Brain resilience: Shedding light into the black box of adventure procesess

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Abstract

Understanding of the active beneficial processes of adventure learning remains elusive. Resilience may provide one foundation for understanding the positive adaptation derived from Outdoor Adventure Education (OAE) and Adventure Therapy (AT) programming. From a neurological perspective, resilience may be explained by the brain's innate capability to adapt its structure (growth of new cells) and function (re-wiring of existing cells) directly in response to environmental exposure. This paper explores the role of known brain responses to experiences analogous to adventure programming based on themes from a key literature review. The fundamental paradigm of "stress and recovery" contends that a balance of neurobiological processes help realign psychosocial equilibrium in the short term and over time. Through progressive, repeated exposure to custom-built outdoor challenges, the concept of brain resilience may provide a scientific platform for understanding the mechanisms of achieving meaningful, authentic and healthy outcomes. It could also help to begin to illuminate a section of the black box of adventure processes.

Key words: adventure learning, neurobiological lens, brain resilience, scientific platform, psycho-social equilibrium

Introduction

Outdoor adventure education (OAE) and adventure therapy (AT) research continues to identify active processes that produce positive adaptation in these settings. This exploration has provided insight into the mechanisms and outcomes across a range of areas including personal empowerment (Shellman & Ewert, 2010), transferable skill learning (Sibthorp, Paisley, Gookin & Furman, 2008), and ecological healing (Beringer & Martin, 2003). Nevertheless, a perennial quest is to de-mystify the inner workings of Ewert's (1989) educational "black box" by explaining what underpins these adaptations. Ewert's notion implies that OAE and AT outcomes are derived from an undefined interdependence of personal, social and environmental processes. Yet, any blanket acceptance of unexplained complexity is problematic for further advancing our understanding of active processes, especially given today's evidence-based climate (Gass, 2005), and the increased plurality of learners requiring innovative programming. Shining a scientific light into the black box of adventure-based outcomes may help to reveal a structure and order of what is present. A growing scientific awareness of what is known, and of understanding what is now emerging, will help to develop more credible insights and refine both practice-based evidence and deliver evidence-based practices.

Resilience

Resilience encapsulates a developing area of psychology. It helps to summarise the positive adaptations that can emanate from participating in adventure programming (e.g. Passarelli, Hall & Anderson, 2010). Indeed, the link between resilience and adventure are among the strongest of those between 60 personal character strengths (Linley, 2009). We view resilience as an adaptive capacity for growth acquired from progressively optimised challenges (Masten & Obradovic, 2006). Resilience is derived from a complex interplay of personal and environmental factors rather than a single quality or set of traits. It is a multi-dimensional construct made up of individual assets and resources which reflect relative strengths in emotional and cognitive competence, social connectivity and physical capability.

Contemporary resilience research is evolving, in part, through advances in neurobiology. This field of enquiry is so new that in 1998 90% of all the neuroscientists who ever lived were still alive (Brandt & Wolfe, 1998). In this paper, we argue that any of the adventure-based responses that might occur, whether they are achieved inter alia through controlled dissonance (McKenzie, 2000), stress inoculation (Neill & Dias, 2001), or strength-based learning (e.g. Berman & Davis-Berman, 2005), will each be underpinned by adaptive changes in brain functioning. Our hope is that a neurobiological lens, which connects contemporary outdoor literature with mainstream science, will not only reassure individuals about the good in what they are already doing, but also stimulate questions and ideas to refine pedagogy and programme design. It may also provide a framework through which practitioners can elucidate processes associated with adaptive outcomes directly to their client groups. To structure our account, McKenzie's (2000) literature review is used, since it addresses why adventure works while also providing explanatory factors for programme outcomes based around six elements. These are; the physical environment, activities, processing, the group, instructors, and the participant.

The brain is a complex electrical, adaptive organ. Liquids provide the medium in which electrical signals pass between and within an infinite number of brain cells and these connections (synapses) are continually being developed, strengthened and also lost (pruned), depending on how each cell is used. High resolution "connectomics" (Mrsic-Flogel, 2011), which map neural connections in the brain, now suggests that each human brain contains one hundred billion neurons. Each neuron is connected to thousands of other nerve cells, making an estimated 150 trillion synapses. Each neuron is also supported by one or more non-neuronal glial cells (which make up 85% of brain volume and whose functioning is only beginning to be understood). This incredibly complex architecture supports all forms of learning and underlies why individualisation is such an important issue in any learning programme. Contrary to previous understanding that brain capacity is fixed and finite, new evidence confirms the immense malleability of the brain across all stages of the lifecycle. Indeed, the brain's resilience is achieved through two main processes; neurogenesis (growth of neural tissue) and neuroplasticity (the re-wiring of neural tissue).

In terms of structure, the triune theory (MacLean, 1990) contends that there are three main regions of the brain. Each area denotes an addition made to the brain's ancient inner core as humans evolved from amphibians into land-animals and then into primates. The "reptilian brain" or the "sensing brain," supports basic physiological functioning such as breathing and heart rate. Our second brain, the "paleomammalian" or "feeling brain" stimulates automatic freeze, fight and flight responses. This region houses the amygdala and hippocampus – the primary centres for production of emotion and memory - and the thalamus, which co-ordinates sensory signals. The outer surface structure of the brain represents the powerful "thinking brain" or cerebral cortex, which controls higher order cognitive skills and emotional regulation. The pre-frontal cortex (PFC), at the front of the brain is implicated in general human intelligence, personality and, crucially, motivated behaviour. MacLean's theory has been criticised for oversimplifying the often interconnected responses of each division to stimuli (Butler & Hodos, 2005). Nevertheless, this three layered conceptualisation provides a useful overview of mammalian brain organisation and is important since it highlights that thinking is not the main business of the brain. Indeed, even though less than 25% of actions are driven by conscious decision-making, learning still takes place in the sensing and feeling brains. Since these areas are central in dealing with potentially challenging stimuli, it makes them particularly important for development through OAE and AT.

