Muziki
Journal of Music Research in Africa

ISSN: 1812-5980 (Print) 1753-593X (Online) Journal homepage: http://www.tandfonline.com/loi/rmuz20

New developments in neuroscience can benefit the learning and performance of music

Inette Swart

To cite this article: Inette Swart (2016): New developments in neuroscience can benefit the learning and performance of music, Muziki, DOI: 10.1080/18125980.2016.1182386

To link to this article: http://dx.doi.org/10.1080/18125980.2016.1182386

NEW DEVELOPMENTS IN NEUROSCIENCE CAN BENEFIT THE LEARNING AND PERFORMANCE OF MUSIC

Inette Swart
North-West University
Musical Arts in South Africa: Resources and Applications (MASARA)
inette2@yahoo.com

ABSTRACT

As advancements in neuroscience increasingly illuminate the traditional understanding of the human mind, many of the new insights are also of relevance to musicians as well as to music pedagogy. Especially the greater understanding of how intersubjective processes are integral to the development of the right brain has shown how, according to the neuropsychoanalyst Allan Schore, right-brain models can bridge the fields of psychiatry, music and trauma. Following a short introduction, the article discusses the development of ego boundaries and their relevance to young aspiring musicians as well as the close relation to self-esteem. This is followed by a short explanation of the psychodynamic processes underlying interpersonal interaction and relation. Right-brain function in development and trauma is discussed and its links to music are highlighted; the issue of fear and learned helplessness in musicians is also considered briefly. A discussion on the impact of fear on musicians' memory follows. The paper concludes by showing that, while brain pathology can be associated with creativity, creative processes in and of themselves are not pathological. Throughout, special reference is made to aspects that have particular relevance to previously disadvantaged music learners.

UNISA university of south africa
Routledge Taylor & Francis Group

Muziki
pp. 1–24

DOI: 10.1080/18125980.2016.1182386
Print ISSN 1812-5980 | Online ISSN 1753-593X

Keywords: creativity, emotion, implicit self, intersubjectivity, right-brain development, music pedagogy, neuroscience, previously disadvantaged, relational unconscious

INTRODUCTION

George Bush's project 'the Decade of the Brain', spanning the years 1990–1999, has already acknowledged the need to 'enhance public awareness of the benefits to be derived from brain research' (Library of Congress 2000). I believe that some advances in neuroscience from the past few decades can be applied to musicians to benefit their health. I have argued previously (Swart 2010) that there is a need to incorporate training in psychology into the music education system. Others also mention the importance of cross-fertilisation from fields such as psychology, sociology and curriculum scholarship in new approaches to the teaching and learning process in holistic programmes for music teachers (for example, Veenhoven Guidarian 2014, 186). Today there is more neuroscientific knowledge available to support and inform such education.

Music-making is an incredibly complex activity that involves many different brain structures (Altenmüller and Schlaug 2015, 237–238). The conscious perception of auditory, visual and somatosensory inputs relies on primary and secondary regions in the cerebral cortex (Altenmüller and Schlaug 2015, 237), while most other parts of the brain are intricately involved in the automatic or unconscious facets of music-making. One needs the motor control and co-ordination to enable dexterity at playing an instrument; the emotional centres of the brain and the neo-cortex have to communicate well with each other to enable emotional communication through music; one needs the capacity to be creative; and special structures for remembering music are required (Levitin 2006, 220). Levitin (2006, 270–271) states that music processing functions are distributed throughout the brain, and gives a summary of the structures involved and their respective functions. The prefrontal cortex is where the creation of expectation, as well as the violation and satisfaction of expectations, is processed (Levitin 2006, 270). By its nature, music creates tension (for example, dissonance), which is then resolved (consonance or cadences or resting points), as interpreted in the prefrontal cortex. The motor cortex is involved in movement, foot tapping, dancing and playing an instrument, while the sensory cortex is responsible for interpreting tactile feedback from such activities (Levitin 2006, 270). Both cortices play a role in the memory required for the actions of performing music, and the fine control and gradation necessary in the execution process, which could be on a different instrument, for instance, or in a different hall, making it necessary to adjust to a different acoustic. The auditory cortex is involved in the first stages of listening, perceiving sounds and analysing tones (Levitin 2006, 270). The visual cortex is responsible for reading music; the corpus callosum for communication between the left and right hemispheres; the nucleus accumbens and amygdala for emotional

reactions to music; the hippocampus for memory of music and musical experiences; and the cerebellum for the coordination of movement as well as some involvement in emotional reactions to music (Levitin 2006, 270–271). The cerebellum is also essential for timing and rhythm (Altenmüller and Schlaug 2015, 237).

