, health care facility waiting rooms, storefront pedestrian promenades, convention facilities, nurse's quarters, meeting rooms and auditoriums, lecture rooms, dormitories, exercise/gym centers, indoor arenas and back-of-house and night shift worker's areas.

FracArt produces a form of fractal art by 'Computer technology using the algorithms of mathematical and geometric functions can produce fractal designs If a fractal design is being created, consider using geometries with a mid-range dimensional ratio (broadly speaking, $D=1.3 - 1.75$). Over-use of and/or extended exposure to high-fractal dimensions could instill discomfort or even fear, countering

the intended response: to nourish and reduce stress. Avoidance or under-utilization of fractals in design could result in complete predictability and disinterest.’ (Terrapin Bright Green LLC (2014), p43).

Floral-patterns and botanic graphics i.e. leaves, flowers and nature images have featured in interior environments on fabrics, wall hangings and interior décor as well as fashion through the ages and all levels of society.

FracArt research is in regard to ‘a general sense for the purpose of addressing universal issues of human health and well-being’ (e.g., stress, visual acuity, hormone balance, creativity) within program-based or sector-specific public space types (e.g., health care facility waiting rooms workplaces, or storefronts or pedestrian corridors/walkways). As such, the focus is on patterns in nature known, suggested or theorised to mitigate common stressors or enhance desirable qualities that can be applied across various sectors and scales’. (Terrapin Bright Green LLC (2014), p5).

‘There is also evidence for stress reduction related to both experiencing real nature and seeing images of nature. Visual access to biodiversity is reportedly more beneficial to our psychological health than access to land area (i.e., quantity of land).[P1]’. (Terrapin Bright Green LLC (2014), p24).

A study from Berman (2008) shows that breaks taken in nature can stimulate attention and productivity of working memory. Some participants were asked to relax during work time for ten minutes in a room with pictures of nature and in the other part, in a room with city photographs. The results showed that working memory, attention, and relaxation were 20% better for those who were exposed to nature (Berman, 2008). Nature seems to reduce stress and improve memory and attention even when it is present just in pictures (Simion, 2016).

7 Fractal dimension

Fractals are the smallest unit of a self-similar shape. They can be found in many natural occurring arrangements such as river paths, coastlines, mountain ranges, clouds, waves, vegetables like broccoli, trees, some flowers, froth bubbles and some plants such as ferns.

‘An art pattern with good complexity & order feels engaging and information-rich, as an intriguing balance between boring and overwhelming’ (Terrapin Bright Green LLC (2014), p42). FracArt’s ‘complexity & order patterns has evolved from research on fractal geometries and preferred views; the perceptual and physiological responses, to the complexity of fractals in nature, art and the predictability of the occurrence of design flows and patterns in nature.(P10)’ (Terrapin Bright Green LLC (2014), p42).

Salingaros ‘has examined a series of fractal perspectives with great clarity stating ‘research has repeatedly confirmed Goldberger, Joye, Taylor, Wise, and I (and other researchers in this field) agree on one fundamental point: there appears to be a certain resonance between our cognitive apparatus and environments that possess fractal properties. Furthermore, not all fractals elicit the same degree of positive emotion leading to physiological stress reduction, but specifically midrange fractals with fractal dimension around $D=1.4$ ’ ... (Salingaros N (2012), p22).

Richard Taylor a Professor of Physics, Psychology, and Art / Head, Department of Physics elaborated on fractals as a natural stress-reducer ... ‘I lead an interdisciplinary research network that investigates the positive physiological changes that occur in people when they look at fractal patterns. The experiments - which use eye-tracking equipment to examine how people look at the patterns, and qEEG with fMRI probing techniques to quantify the resulting brain activity - indicate that people are ‘hard-wired’ to respond to a specific form of fractal found in nature, one that reduces stress levels by up to 60%. This stress-reduction is triggered by a physiological resonance that occurs when the fractal structure of the visual system matches that of the fractal image being viewed. Our discovery that exposure to fractals automatically relaxes people holds crucial implications for society: the U.S. spends over \$300 billion

annually on stress-induced illnesses, and stress is increasing blamed for precipitating debilitating disorders such as schizophrenia. As society increasingly surrounds itself with urban landscapes, people risk disconnecting from this natural stress-reducer'. (Taylor, Richard (February 3, 2016)

Salingaros believes that 'architecture that is adapted to human physiology is nourishing because it generates positive feelings through cognitive response to symmetries and fractal structures (Salingaros 2003). 'An artificial environment with those measurable qualities provides a better quality of life (Salingaros 2012). 'By contrast, stressful environments with the opposite characteristics induce anxiety and depressive behaviour, and ultimately pathology in their users and residents.' Salingaros (2012), p14).

#8 The Future

Future research is motivated by the prospect of customizing visual landscapes and wall art to aid human functioning and stress reduction in mentally demanding indoor and outdoor environments. More generally, fractals could play a growing role in incorporating favorable visual properties in our everyday environments to foster general well-being. FracArt expertise ensures that we take the 'middle ground' i.e. at either end of the spectrum, both non-fractal artwork and high dimensional fractal artwork have been shown to induce stress (Hagerhall et al., 2008; Taylor, 2006). (Terrapin Bright Green LLC (2014), p.22). The calm benefits of FracArt visuals of real nature can help maintain mind balance, with indoor interventions delivering the desired response through-out the seasons.

FracArt would like to initiate talks with The Australian Department of Education to introduce FracArt work into the use of stress and anxiety reduction in the school setting. This document contains a summary of the benefits involved in establishing nature-health relationships to every-day lives.

Subject to a favorable response, FracArt foresees forward steps to include

working sessions where these concepts are discussed with a group designated by the Australian Department of Education.

Salingaros states ‘The work summarized here addresses how fractal visuals influence human beings during the performance of stressful mental work. Beneficial, restorative environments dampen the inevitable rise in physiological stress while performing a necessary task requiring concentration. The opposite, those environments that actually boost the stress levels of normal mental concentration, should be considered harmful to our health in the long term. Despite the voluminous literature on learning and workplace environments, the effect of fractal scenes on reducing stress has not yet assumed the central importance it deserves’. (Salingaros, N, (2012), p25).

We, in FracArt, are convinced that the effect of fractal scenes on reducing stress in learning and workplace environments will rise in priorities until it assumes the central importance it deserves.

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