Research developments over the last decade have identified a number of neurochemicals which have prominent roles in responding to stress and the development of brain resilience. Although these substances act as agents for growth and protection of brain tissue in optimal conditions, this may be inhibited in situations of significant stress. For example, the neurotrophics represent a powerful group of proteins that underpin neuroplasticity while also protecting against neuronal impairment (e.g. Radecki, Brown, Martinez, & Teyler, 2005). In particular, Brain-Derived Neurotrophic Factor (BDNF) augments brain health and learning by protecting and contributing to growth and differentiation of new stem cells, glial cells and synapses, particularly in the hippocampus (Mata, Thompson & Gotlib, 2010). The significance of BDNF to neurogenesis has led to it being referred to as "miraclegrow for the brain". Elevated BDNF levels are associated with involvement in moderate intensity physical activity (Tang, Chu & Hui, 2008) and respond to repeated short-term stimuli, meaning that "regular and often" is the order of the day. This mechanism is central to the logic being used to advocate the adoption of active lessons, and more energetic engagement during playground periods in schools.

Neuropeptide Y (NPY) is a protein which has counter-regulatory effects on stress in the brain regions involved in the expression of anxiety, fear and depression (Feder, Nestler & Charney, 2010). Higher levels of NPY may be associated with resilience against, and recovery from, posttraumatic stress disorder (Yehuda, Brand & Young, 2006). NPY dampens the fear response, allowing individuals to perform better under extreme stress (Morgan et al; 2000). There also seems to be a significant role for cortisol; a hormone best known for regulating carbohydrate metabolism, the immune system and for maintaining blood pressure. Emerging neurobiochemical research indicates that in optimised conditions of stress cortisol helps stimulate memory formation in the hippocampus. However, in prolonged highly stressful situations, cortisol can suppress or destroy memories by damaging glial cells in the hippocampus and amygdala (McEwen & Wingfield, 2003). This means that "what does not kill you only strengthens" is a fallacy. Stabilised levels of cortisol equate with better performance under stress in military soldiers on exercise (Morgan, Southwick, Hazlett, Rasmusson & Hoyt, 2004) and optimise the replenishment of brain-based energy stores following a stress response (de Kloet, Vermetten & Heijics, 2007).

Dopamine is a neurotransmitter commonly associated with the reward system of the brain, providing feelings of enjoyment. It also increases attentional capacity. Stress activates dopamine release in the medial PFC and inhibits its release in the nucleus accumbens – the brain's pleasure centre. The balance between cortisol and dopamine during stressful experiences may be crucial in protecting against the negative impacts of stress on mood and well-being.

The physical environment

Although outdoor settings may provide a context for successful adaptive functioning (e.g. Fletcher & Hinkle, 2002), the dynamic interplay between outdoor exposure and resilient outcomes remains unclear. McKenzie (2000) ascribes unfamiliar and authentic environments with the capacity to foster growth by requiring humans to resolve the disruption to normality that this may cause. The brain use that results from interaction with unfamiliar environments will require problem-recognition and idea creation, all of which are activities of the "thinking brain". This explanation shows clearly that the physical environment is neutral up to the point when individuals impose themselves into such spaces. Central to the impact of the environment is the perception it generates; a calming effect indicates engagement of the powerfully positive and relaxing parasympathetic nervous system. In contrast, fear and anxiety mobilise cortical production by stimulating the sympathetic nervous system. These responses create the internal climate for brain responses and for the behavioural options that, once undertaken, further refine brain structure. Clearly then, any individual's interpretation of a given scenario exerts a powerful short-term brain modifying effect.

Multi-sensory perception and neural adaptation

The multi-sensory nature of outdoor environments has a profound impact upon brain function and adaptation. To survive and prosper within harsh ecosystems, the brain has evolved to become multi-functional; this involves receiving and processing new information and learning from mistakes in rapidly changing conditions. Human perceptive quality is driven by the brain's ability, specifically within the thalamus, to interpret and act upon incoming sensory information as a whole. This superadditive integration of senses - where the contributions of multi-sensory experiences are greater than the sum of their parts - enriches encoding of information at the moment of learning (Werner & Noppeney, 2009). This adaptive quality allows people who learn in multi-sensory environments to perform better across a range of physical and cognitive tasks than those in uni-sensory environments (Mayer, 2001). In this respect, environments that are perceived as exciting and which provide multiple cues for different senses have a greater potential for positive learning than do environments seen as dull and hard to manage.

From this, perception itself, let alone other bodily responses, will result in the physical alteration of neurons throughout the brain. The phrase what wires together fires together signifies long term potentiation – the dynamic, strengthening of affinity between nearby neurons which allows the brain to take on new information. Within limits of active engagement the more elaborate and repetitive the information the stronger the attraction becomes between neurons. Progressive overload of experiences stimulates the brain to act like a muscle when activated by physical exertion, becoming larger, more complex and hardier for handling future challenges. BDNF augments the acute effects of brain resilience within the hippocampus – the region deeply involved in consolidating new experiences. Furthermore, this adaptive response corresponds directly to the type and frequency of environmental stimuli to which the brain is exposed. For example, the neural wiring that strengthens and expands in response to climbing will differ from that developed through surfing. Also, just as what wires together fires together, it holds that what fires alone, dies alone, indicating the importance of repetition for creating distinctive cortical maps. This also negates the idea that responses are only short-term effects. In addition, there is evidence to show that the PFC will apply the mental power of physical skills to other situations (Ratey, 2008). This may mean that learning to climb, which involves precise decision-making, may make it easier to perform similar cognitive tasks elsewhere.