The brain changes and adapts as a result of activities performed, such as practising an instrument or singing, as well as environmental demands made on a person (Altenmüller and Schlaug 2015, 238). Measurable differences found in musicians' brains as evidenced by structural Magnetic Resonance Imaging (MRI) data include larger volumes found in the sensorimotor cortex, the posterior half of the corpus callosum, the entorhinal cortex and the superior parietal lobe (Gärtner, Minnerop, Pieperhoff, Schleicher, Zilles, Altenmüller and Amunts 2013). Gärtner et al. (2013) hypothesise that musician-specific requirements such as sight-playing, memorising of scores and motor training may be responsible for this plastic effect witnessed in these specific brain regions. Furthermore, changes were strongly intensity-dependent, depending on length of study, early onset of musical studies in life, and number of hours involved in specialised music practice per day; larger brain volumes in the sensorimotor cortex and corticospinal tracts were strongly evident in keyboard players who were known to have had early-onset, long, high-intensity training (Gärtner et al. 2013, 11).

Human skills such as imitation and empathy are important for the learning of musical skills and emotional expressiveness, and are dependent on the integrative capacity of the frontal lobe while the multisensory integration required in musical activities takes place in the parietal lobe and temporo-occipital areas (Altenmüller and Schlaug 2015). Altenmüller and Schlaug (2015, 237) state that this multisensory brain representation constitutes the typical musical experience. Emotional communication may be particularly reliant on the temporal pole, an area that functions as a paralimbic region, research of which is still in its infancy (Olson, Plotzker and Ezzyat 2007, 1727). Research points towards the importance of the temporal pole in coupling complex, highly processed perceptual inputs to visceral emotional responses (Olson, Plotzker and Ezzyat 2007). Olson et al. (2007, 1718) point out that the integration of emotion with perception might be channel-specific since perceptual inputs remain segregated into dorsal (auditory), medial (olfactory) and ventral (visual) streams. Motivation for researchers in this field is driven partially by the need to understand disrupted socio-emotional processing, which plays a strong role in the aetiology of many psychological disorders (Olson, Plotzker and Ezzyat 2007, 1718). Therefore, a fuller understanding of this might also inform the socio-emotional aspects of music's ability to heal, as well as its function in the socio-emotional processing necessary for these healing processes to take place. This has direct relevance to relational aspects involved in music's healing powers, the latter of which is provisionally explicated in this paper.

An individual's motivation to engage in musical activities relies on the emotional networks of the brain, described above, including the newer and older emotional parts of the brain (Altenmüller and Schlaug 2015, 237). Levitin (2006, 192) states that the brain's involvement with music engages the oldest and newest parts of the brain and that it involves

> a precision choreography of neurochemical release and uptake between logical prediction systems and emotional reward systems. When we love a piece of music, it reminds us of other music we heard, and it activates memory traces of emotional times in our lives. (Levitin 2006, 192)

This subtle balance can be affected by the neurological changes resulting from traumatic experience (for example, Siegel 2012, 21–22; Swart 2010, 16, 48–49). Trauma can change the brain's response to new events through increasing activity in particular emotional memory regions, namely, the amygdala, hippocampus and midline frontal and posterior regions, as evidenced by Magnetic Resonance Imaging (MRI) (Palombo, McKinnon, McIntosh, Anderson, Todd and Levine 2015). Most notably, the amygdala and hippocampus are structures that will later be shown to be important in the processing, learning and unlearning of fear. Underlying this are actual neuronal pathway and receptor changes incurred by traumatic events. In a process that relies heavily on our brains' innate tendency to form associations in order to make sense of new incoming stimuli from the environment (discussed more fully in the section 'Memory for music and fear' below), musical sounds become linked with particular moods; different ways of dividing up the octave elicit different moods as well as particular memories of events, including scenes from movies (Levitin 2006, 39), and composers and performers communicate emotion through knowing what our expectations are and controlling when those will and will not be met (Levitin 2006, 111).

Special consideration is given in this article to aspects with particular relevance to previously disadvantaged[1] South African learners. They very often come from traumatic backgrounds and may be affected by poverty as well as the effects of HIV/AIDS, which impact on families. Some learners may even have lost parents as a result of the illness (Pruneau 2013). Furthermore, racial discrimination from the past may still impact on their sense of self-esteem. Traumatic circumstances that affect these children include a lack of family structure with many children having to stay with their grandmothers, and some being from child-headed households. Children being deprived of parental role models, parental care and family structure, all essential components for normal attachments to form and normal child development to occur, could result in criminal behaviour – sometimes in order to survive (Pruneau 2013). Pruneau also mentions that part of the reason why music has made such an impact on these children's lives was because teachers became role models for them. Reasons

underlying this are elucidated through a discussion of the importance of attachment relationships in child development later in this article.

The focus is mainly on development, especially since many previously disadvantaged learners suffer from attachment trauma that could have a pervasive influence on the rest of their lives. However, this is not exclusive to these children, as many others from more privileged backgrounds are also affected. It is shown how right-brain development and function is important in the understanding and handling of traumatised learners (Schore 2012), as well as how carefully navigating the important developmental processes of the development of ego boundaries and self-esteem has particular relevance to aspiring music performers (Swart 2015). Neuropsychoanalyst Allan Schore asserts that right-brain models can bridge the fields of psychiatry, music and trauma (Schore 2015).

NEURODEVELOPMENT

Neuroscience is increasingly showing how one cannot separate the physical working of the brain from psychological and developmental aspects involved in brain functioning. I have elsewhere discussed the development of ego boundaries and self-esteem in aspiring performers (Swart 2015). Aspects most relevant to teaching will be explained in simplified terms in this article, but with greater emphasis on right-brain developmental processes.