Authentic, physical connectedness

Responding to the physical environment in a variety of ways may influence subsequent resilient responses. Ecological experiences may generate unique health benefits based largely on the premise that humans possess a biological imperative to connect with or be "healed" by nature (Beringer, 2004). In a report assessing the value of natural resources to the UK economy, it is estimated that the health benefits of merely living next to a green space is worth up to £300 per person per year (Black, 2011). Regular physical activity has been shown to have positive effects on the neurobiological effects that endorse resilience (e.g. Cotman & Berchtold, 2002). As little as five minutes of exercise undertaken in an urban green space such as a park or nature trail may be sufficient to boost physical and mental well-being through "biophilia" (Wilson, 1984), described as an innate connection to nature, especially in the young and those suffering from mental illness (Barton & Pretty, 2010). Exposures to natural environments are associated with elevated mood states and physiologic alterations, such as normalised heart rate and blood pressure (Laumann, Garling & Stormark, 2003), which as indicators of emotional regulation are also independent predictors of increased resilience in adolescents. Indeed, in natural settings youngsters with attention deficit hyper-activity disorder (ADHD) display fewer symptoms and behavioural problems and are better able to focus on a particular task (Lehrer, 2009). Even within situations that appear to represent extreme hardship an immediate awareness of nature may provide a source of spiritual enlightenment and of hope (Frankl, 1946) through its relaxing effect on nervous stimulation. A spiritual connectedness with a greater good (e.g. Unger, Dumond, & McDonald, 2005) or being inspired by the countryside has predicted resilience outcomes from short-term exposure to residential adventure programming (McKenna & Allan, 2010). This grand meaning, or sense of awe, may simply reflect an altered brain state acquired through attunement to a prevailing physical environment. In this moment the PFC can attach meaning to any event or experience.

Activities

There is no inherent magic in any specific activities for generating growth. Although familiar engaging activities may trigger already strong neural pathways, unfamiliar activities may also generate less well developed pathways to growth. As McKenzie (2000) suggests exposure to a differentiated diet of holistic and well-ordered challenges, which allow participants both to fail and succeed, is what helps develop adaptability rather than the activities themselves. She also contends that growth emerges by overcoming progressive levels of constructive anxiety. Indeed, augmented challenges from activities within adventure programming have been associated with enhanced resilience (Ewert & Yoshino, 2008; 2011). The speed with which homeostasis is re-established is a function of internal assets (e.g. brain resilience), external resources (e.g. support) and the nature of the challenge. So activities may be selected for their capacity to enhance trajectories of development in any of the areas of resilience. Due to the plethora of possible combinations of outcome and brain adaptations, resilience must be considered content-specific and, as such, may manifest itself differently within and across activities.

From surviving to thriving

Resilient behaviour has been suggested as ranging from surviving to thriving (Calhoun & Tedeschi, 2004). Positioning on this continuum may be indicative of the pre-existing repertoire of adaptive neural capacities developed by overcoming previous challenges. For individuals with limited experiences to draw upon (from the hippocampus), threatening situations evoke survival responses. These more readily inhibit emotional regulation and cognitive functioning (in the PFC). As stress is heightened, reactionary mental processing in the feeling brain may result in impulsive actions generated to alleviate the source of stress. This downshift to lower order functioning is fuelled by cortisol which can irreparably damage hippocampal cells. This may also occur within activities which fail to stimulate interest, restrict autonomy and limit personalised meaning. In contrast, "thriving-related" activities induce invigorating stress and recovery responses allow access to existing memories and create new ones. This enables up-shifting to higher order cognitive skills in the thinking brain which provides for a clearer analysis of problems. Activities which promote up-shifting responses include those which (a) are relatively open-ended, (b) promote choice, (c) emphasise intrinsic motivation and (d) offer personal support (Roberts, 2002). In this respect, it is important to gauge any individual's perception of the level of challenge and personal capacity to function in each given scenario. Central to operationalising this understanding is that the learner sees activities as interesting and personally challenging.

Emotional mountaineering

The brain creates and regulates a combination of negative and positive emotions to support adaptive behaviour. Negative emotions resonate more strongly than positive feelings in situations perceived as threatening. Possibly for evolutionary reasons, they are also logged more readily in memory so similar circumstances can be avoided later. Positive processes impact more significantly on longer-term outcomes and demonstrate durable cognitive and social benefits. They also offer a wider range of cognitive and behavioural options (in the PFC) whereas negative emotions often elicit an unhelpful narrowing effect (Fredrickson, 2004). This may suggest that activities which solely rely on anxiety as a means of generating growth may be effective for immediate reduction in risks but increase the possibility of creating lower-order thinking and conformist effects (Brookes, 2003). They also risk imprinting indelible negative associations with the specific activity. The potency of negative affect suggests that each negative emotional experience must be countered by at least three positive emotional experiences to optimise human functioning. There has been some consensus that this "golden ratio" may underpin a range of human adaptive behaviour, including effective teamwork (Losada & Heaphy, 2004) flourishing mental health (Fredrickson & Losada, 2005) and stable marriage (Gottman, 1994).

Building capacity for dealing with threats to individual well-being involves being able to estimate vulnerabilities (negatives) to defend against harm while also drawing upon strengths (positives) to create forward momentum. The fundamental biological paradigm of "stress and recovery" facilitates a learned shift along the resilience continuum from momentary instability (overcoming threats) towards sustained well-being (maintenance of competent functioning). This inherent capacity for growth has to be nurtured and the impact of any activities will vary according to the unique set of neural responses - or the connectome - which operate at any given time. Resilience may result from individuals tolerating immediate emotional distress which can be instrumental in generating adaptive changes (or a "steeling effect") that can be deployed to overcome later adversity (Rutter, 2006). Nevertheless, it may seem appropriate that for participants to adapt, they need to experience activities which are scaled according to capacity. This scaling is what facilitates successful negotiation of risk exposure and meaningful learning through both testing experiences and autonomy- supportive practices.

Processing

Processing involves the brain systematically deriving meaning from incoming stimuli. Further, the brain's ability to draw from layers of meaning provides the bedrock for behavioural adaptation and sustainable growth. McKenzie (2000) considers the sorting and ordering of meaningful information as part of the significant learning that emerges through adventurous experiences. The importance of internalising meaning directly and then metaphorically and actually transferring this to daily life has resulted in a variety of models of OAE and AT reflective practice (e.g. Bacon, 1997). This has also become a continual research endeavour in programming (e.g. Taniguchi, Freeman & LeGrand Richards, 2005).

Meaningfulnes: From attention to detail

We have already noted that the functional and structural strengthening of the brain is largely experience-dependent. Although multi-sensory experiences provide for unbridled information gathering, the brain optimises input by actively resisting meaningless (boring) information, preferring to search for new, interesting experiences which can be integrated into existing structures. Activities, therefore, may need to balance novelty - which supports inquisitiveness - with known experiences, to make it worth learning. This underlines the importance of identifying the relevance of any adventure experience or event to everyday life (Brown, 2008). The principle of meaningfulness is central to how the brain attends to, and then retains information. Focus and recall is influenced by the exploratory value and emotional intensity of an experience. Meaning is then attributed by the PFC in conjunction with the amygdala which releases dopamine to provide the necessary drive for something that is biologically rewarding. Due to the overwhelming significance of emotions to the creation and recall of memories, the brain tends to remember the emotional components of experiences before storing precise detail. This meaning before detail may be reflected in allowing participants exploratory forays into activities before giving specific technical instruction.

Stimulate and accumulate meaning

With all of this in mind, long, lacklustre and overly-controlled activities may cause some individuals to switch off through lack of purposeful stimulation. On the other hand, varied events of short deliberately spaced cycles, which are responsive to enquiring minds and that use relevant emotional stimuli to trigger emotions, such as laughter, incredulity and even mild apprehension, often generate more meaningful learning. Humour is recognised as a highly adapted mental mechanism of the right PFC which allows for conscious awareness of feelings, ideas and their consequences (Valiant, 2000). Interspersing organised chunks of learning with interruptions for explanation, or quiet time, allows new material to be absorbed as new brain cells are created and neural pathways strengthened. Since this occurs at the moment of the experience and again through subsequent reflection, it may also permit the brain to focus on experiences sequentially, without the need to multi-task; an ability that is not, despite popular assertions to the contrary, within the remit of the human brain. This process may be more correctly understood as sequential, repetitive task hopping and making sense of challenging experiences in this way may impact more upon resiliency than the actual events themselves.

The Group

Developing interpersonal qualities within groups has become a central tenet of adventure programming and this includes improving group cohesion (Rickinson et al; 2004), moral behaviour (Smith, Strand & Bunting, 2002) and psychological resilience (Neill & Dias, 2001). This may not be so surprising since human brains have evolved profound adaptive capabilities that are enhanced through the social interactions that can occur within unpredictable natural settings. Indeed, the origins of language, trust and morality may all have ultimately evolved from individuals exchanging knowledge to increase their probability of survival on ancient grasslands. McKenzie (2000) outlines a number of group characteristics which contribute to programme effectiveness and personal growth. These include having group sizes between seven and 15 people since these enhance reciprocity while also facilitating the independence of group members, group cohesion and the development of relationships. All social scenarios have strong links to brain functioning and specialised neural structures and mechanisms have evolved to process social information. Dunbar, Gamble and Gowlett (2009) propose that the size of the brain has evolved in direct proportion to its ability to handle a certain size of group which is up to 150 and not 1500 (as some social networking websites may suggest). Siegel (1999) proposes interpersonal neurobiology, based on the idea that the brain is the social organ of the body, noting that human connections create neural connections. A review of the anatomy of the middle PFC reveals that it contains a major integrative function for attuned communication, empathy, altruism, insight, intuition and morality. Functional MRI scanning has defined the circuitry of a social brain, including areas dedicated to the perception of social signals, the formation of a social memory and motivation for pair bonding (Insel & Fernald, 2004). All of this evidence supports the notion that relationships and their inherent qualities are brain rewiring agents which protect and provide potential for growth.

Reading hearts and minds

The neurobiological processes that develop social interaction within groups are summarised in the theory of mind mechanisms (ToMM) (Baron-Cohen, Tager-Flusberg & Cohen, 2000) or Mindsight (Siegel, 2001). ToMM and Mindsight each describe the capacity of one mind to perceive representations of the mind of another. By understanding the connections between one's own emotion and behaviour, Mindsight proposes that the brain develops the ability to attribute thoughts, desires and intentions to others. This process then may be used to predict their behaviour. ToMM and Mindsight are achieved in part through the actions of mirror neurons and spindle cells (Rizzolatti, Fogassi & Gallese, 2001). Mirror neurons are brain cells located in the feeling brain which activate in sympathy and in the same brain location as brain cells of the person whose actions are being watched. These neurons help us to sense what others intend and help us connect with what they feel. Humans resonate emotionally with another's state, for example when they wince with pain. Mirror neurons in the face respond to expressions in the face of the other and these activate similar sites for emotion, leading us to believe we know what the other is feeling. Although the precise use of these systems may be contested (e.g. Dinstein, Thomas, Behrmann & Heeger, 2008), they allow for the interpretation of others actions and feelings and may provide the platform for effective communication and deep empathy especially within challenging circumstances. They also help individuals to learn through copying the actions of others, so they also play a role in learning gross and fine motor skills, especially in childhood.

Caring and sharing

Potential hazards in adventure programmes necessitate that groups develop regard for each others' well-being. ToMM and mirror neurons may represent the neurobiological infrastructure that creates intentions and the unconditional support for others. Marsh et al (2010) showed that sensitivity to others' fearful facial expressions predicts altruism better than gender, mood or self-reported empathy.