There has long been an understanding in psychology that an individual's sense of self develops from not being aware initially of the distinction between oneself and one's surroundings towards developing a sense of the characteristics that form part of oneself and of what belongs to the environment or to other persons (this idea is explicated at length in Federn 1952). As the individual matures, so does the knowledge about where their control over their environment ends. By moving their limbs, for instance, infants develop an understanding that their arms and legs are part of themselves and that these limbs can be controlled by them. This fundamental primary developmental process is called 'ego boundary development' and has physical as well as psychological or mental aspects to it (Federn 1952). New neuroscientific data have supported the notion that ego boundary development occurs very much in an intersubjective fashion.

Beyond merely being a perception of our own worth, on an emotional level, self-esteem is based on our experience of the authenticity of our own feelings, emotions and needs (Miller 1997, 28). Therefore, ego boundary development, as forming the limit of our own experience, and self-esteem development, as constituting our perception of the authenticity of our own feelings, of experiencing these feelings as having validity and as belonging to ourselves, are narrowly related developmental entities (Swart 2015). This is corroborated by Denise Grocke who showed how ego boundaries can be strengthened through affirmation of a music therapy client's feelings and acceptance of the client's own emotional state and emotional changes

(Grocke 2005, 98). Alf Gabrielsson also asserts that the performance of music brings with it the possibility to test boundaries (2011, 207). One of the functions of musicians in society is to challenge existing boundaries (including emotional associations to events and experiences – even to challenge emotional memories of a culture). But before an artist can act in this capacity, he or she must first develop a thorough understanding of boundaries in society, as well as of emotions accompanying ideas and events (Swart 2015; Perry 1999, 18).

A sense of self, including a sense of ego boundaries, as well as the ability to regulate affect, is thought to develop in an intersubjective manner. The earliest-forming parts of the developing self and identity originate from the emotion-processing right hemisphere and its associated homeostatic-survival and communication functions, forming the 'implicit self', which is also the structural system of the human unconscious (Schore 2012, 118–119). The conscious explicit self only develops later, and is associated with the left brain as well as with the processing of language functions (Schore 2012, 119–120). Humans are social beings whose survival depends on the capacity to communicate their internal subjective states to others and to receive a response (Schore and Schore 2014, 182). Allan Schore writes: 'Attachment intersubjectivity allows psychic structure to be built and shaped into a unique human being' (Schore 2012, 44). While the right and left hemispheres of the brain are in constant communication with each other through a bundle of neural fibres called the corpus callosum, a brain structure which has been found to be larger in musicians (Schlaug et al. 1995), the right and left hemispheres of the brain function differently and also develop at different ages. Non-verbal emotional communication (a right-brain function) develops before verbal, cognitive communication (a left-brain function) and the right brain is more connected to the limbic and autonomic nervous systems (Schore and Schore 2014, 183). It is the first to develop (through the physiological processes of synaptogenesis, volume increases and nerve fibres becoming myelinated) through interaction and early emotional transactions taking place between the right brains of the infant and the caregiver, impacting on the development of psychic structure (Schore and Schore 2014, 180). The caregiver regulates the infant's levels of arousal. Moments of dysregulation inevitably occur and are mediated by interactive repair, which forms the basis for the young child's development of autoregulatory functions. A secure primary attachment figure down-regulates negative fear states and up-regulates positive emotions in loving and play states (Schore and Schore 2014, 183–184). Schore states that the right brain has a different anatomy, physiology and biochemistry from the left hemisphere, which develops later, and it is the locus of implicit procedural memory systems and in particular those involved in non-verbal social communications (Schore 2012, 31). Attachment – as the 'regulation of biological synchronicity between and within organisms' (Schore 2012, 32) – is the outcome of a child's genetically determined

temperamental disposition as well as the result of the influence of a particular combination of caregivers plus environment on a child (Schore 2012, 32).

Integration of and communication between the two hemispheres is required for music activities; therefore the conception that the right brain is the artistic side of the brain is overly simplistic (Levitin 2006, 134). However, as regards the emotional aspects involved, the right brain appears to contribute most to the emotional meaning of music as well as of speech. Levitin states that while speech processing is primarily a left-hemispheric function, intonation of voice, emphasis and pitch pattern – aspects integral to distinguishing subtle emotional meanings in speech – are right-brain functions (Levitin 2006, 134). Through its capacity for decoding auditory prosodic communications, the right brain processes the '"music" behind our words' (Schore 2012, 38). Taylor (2008, 32) says that the seat of the ego, as the entity that defines your self by saying 'I am', lies in the left brain. The left brain categorises information, such as our credentials, individuality, uniqueness, separateness, likes and dislikes (Taylor 2008, 32–33). Yet it appears that the right brain is where the larger, emotional awareness of ourselves as experiencing beings is developed, and where our unconscious implicit self originates as our experiencing, interacting, feeling 'self' (Schore 2012, 34).

From a developmental perspective, an important consideration is that individuality and a sense of self should be allowed to develop independently from a child's identity as a musician, up to the age of 7, before a musical identity is developed (Lamont 2002, 43–44). This is because, according to Lamont, seven is roughly the age at which children can master the understanding of a differentiated identity through making social comparisons. Prior to this, children's personal identities should be influenced by features of self-understanding not exclusively related to music (Lamont 2002, 43). This goes hand in hand with ego boundary development and the importance of facilitating a healthy development of strong ego boundaries before young musicians can be expected to stretch existing boundaries. With the age at which young people compete in music competitions becoming younger and younger, this may be challenging to achieve.

In her book *Drama of the Gifted Child. The Search for the True Self*, Alice Miller (1997) explains at length the dynamics underlying the influence of narcissism on the development of young talented learners. When there is a narcissistic parent or teacher, defined as someone who essentially lacks a well-developed sense of self, the emotional needs of the learner take second place to the needs of the adult with the result that, in order to cope, the learner negates his or her own feelings and caters to the needs of the emotionally abusive individual (Miller 1997). This can now be understood neurobiologically in that, if the injury occurs early enough and a young child does not experience empathic validation of their existence and their emotional experience, their affective development is altered and the result is an impaired ability to regulate affect (Schore 2012).

Abuse has both neurological as well as social consequences. The neurological may even lead to the social, or vice versa – potentially perpetuating cycles of fear, or cycles of mistrust, or cycles of violence, establishing ingrained personality patterns and, for some, even leading to personality disorders (for example, Scaer 2005; Schore 2012). These are enduring patterns of inner experience and behaviour that are pervasive and inflexible, and that cause the individual distress or impairment in functioning; they start in adolescence or early adulthood and deviate from expectations of the person's culture (APA 2013, 645). Personality disorders are generally resistant to modification and could have both genetic as well as environmental components in their aetiology (Gunderson and Choi-Kain 2012).

Intergenerational transmission of trauma is a phenomenon so real that children of psychotherapists have even observed and written about the effects of unresolved traumas on their parents' parenting styles. Extrapolating this crucial knowledge has specifically important implications for South Africa. With its history of apartheid as well as the Anglo-Boer Wars, to name only a few collective traumas experienced by this nation, as a result of which South Africans have lived through different times and transitions and been allocated to different sides of a struggle as a mere function of birth during this country's divided history. An example stemming from the impact of the Second World War on a psychologist is narrated by her son. In his book *Das wahre Drama des begabten Kindes. Die Tragödie Alice Millers. Wie verdrängte Kriegstraumata in der Familie wirken*, Martin Miller (2013), the son of Alice Miller, describes his mother as a deeply wounded person who could not succeed in incorporating her insights into her own life. Martin Miller portrays Alice (born to Polish-Jewish parents) as a woman who projected her own unresolved traumas and hatred onto her own son, resulting in severe mistreatment, and who tragically failed to protect her son from the hatred and abuse of his German father, missing or purposefully misidentifying the psychic projections in her own family while writing about the details and realities of similar situations in her highly acclaimed books (Miller 2013). This example can support the argument that to truly understand the impact of the collective past, including intergenerational influences, on previously disadvantaged learners is an exceptionally complex task and should be very carefully approached by teachers. Trauma is not always verbalised. While some trauma is preverbal, even that which is not is sometimes so deeply rooted in shame about issues such as HIV, racial discrimination and humiliation that music may become a safe avenue for learners to express their emotions. Music can enter emotional centres of the brain directly through bypassing cortical functioning (Montello 2002, 124). As such, music can be cathartic.

PSYCHODYNAMICS

The observations and hypotheses on which psychodynamic theory is based existed long before those concepts could be explained in terms of brain functioning and

development. While much of the theoretical understanding was built on initial work by Sigmund Freud, there are various schools of thought within the discipline (for example, Klein 1948; Gomez 1997). There are a few important concepts in psychodynamic theory that every teacher should understand. In simplified terms, psychodynamic theory incorporates the ideas that a sense of ego boundaries (or the limits of our perception and control) develops in the infant and child, while the ego then develops within these ego boundaries. The id refers to the instinctive part of the personality, while the superego is our sense of morality, which in traditional thinking is developed through a response to parental punishment or approval, establishing a sense of right and wrong. The ego mediates impulses between the id and the superego and forms the executive part of the personality. The ego is the lasting and recurring aspect of the personality that forms a continuity of body and mind in space, time and causality (Federn 1952a, 94). Federn draws attention to the seeming paradox that, while the ego is the bearer of consciousness, the ego is also conscious of itself, therefore being subject ('I') as well as object ('the self') (Federn 1952b, 185). Freud described the defence mechanisms, namely repression (keeping threatening thoughts or events out of awareness), denial (blocking external events from awareness), projection (attributing unwanted characteristics in oneself to another person), and displacement (satisfying an impulse towards someone or something – such as aggression – through a substitute person or object, such as redirecting anger towards someone other than the person who elicited the anger in the first place) (Freud 1962). Sublimation is a mature defence in which an individual satisfies unacceptable impulses by expressing them in an altered, socially acceptable form (Freud 1962), such as sublimating aggressive impulses by becoming a surgeon. Object relation patterns unique to the genetic make-up and environmental influences impacting on each individual develop and profoundly influence future patterns of relating on an unconscious level (Hamilton 1996, 69).