Relational resilience (Hartling, 2003) reflects the mutually empowering growth-fostering connections demonstrated in the face of testing conditions. Emphasising relational resilience accentuates strengthening relationships rather than focusing on individual character strengths, suggesting that asking for and giving help are signs of emerging mutuality. Both of these relational competencies will be dependent on reciprocated trust being developed and on the idea that such reciprocity has strong personal meaning. However, the reality of OAE and AT is that changeable circumstances will often result in conflicting opinions and a requirement for negotiation and compromise. From the specific social patterning of the brain, the group provides a profound mechanism for developing adaptability through threatening and supportive experiences. The basis of group-based creative activities will also be influenced by the combination of negative emotional experiences and positive emotions. Outdoor contexts which foster secure attachments through caring and a shared appreciation of the environment tend to lead to healthier outcomes and have the capacity to develop the core components of resilience. To consolidate relationships within testing circumstances, Gottman (1994) proposes the importance of achieving a ratio of five positive interactions to one negative shared experience. Mutual engagement in the outdoors maybe sustained through pursuing an enterprise together, developing collective agency (a reservoir of positive feeling) rather than through enforcing co-operation or becoming pre-occupied with team productivity.

Instructors

McKenzie (2000) details a range of instructor attributes favoured by participants in adventure programming. The skills of instructors will not, however, be determined by compiled lists or participant expectations. Instructor competency may instead be representative of practices which shape the experiences through which brains, including that of instructors, become resilient.

Building bridges and reading minds

Effective learning and resilience may be founded upon connections which foster trust and support. Graham (1997) contends that good instructors will not depend on their position to give them authority; trust is continually developed and changed by behaviours and events that indicate mutual respect and honesty (or not). It is crucial for instructors to recognise that trust plays a major role in either facilitating or blocking the possibility of behaviour change. Indeed, the common factors model, from counselling literature, identifies that 30% of the outcomes of therapy are entirely attributable to the qualities of the counsellor-client relationship, which is double that attributable to counselling techniques (Goldfried, Greenberg and Marmar, 2001). Reciprocated relationships between instructor and participant take on further significance when a participant's reaction to risk is a further contributor to their learning. When individuals feel unsafe with an instructor, they are unlikely to perform optimally. It is also well documented that instructors find it difficult to accurately assess the emotional state of learners (e.g. Davis-Berman & Berman, 2002). Indeed, this difficulty in interpretation is a primary argument against instructors manipulating perceived risk to achieve personal growth; the odds are that instructors may be unable to gauge the appropriate level of risk for someone else.

A quality associated with effective instruction is the intuitive capacity to move others towards achievement. Intuition is another feature created through the reptilian and feeling brains, which has been described as a different way of knowing; it is not reliant on fluent articulation but involves a holistic appreciation of a given situation (Claxton, 2000). For example, spindle cells located in the brain's cortex, which play a central role in decision-making in unpredictable circumstances, are also located along the intestinal tract providing the rationale for a "gut instinct". Such insight is representative of a contemporary, deeper understanding of human nature. This view signifies the power of the unconscious mind, the central importance of emotion to human perception and the interpenetrated relationships humans possess with one another (Brooks, 2011). From this, instructors may use their brain in a holistic fashion which in turn expands their own adaptive capacity. Combining the logic of the right hemisphere of the PFC with the creativity of the left hemisphere may provide insight into others' behavioural intentions. Engaging ToMMs may also detect characteristics which indicate if instruction is being transformed into learning. Since exploratory exercises help to establish appropriate learning modalities and safe practices, the use of mirror neurons and spindle cells may help instructors to recognise the tell-tale signs of imprecise decision-making which is a signal of the feeling brain being in action or fear where the sensing brain predominates. Developing the social and empathetic connections of the brain to establish an appropriate needs perspective will enable instructors to manage client-specific progressions in skill learning. At the same time they will not only earn, but generate further inter-personal trust.

Independent strong brains

Becoming intuitive and keeping track of many minds requires sophisticated brain functioning enlisting each of the three brains. This provides a rationale for using small group sizes to optimise learning potential. Although there is a strong need for rationality and intentionality in adventure programming, too much control of individuals may also inhibit the potential for learning and building brain resilience. Reliance on a central figure prevents "challenge-by-choice", a notion that is central to effective adventure pedagogy and in developing resilience. Promoting reciprocal learning and autonomy may enable relationships between instructors and participants to be reframed so that individuals are trusted and motivated to develop themselves and each other. This does not denigrate the importance of the instructor. Rather, it liberates participants to self-regulate risk taking and concern for others, which provides authentic and immediately observable consequences for these actions.

The Participant

Adventure programmes continue to challenge a widening spectrum of client groups in ways that require them to rely upon and/or develop personal resources. Although recurring attributes of person and context emerge as predictors of resilience (Masten & Obradovic, 2006), attributing individuals to a particular level of resilience (e.g. low or high) will mask considerable and profound intra-personal variability. Further, what constitutes a risk factor for one person may offer protection or the opportunity for growth in another.

Custom-built brains

The complexity and individuality of resilience has roots in the genetic construction and malleability of the human brain. Although all human brains possess standard neuroanatomy, each adapts to reflect the demands of past and prevailing environments, so that even the brains of identical twins become wired differently in response to the same stimuli (Medina, 2008). Brain plasticity ensures remarkable differences between individuals in terms of their physiology, neural wiring, biochemical balance and stage of development. This plasticity is so integral to human existence that learning is possible at all ages. Age, gender and background may have bearing on the level of engagement and nature of outcomes emanating from adventure programmes. Notwithstanding their innate capacities to develop all forms of response, genetic differences ensure that male and female brains vary structurally and biochemically. For instance, in stressful situations, women activate the left hemisphere of the amygdala and tend to remember emotional details of experiences with more precision than men who use the right amygdala (Cahill, 2004). Gene variation may also affect amygdala responses, predisposing some individuals to the risk of an anxiety disorder and others to adaptable positive attributes, such as increased vigilance (Hariri & Weinberger, 2003).