Through observing transference and countertransference patterns, it is possible to bring processes that were largely unconscious into conscious awareness and modify them (for example, Hamilton 1990, 219; Katz 2014). Transference occurs when an individual redirects feelings relevant to either early relationships with caregivers or other significant individuals in a person's life towards persons and situations where they do not necessarily hold true, essentially disturbing their objective sense of reality through interpreting the present heavily based on past experience and reminders. Countertransference occurs in the therapeutic environment when a therapist responds to a patient through redirecting such subjective feelings from the therapist's own past to their patient. However, countertransference also exists in other human interactions where an attribute or response in one person elicits a counter-response in another person that is rooted in past experience and that deviates from objective present reality (for example, Katz 2014). Yet, this is not often given sufficient consideration. Alexander Stein (2007, 444) acknowledges that these

psychic operatives can be at work in relationships between music, performer, and audience. Transference-countertransference also applies to the pedagogic situation. Even for those who prefer Cognitive-Behavioural Therapy (CBT) approaches to the modification of behavioural patterns above psychodynamic principles, transference-countertransference phenomena still have equal relevance. Gordon goes as far as stating that therapists who do not believe in or concern themselves with understanding transference-countertransference phenomena are like physicians saying that 'since they do not practice as did Louis Pasteur, they need not concern themselves with germs' (Gordon 1997).

By understanding the adaptive function of certain patterns and responses, they can be successfully navigated and utilised. In 1990 John Bowlby said: 'Emotion is nonverbal communication of basic but very powerful attitudes in mind and potential action' (in Tondo 2011, 167). Sacks discussed how transference and emotion are deeply linked and how implicit emotional memories from the first years of life have the potential to influence a person's behaviour for a lifetime, made possible through deep emotional memories or associations formed by the brain even before the ability to retain explicit memories develops (Sacks 2008, 217–218). Furthermore, Stein states that music is a language that can be considered in the context of psychic mechanisms and explained in terms of processes involved in verbalisation (Stein 2012, 556). Musicians are in the business of communicating emotion, as well as of recreating emotion communicated by the composer through a musical score, sometimes hundreds of years after its initial composition. Therefore the implications of early developmental processes in these nonverbal communication patterns have to be considered. When emotion is linked to previous emotional responses to important individuals in a learner's life, an understanding of psychodynamic processes makes it possible to evaluate the ways in which past experience may have impacted on a learner by observing present relations. That said, emotional memory is still one of the deepest and least understood types of memory (Sacks 2008, 217). Through observing relational patterns, a teacher can gain insight into the transference of previous patterns/fearful behaviour/lack of trust (the latter in particular has been found to be exceedingly common among previously disadvantaged learners (Pruneau 2013)) into interactions taking place in the present, become equipped to understand them, and know that modification is possible with patience and repeated reinforcement of positive or adaptive behavioural patterns. Without previous experience, these processes might initially be challenging to understand and identify, but a few examples involving well-known individuals will serve to illustrate this, specifically emphasising the impact of trauma.

The role of music in a traumatised musician's life could have psychodynamic significance. In some instances, especially in traumatic circumstances around the Second World War, their art has held a very specific place in psychodynamic terms for some artists. A famous example is Artur Rubinstein (1887–1982), who was the

only member of his family to survive World War II (Rosen 2004). Jolanta Welbel (2009), music psychologist formerly associated with the Fryderyk Chopin University of Music, draws attention to the significance of Rubinstein's traumas, describing the first as his mother leaving him in Berlin at the age of 13 and the second as the Holocaust. She states that Berlin was the only place where he experienced stage anxiety. Welbel (2009) explains that, for Rubinstein, the piano may possibly have been the primary love object that leaves and returns, which explains the relationship to his instrument in terms of primary attachment processes. In the documentary *Rubinstein Remembered*, his son John Rubinstein says that his father started practising seriously and working hard to make his mother (Rubinstein's wife) proud – he did not want people to say that her husband had a great talent that was never fully developed (Rosen 2004). It may have value to consider the role of music in a learner's life and to utilise this to their advantage in the teaching strategy. Especially in the case of learners who have suffered significant trauma, it is essential to understand what role music fulfils in their lives, not only to understand what best motivates them, but also to ensure an understanding of how their goals and their reasons for participation in music might be different from a teacher's expectations of them. Then learning programmes could be tailored according to their needs, which may, in many cases, involve group work.

The concept of *ubuntu*[2] is very important in African culture, making relationships of primary importance. While much of the psychodynamic literature focuses on the early few significant relationships in an individual's life and their impact on identity formation from a decidedly individualistic perspective, consideration should also be given to how these processes may differ in cultures where the emphasis is on the group, and the individual is defined through the group. Wohlitz quotes John Roos, founder of the Unisa Music Outreach Project, as saying that these children function better in groups since they are used to being among many people in their cultures (Wohlitz 2013). Therefore group teaching and performance may be the key to helping previously disadvantaged learners reach their full potential.

TRAUMA AND THE BRAIN

Music therapy is widely used in the treatment of traumatised patients (for example, Sutton 2002), yet it has also been shown how trauma can impact on music creation, interpretation and performance (Swart 2013). Psychological consequences of trauma such as post-traumatic stress disorder (PTSD) or acute stress disorder (ASD) directly affect the brain. However, the focus of this discussion will not be on these disorders, but on the developmental aspects of trauma, which are more likely to affect music learners, as well as its effects on the brain as understood in the light of new neuropsychological research (for example, Schore 2012).

Humans learn by imitation. What is known today about the human mirror neuron system also supports this intersubjective self-other understanding. Daniel Siegel explains how, when a child is traumatised at a young age, they can subsequently misinterpret situations in their environment as being fear-inducing, since the human mirror neuron system learns by experience (Siegel 2010, 42). Mirror neurons are visuomotor neurons situated in the premotor cortex involved in learning through imitation and in understanding the actions and emotions of others (Rizzolatti and Craighero 2004). Human mirror neurons are especially involved in the neurocognitive function underlying social cognition (Rajmohan and Mohandas 2007, 66–9). Our evolutionary adaptive response to fear, in the face of perceived danger, is the fight/flight/freeze/faint response (Siegel 2010, 21). Siegel explains that it is theorised that it is our interactions with others that determine whether our deep brain structures respond with a sense of receptivity and safety, or with a sense of danger to situations in life (Siegel 2010, 21). Whether these responses are adaptive or have, through adverse experience, become maladaptive profoundly influences daily functioning in many different situations.

Traumatic experiences early in life affect the integrative structures of the brain (Siegel 2012, 22). Siegel elucidates how early experience affects synaptic growth and survival, influences the response to stress through the hypothalamic-pituitary-adrenal (HPA) axis, and may also influence patterns of gene expression or epigenetics. Neurons responsible for the fight/flight/freeze/faint response to imminent danger are located in the primitive parts of the brain, therefore these responses are instinctive (Siegel 2012, 21–22). Siegel explains that primitive responses such as violence can result if subcortical impulses to threat are not brought under cortical control.

It is now understood that attachment trauma has an enduring detrimental impact on brain development, emotional processes and stress regulation (Schore 2012, 154). When a child is raised in an environment where interaction between the child and caregivers is frequently dysregulated and where negative affective states are allowed to continue unrepaired, insecure attachment results and these insecure/disorganised/avoidant patterns of attachment are imprinted on the highly impressionable and malleable early developing right brain of the child (Schore and Schore 2014, 185). Judith and Allan Schore further explain that the defence against trauma, namely dissociation, is stored in implicit-procedural memory, becoming a blueprint for response during times of interpersonal stress. In the face of trauma or threat, dissociation is a very common response. Affects become dissociated: a disconnect occurs between right-brain cortical and subcortical systems and so the brain's capacity for integrating the traumatic experience or for integrating subsequent experiences in any way resembling the original traumatic experience is compromised (Schore 2012, 294–295). According to Schore and Schore, deficits in affect regulation and right-brain relational processes underlie psychological and psychiatric disorders (2014, 185).

Where trauma is concerned, it is very important that music teachers understand the concept of 'learned helplessness'. In learners who have been involved in uncontrollable events of a traumatic nature during which they felt they had no control over the situation, the brain can literally be rewired and cause receptor sites for neurotransmitters in the brain to be altered (Jensen 1998, 57). If choice could be exercised during such a traumatic event, this does not result. However, even one traumatic experience of helplessness and fear needs many subsequent instances of showing a learner that they can exercise control again to counteract the effects of such a demotivating state, manifesting as learned helplessness (Jensen 1998, 57). Many South African learners could be affected, especially those coming from previously disadvantaged backgrounds. This is supported by the experiences of a teacher who has worked with previously disadvantaged music learners for many years. Pruneau (2013) observed that they cannot handle inconsistency and tend to give up when they perceive their environment (or lesson times, or the teaching style) as inconsistent (Pruneau 2013). In the light of this, it might be argued that previously disadvantaged learners perceive their environment as uncontrollable in the face of inconsistency and that this activates a sense of learned helplessness.

Schore explains how it is possible to heal attachment trauma through empathic relationship. All aspects that were found to be relevant to previously disadvantaged learners apply here, including consistency and earning trust. The neuro-regenerative potential of such earned secure attachments is vast (Schore 2003, 281). New neuronal connections and patterns can be formed, and previous maladaptive patterns gradually extinguished. It is the aim of therapeutic intervention models to improve auto-regulatory and interactive repair processes (Schore and Schore 2014, 185). Music has great potential for utilisation in these processes, especially considering that Schore (2012, 39) now sees the value of psychotherapy not as a 'talking cure', but as a 'communicating cure'. This could be facilitated by choosing music that complements a learner's character or, sometimes, that expresses moods and feelings opposite to his or her outwardly observable personality. Most importantly, learners should be involved in choosing which music they would like to play, allowing them to exercise choice and instill a sense of control over their learning experience. More so than any other subject taught at school, music as a subject provides both a relational context as well as an interactive, emotionally expressive context in which these processes could be reactivated and growth and change could occur, facilitated by trained, sensitive teachers. This has great potential for providing emotionally and relationally reparative experiences, particularly (but not exclusively) to previously disadvantaged learners.