Preferences for coping may offer another useful illustration of how these differences occur and are strengthened. For example, females are more likely to cope with stress by adopting relation-based "tend and befriend" responses (Taylor et al, 2000), while adolescents emphasise using emotion-focused coping strategies, such as denial or wishful thinking, to minimise the impacts of the perceived threat. This contrasts with the adult preference to adopt not only a wider repertoire of options, but also more problem-focused and meaning-focused coping. Mature patterns of adaptive coping involve finding meaning in adversity by drawing on values and beliefs to refine personal goals and life directions (Park & Folkman, 1997).

Given such complexity and variability, one challenge facing OAE and AT is to show its delivery of deeper, customised participant growth. Brains do not recognise age-restricted expectations of learning, for example, within a group of 14 year old youngsters, there will be considerable differences in their capacity to learn. Individual wiring as reflected in the connectome contends that brains of the same age will always comprehend similar experiences differently. The complex interplay between risk factors and processes which enables successful adaptation may also indicate that standard paradigms of perceived risk taking (e.g. Luckner & Nadler, 1997) step-wise models of experiential learning (Seaman, 2008), and self-efficacy theories (Bandura, 1997) only inconsistently account for individual needs.

Strengthening individual wiring

Character strengths can be seen as representing evolved adaptations drawn from responding to life environments. Indeed, interventions modelled on the strength-based approach aim to build positive emotion and meaning (Seligman & Cskiszentmihalyi, 2000), since these are factors that help to optimise brain functioning. However, there are reservations about an uncritical acceptance of strength-building to enhance resilience, especially where self-fulfilment becomes the panacea for all aspects of development. Here the issue is that individuals draw learning from their unsuccessful activities as they do from success. Therefore, it remains important that individuals perceive that they have the freedom to fail.

We have considered how strong emotions such as anxiety and anger are generated by the brains instinctive alarm system; these galvanise overcoming threats to well-being. In optimal doses, stress produces an inoculation effect on neurons, causing them to overcompensate to protect against possible recurrence. Cushioning frustration and allowing individuals to avoid significant challenges may impede the development of brain resilience and subsequent persistence and instigate avoidance strategies which, ultimately, may only serve to perpetuate fears. Dweck (2006) suggests that over-focusing on outcomes, as opposed to emphasising the effort and hard work required to achieve them, reinforces a fixed, rather than a growth view of intelligence and of self-assessment. This view may even verify the belief that trying hard is a sign of weakness and lead some individuals to fear failure, avoid risks and cope poorly with set-backs. Paradoxically, this belief may be at odds with the neurobiological reality wherein concerted effort is central to constructing strong, distinct and enduring neural pathways for effective learning and greater resistance to future challenges.

Conclusion

Mystique persists surrounding the positive adaptation that emanate from processes inherent to OAE and AT. Although this adaptive capacity has been described as "ordinary magic" (Masten, 2001), brain resilience proposes that all adaptive functioning is underpinned by non-mystical changes to brain structure and function. Each of McKenzie's (2000) components of adventure programming offers ways to optimise this functionality, all underpinned by brain responses. The physical environment interconnects with healthy, adaptable brain functioning; promoting learning through natural, multi-sensory stimulation. Carefully scaled activities of negative and positive challenges build neurological capacity for the realignment of psychosocial equilibrium immediately and over time. The processing of information in adventure learning is enhanced through the brain actively seeking and responding to biologically rewarding and meaningful stimuli. The group uses specially adapted neural structures and capacities which empower growth-fostering connections in testing conditions. The power of the unconscious mind allows the instructor to develop intuitive insight into the fears and aspirations of others and this helps to consolidate reciprocated trust. Remarkable differences in the brain biology of the participant create the opportunity for effort-driven, custom built challenges which build strong and enduring neural pathways which we recognise as personal growth.

Our commentary was never intended to illuminate every section of the black box. Even the expansion in brain science that is reported here is inadequate to fully account for the fusion of personal, social and environmental variables which affect outdoor programme outcomes. As a consequence, there is an imperative to continue investigating biological and environmental transactions which may underpin resilient behaviour within and across adventure learning contexts. While recognising this requirement, the issues raised here may deepen our understanding of the attainment of personal growth objectives which are less prone to chance. It also highlights the reciprocal nature of the many processes inherent to contemporary adventure programming. While more will emerge as science advances, there is still ample evidence to clarify in line with existing bodies of research, as to why OAE and AT programmes provide demonstrable benefits.

References

Bacon, S.B. (1997). *The evolution of the Outward Bound process.* Greenwich CT, Outward Bound.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: WH Freeman.

Baron-Cohen, S., Tager-Flusberg, H., & Cohen, D.J. (Eds.). (2000).*Understanding other minds: Perspectives from developmental cognitive neuroscience.* Oxford: Oxford University Press.

Barton J., & Pretty, J. (2010).What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science and Technology, 44*(10), 3947-3955.

Beringer, A. (2004). Toward an ecological paradigm in adventure therapy. J*ournal of Experiential Education, 27*(1), 51-66.

Beringer, A., & Martin, P. (2003). On adventure therapy and the natural worlds: Respecting nature's healing. *Journal of Adventure Education and Outdoor Learning, 3*(1), 29-40.

Berman, D.S., & Davis-Berman (2005). Positive psychology and outdoor education. *Journal of Experiential Education, 28*(1), 17-24.

Black, R. (2011). *Nature is worth billions to UK.* BBC News, Science & Environment. Retrieved from http://www.bbcnews. co.uk

Brandt, R., & Wolfe, P. (1998). What do we know from brain research? *Educational Leadership, 56* (3), 8-13.

Brooks, D. (2011). *The social animal: A story of how success happens.* United States of America: Short Books.

Brookes, A. (2003). A critique of Neo-Hahnian outdoor education theory. Part one: Challenges to the concept of "character building". *Journal of Adventure Education and Outdoor Learning, 3*(1), 49–62.

Brown, M. (2008). Comfort zone: Model or metaphor? *Australian Journal of Outdoor Education, 12*(1), 3-12.

Butler, A.B., & Hodos, W. (2005). *Comparative vertebrate neuroanatomy. Evolution and adaptation* (2nd Ed.). Hoboken: John Wiley & Sons.

Cahill, L. (2004). Sex-related hemispheric lateralization of amygdala function in emotionally influenced memory: an fMRI investigation. *Learning and Memory, 11*(3), 261 – 266.

Calhoun, L.G., & Tedeschi, R.G. (2004). The Foundations of posttraumatic growth: New considerations. *Psychological Inquiry, 15*, 93-102.

Claxton, G. (2000). The anatomy of intuition. In T. Atkinson & G. Claxton, G. (Eds), *The intuitive practitioner, On the value of not always knowing what one is doing* (pp. 32-52). Buckingham: Open University Press.

Cotman, C.W., & Berchtold, N.C. (2002). Exercise: a behavioural intervention to enhance brain health and plasticity. *Trends in Neuroscience, 25*(6), 295-301.

Davis-Berman, J., & Berman, D. (2002). Risk and anxiety in adventure programming. *Journal of Experiential Education, 25*(2), 305-310.

de Kloet, C.S., Vermetten, E., & Heijics, C.J. (2007). Enhanced cortisol suppression in response to dexamethasone administration in traumatized veterans with and without posttraumatic stress disorder. *Psychoneuroendocrinology, 32*(3), 215-226.

Dinstein, I., Thomas, C., Behrmann, M., & Heeger, D. J. (2008). A mirror up to nature. *Current Biology, 18*(1), 13-18.

Dunbar, R., Gamble, C., & Gowlett, J. (Eds.). (2009). *Social brain, distributed mind.* Oxford: Oxford University Press.

Dweck, C. (2006). *Mindset: The new psychology of success.* New York: Random House.

Ewert, A. (1989). *Outdoor adventure pursuits: Foundations, models, and theories*. Scottsdale: AZ Publishing Horizons.

Ewert, A., & Yoshino, A. (2008). A Preliminary exploration of the influence of short-term adventure-based expeditions on levels of resilience. *Journal of Experiential Education, 30*(3), 262-266.

Ewert, A., & Yoshino, A. (2011). The influence of short-term adventure-based experiences on levels of resilience. *Journal of Adventure Education & Outdoor Learning, 1*(1), 35-50.

Feder, A., Nestler, E., & Charney, D. (2010). Psychobiology and molecular genetics of resilience. *Nature Reviews Neuroscience, 10,* 446-457.

Fletcher, T.B., & Hinkle, J.S. (2002). Adventure based counselling: An innovation in counselling. *Journal of Counselling and Development, 80*(3), 277-285.

Frankl, V. (1946). *Man's Search for Meaning*. Boston: Beacon Press.

Fredrickson, B.L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist: Special Issue, 56*, 218-226.

Fredrickson, B.L., & Losada, M. (2005). Positive affect and the complex dynamics of human flourishing. *American Psychologist, 60*(7), 678-686.

Gass, M. (2005). Comprehending the value structures influencing significance and power behind experiential education research. *Journal of Experiential Education, 27*(3), 286-296.

Goldfried, M.R., Greenberg, L., & Marmar, C. (2001). Individual psychotherapy: process and outcome. In: Hyer, L.A., & Sohnle, S.J. (Eds.). *Trauma among older people, Issues and Treatment.* United States of America: Taylor & Francis.

Gottman, J. M. (1994). *What Predicts Divorce: The Relationship between marital processes and marital outcomes.* New York: Lawrence Erlbaum.

Graham, J. (1997). *Outdoor Leadership, technique, common sense and self-confidence.* Seattle: The Mountaineers.

Hariri, A. R., & Weinberger D. R. (2003). Functional neuroimaging of genetic variation in sertonergic neurotransmission. *Genes, Brain and Behaviour, 2*(6), 341-349.

Hartling, L. (2003). Strengthening resilience in a risky world. It's all about relationships. *Women in Therapy, 2*(31), 51-70.

Insel, T.R., & Fernald, R.D., (2004). How the brain processes social information, searching for the social brain. *Annual Review of Neuroscience, 27*, 697-722.

Laumann, K., Garling, T., Stormark, K.M. (2003). Selective attention and heart rate responses to natural and urban environments. *Journal of Environmental Psychology, 23*, 125-134.

Lehrer, J. (2009). *How the city hurts your brain, and what you can do about it.* The Boston Globe, retrieved from http://www.boston.com/bostonglobe/ideas/articles/2009/01/04/how_the_city_hurts_your_brain/

Linley, A. (2009). *Strengths measure, Realise 2. Centre of applied positive psychology*. Coventry, UK: Technical manual and statistical properties.

Losada, M., & Heaphy, E. (2004). The role of positivity and connectivity in the performance of business teams. *The American Behavioral Scientist, 4* (6), 740-765.

Luckner, J.L., & Nadler, R.S. (1997). *Processing the experience: Strategies to enhance and generalise learning.* Dubuque, IA: Kendall/Hunt Publishing Company.

McEwen, B.S., & Wingfield, J.C. (2003). The concept of allostasis in biology and biomedicine. *Hormones and Behaviour, 43*, 2-15.

McKenna, J., & Allan, J. (2010). Resilience. In. C. Cooke, D. Bunting, & J. O'Hara, (Eds.), *Mountaineering training and preparation* (pp. 233-245). United States of America: Human Kinetics.

McKenzie, M.D. (2000). How are adventure education program outcomes achieved? A review of the literature. *Australian Journal of Outdoor Education, 5*(1), 19-28.