The purpose of this discussion is not to link neuroscientific principles directly to the learning and performance of music by previously disadvantaged learners, but to show how relational patterns affect development, and how music is a very important medium in and through which communication and relationship occur. As such,

music can become a powerful medium through which healing can take place. This is enhanced by music's ability to process emotion – both in terms of intensifying as well as releasing emotion, and particularly in terms of its ability to bypass the conscious mind (Montello 2002, 124) and to 'pierce the heart directly', to borrow the words of Oliver Sacks (2008, 329). Music can be joyous or cathartic, and has the potential to allow emotion to flow again in individuals whose feelings have become 'frozen', or who have become depressed and anhedonic (Sacks 2008, 327–328). Sacks argues that music is so fundamental and that it may resist or survive even the distortions of psychosis and schizophrenia, the losses of amnesia and Alzheimer's, and the deficits of parkinsonism (Sacks 2008, 330–332). He believes that it has the potential to penetrate the deepest states of melancholia or madness, even in cases that are treatment-resistant in other respects (Sacks 2008, 332).

Healing and lasting change do not occur through searching for left-brain conscious solutions (Schore and Schore 2014, 189), but through an attentive other who engages emotionally with a learner 'right brain to right brain'. Such communications should be reliable and consistent, especially during affectively stressful moments (Schore and Schore 2014, 189). An interactively regulated relationship provides an environment in which a learner can safely experience a broader range of emotions and let go of previously utilised rigid defences through allowing improved integration, interconnectivity and eliciting increased neuroplasticity of the brain (Schore and Schore 2014, 190). Music may potentially provide a medium in and through which autoregulation of emotions can be practised. Levitin (2006, 202–203) states that 'an organism is acted on by the world as a function of its appearance' – a social psychological explanation of how a person's outward appearance influences the treatment he or she receives. It could be argued that the same applies to the appearance (to others) of a person's behaviour. Responses and counter-responses are elicited through behavioural patterns that may have been rooted in past events, yet continue a cycle of a certain pattern of interaction or response. Therefore a conscious understanding of these processes is needed, otherwise it remains likely that cycles continue, fuelled by deficient insight into the determinants underlying observed behaviour. Facilitating neural change takes discipline, while intersubjective models of human behaviour such as those proposed by Schore (2012) have shown clearly that human actions and development do not occur in isolation. It is time that this discipline becomes a shared societal responsibility.

MEMORY FOR MUSIC AND FEAR

The performance or perception of music is dependent on activating neurons in an organised fashion, while remembering music requires reactivating that particular pattern of connectivity and reproducing fire rates as close as possible to the original levels through recruiting neurons in the hippocampus, amygdala and temporal lobes

by the attention and planning centres of the frontal lobe (Levitin 2006, 210). When a memory is deemed to be important (as are all memories associated with survival threats), neurochemical changes take place and neurochemical tags – as Levitin calls them – are attached to the important memories (Levitin 2006, 198), strengthening those particular pathways and making future retrieval more likely. In fact, since emotionally important events are the ones most necessary to remember for survival, any events eliciting extreme emotions of fright, elation, sadness or anger are thus 'tagged' (Levitin 2014, 52).

While memory for music is acquired and accessed through many different neural pathways, as previously mentioned, the processing of information involves brain structures that are also involved in the processing of memories of fear, most notably the amygdala and hippocampus. LeDoux states (2002, 134) that most neuroscientists now believe that alterations in synaptic connectivity are necessary for learning to take place, and that memory of learnt material constitutes the stabilisation and maintenance of these changes over time. For instance, at a given point in time a musician could be recalling a specific piece of music and playing such a piece of music 'from memory', while many other pieces may be stored in the musician's memory, available for future recall. The degree of accuracy of recall depends, among other factors, on associations made at the time of learning, while the music is stored in various memory systems and available for retrieval (Swart 2010, 27).

Associations with emotional relevance are particularly important to musicians. Both the learning or unlearning of fear patterns and the execution of musical performances are strongly reliant on either forming new or extinguishing previously formed emotional associations. The neuropsychologist Donald Hebb (1949) first stated the idea that neurons that fire together form connections (or 'wire together') and are likely to be retrieved together once an associated memory is recalled; this is clearly important in the memorisation of music. It also has implications for consciously separating the experience of fear or fear memories from the experience of learning music and consolidating memory for music, as well as from the experience of performing music.