MacLean, P.D. (1990). *The triune brain in evolution: role in paleocerebral functions.* New York: Plenum Press.

Marsh, A.A., Kozak, M.N., Wegner, D.M., Reid, N.E., Yu, H.H., & Blair, R.J.R. (2010). The neural substrates of action identification. *Social Cognitive and Affective Neuroscience, 5*, 392-403.

Mata, J., Thompson, R., & Gotlib, I. (2010). BDNF genoetype moderates the relation between physical activity and depressive symptoms. *Health Psychology, 29*(2), 130-133.

Masten, A. S. (2001). Ordinary Magic. *American Psychologist, 56*(3), 227-238.

Masten, A., & Obradovic, J. (2006). Competence and resilience development. *Annals of Academic Science, 1094*, 13-27.

Mayer, R. (2001). *Multimedia Learning*. Cambridge UK: Cambridge University Press.

Medina, J.J. (2008). *Brain rules.* Seattle: Pear Press.

Morgan, C.A., Southwick, S., Hazlett, G., Rasmusson, A., & Hoyt, G. (2004). Relationships among plasma dehydroepiandrosterone sulphate and cortisol levels, symptoms of dissociation, and objective performance in humans exposed to acute stress. *Archives of General Psychiatry, 61*, 819-825.

Morgan, C.A., Wang S., Mason J., Southwick, S.M., Fox, P., & Hazlett, G. (2000). Hormone profiles in humans experiencing military survival training. *Biological Psychiatry, 47*, 891- 901.

Mrsic-Flogel, T. (2011). Functional specificity of local synaptic connections in neocortical networks. *Nature, 473*, 87-91.

Neill, J.T., & Dias, K.L. (2001). Adventure education and resilience; The double-edged sword, *Journal of Adventure Education and Outdoor Learning, 1*(2), 35-42.

Park, C.L., & Folkman, S. (1997). The role of meaning in the context of stress and coping. *General Review of Psychology, 2*, 115-144.

Passarelli, A., Hall, E., & Anderson, M. (2010). A strengths-based approach to outdoor and adventure education: Possibilities for personal growth. *Journal of Experiential Education, 33*(2), 120-135.

Radecki, D.T., Brown, L.M., Martinez, J., & Teyler, T.J. (2005). BDNF protects against stress- induced impairments in spatial learning and memory and LTP. *Hippocampus, 15*, 246-253.

Ratey, J. J. (2008). *Spark: The revolutionary new science of exercise and the brain*. New York: Brown & Company.

Rickinson, M., Dillion, J., Teamey, K., Morris, M., Mee Young, C., Sanders, D., & Benefield, P. (2004). *Review of Research on Outdoor Learning.* London: National Foundation for Educational Research and Kings College.

Rizzolatti G., Fogassi, L., & Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Reviews Neuroscience, 2*, 661-670.

Roberts, J.W. (2002). Beyond learning by doing: The Brain Compatible Approach. *Journal of Experiential Education, 25*(2), 281-285.

Rutter, M. (2006). Implications for Resilience Concepts for Scientific Understanding. *Annals of Academic Science, 1094*, 1-12.

Seaman, J. (2008). Experience, reflect, critique: The end of the "Learning Cycles" era. *Journal of Experiential Education, 31*(1), 3-18.

Seligman, M. E., & Csikszentmihalyi, M. (2000). Positive psychology: An introduction. *American Psychologist, 55*(1), 5-14.

Shellman, A., & Ewert, A. (2010). A Multi-Method approach to understanding empowerment processes and outcomes of Adventure Education program experiences. *Journal of Experiential Education, 32*(3), 275-279.

Sibthorp, J., Paisley, K., Gookin, J., & Furman, N. (2008). The Pedagogic value of student autonomy in Adventure Education. *Journal of Experiential Education, 31*(2), 136-151.

Siegel, D.J. (1999). *The Developing Mind: Toward a neurobiology of interpersonal experience.* New York: The Guildford Press.

Siegel, D.J. (2001). *The Developing Mind: How relationships and the brain interact to shape who we are.* New York: The Guilford Press.

Smith, C.A., Strand, S.E. & Bunting, C.J., (2002). The Influence of challenge course participation on moral and ethical reasoning. *Journal of Experiential Education, 25*(2), 278-280.

Tang S., Chu, E., & Hui, T. (2008). Influence of exercise on serum brain-derived neurotrophic factor concentrations in healthy human subjects. *Neuroscience Letters, 43*(1), 62-65.

Taniguchi, S.T., Freeman, P.A., & LeGrand Richards, A. (2005). Attributes of meaningful learning experiences in an outdoor education program. *Journal of Adventure Education and Outdoor Learning, 5*(2), 131-144.

Taylor, S. E., Klein, L.C., Lewis, B.P., Greuenwarld, T.C., Gurney, R.A., & Updegraff, J.A. (2000). Biobehavioural responses to stress in females: Tend-befriend, not fight-flight. *Psychological Review, 102*(3), 411-429.

Unger, M., Dumond, C., & McDonald, W. (2005). Risk, resilience and Outdoor Programmes for at-risk children. *Journal of Social Work, 5*(3), 319-338.

Valiant, G. E., (2000). Adaptive mental mechanisms: Their role in positive psychology. *American Psychologist, 55*(1), 89-98.

Werner, S., & Noppeney, U. (2009). *Superadditive responses in superior temporal sulcus predict audiovisual benefits in object categorization: Cerebral cortex*. Oxford: Oxford University Press.

Wilson, E.O. (1984). *Biophillia*. Cambridge: Harvard University Press.

Yehuda, R., Brand, S., & Yang, R. (2006). Plasma Neuropeptide Y Concentrations in Combat Exposed Veterans: Relationship to Trauma Exposure, Recovery from PTSD, and Coping. *Biological Psychiatry, 59*(7), 660–663.

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