Visual, acoustic (or aural), kinaesthetic, motoric and analytical memory systems are involved in the memorisation of music, as well as the recall of previously memorised music (Sándor 1981, 192–197). It is now known that in a state of fear the amygdala becomes activated, perception and response are fast-tracked, and the neo-cortex is bypassed to a large extent (for example, Le Doux 2002). When a learner is fearful, the neo-cortex, which is the rational part of the brain, has reduced ability to exercise rational control and integrate new learned material. While the limbic system, or emotional parts of the brain, evolved earlier than the neo-cortex in terms of the evolution of human beings, the neo-cortex also develops later than the limbic system in the individual life-span of a person. Therefore, emotional responses are more innate and quick, while overriding instinctive responses through cognitive evaluation, higher-order processing and inhibitory controls of the neo-cortex is a

slower process (for example, Le Doux 2002; Schore 2012). It follows that using fear as a motivator would rarely, if ever, allow learners to reach their full potential, since it compromises the ability of their neo-cortex to exercise control during the learning process. As discussed earlier, fear may also lead to dissociative responses in learners already predisposed to anxiety. These responses include the dissociation of emotional experience and are based on a structural impairment of right-brain regulatory processes manifesting as functional deficits in affect regulation (Schore 2012, 291–295).

The importance of counteracting and extinguishing these defensive responses through repeated enforcement of remaining 'present' and minimising fear-inducing situations cannot be overemphasised. The negative effects of the stress response in previously traumatised learners are more pronounced, since their fear activation systems have been primed by past negative experiences, their neurocircuitry has been altered, and they might already have developed vulnerabilities or patterns of maladaptive responses to stress. It may benefit these learners to have many repetitions of performance rehearsals in environments where they feel relatively safe, as such practising the art of performing before performing at more important concerts or competitions. This could help to keep music performance associated with the anticipation of a positive experience, and reduce the chances of debilitating stage fright patterns becoming established in these learners. The most important factor counteracting the effects of fear, however, might still be the facilitation of a safe and consistent environment, and instilling relational trust.

When utilised insightfully, music has been shown to have strong potential to heal on various levels, including functioning as a catalyst in healing physiological brain processes. Altenmüller and Schlaug (2015, 237) have shown that musical activities engage multisensory and motor networks, can induce changes within these networks, and can, over time, foster links between functionally related brain regions, even when such regions are located far apart from one another in the physical brain. Music is especially valuable in increasing neurorehabilitative capacity since it taps into the emotion and reward systems of the brain and can, in exerting its multi-modal effects, therefore enhance therapeutic approaches aimed at restoring neurological dysfunction (Altenmüller and Schlaug 2015, 237–238).

Attempting to achieve a holistic and integrated understanding of the brain processes involved in musicianship, as well as separating the relative impact of various external and internal factors on memory, fear conditioning, neurodevelopment and the effects of trauma on the brain, is an incredibly complex task. Such an investigation cannot be complete without considering the interplay between adverse life experiences and enhanced creativity as well as the possible association between creativity, uniqueness, novelty and its more pathological manifestations, which are often colloquially described as 'madness'. A more in-depth understanding thereof

has direct relevance to attempts at bridging the fields of psychiatry, music and trauma (Schore 2015).

GREAT ARTISTS, CREATIVITY AND THE BRAIN

It was seen above how neuroscience can now explain many processes involved in the making of a musician. Particular aspects of the development and function of ego boundaries in aspiring musicians have been discussed. While brain pathology has often been associated with creative individuals, they were still able to function well artistically. Therefore a short discussion of this idiosyncratic aspect of the lives of some great musicians is warranted. A recent special edition of the journal, *Frontiers in Psychology. Psychopathology*, was devoted to investigating the actual nature of the association between madness and creativity (Abraham 2015). Referring to the work of Paul Federn and Peter Giovacchini, it is also argued that the creative process can be explained in terms of ego boundaries and that the creative process itself is not pathological.

There has been much speculation about the frequency with which famous composers and performers appear to have suffered from illnesses involving the brain. Some have considered whether Wolfgang Amadeus Mozart could have suffered from Tourette's Syndrome (Ashoori and Jankovic 2007), but others believe he may have had a mood disorder on the bipolar spectrum (disorders where people suffer from alternating depression and elevated mood or mania) as well as having dependent personality disorder (Huguelet and Perroud 2005). Ludwig von Beethoven is thought to have suffered from bipolar disorder (Mai 2007, 92). However, lead poisoning, potentially leading to lability of mood as well as deafness, is not excluded (Martin 2000), while Paget's bone disease is a likely diagnosis accounting for the thickened skull bones found at autopsy (Mai 2007, 157, 171, 191). Mai additionally hypothesises that the thickened skull bones could have caused compression of Beethoven's auditory nerve, leading to his eventual deafness. Some researchers think that timbre in Maurice Ravel's Boléro was influenced by degeneration of his left brain (Amaducci, Grassi and Boller 2002). In the numerous cases where famous classical composers are thought to have suffered from neurosyphilis, it is clear that they had talent and were creative before the onset of illness. Even though testing was not available yet in those days, among those who are thought to have been affected are Franz Schubert, Robert Schumann and Hugo Wolff (Bäzner and Hennerici 2010, 315). Many composers suffered from depression. On the other side of the spectrum, there are individuals who have never displayed musical talent prior to a major brain injury and who suddenly developed exceptional musical abilities after such an injury (Treffert 2009). Derek Amato is such an unusual individual who acquired musical talent after suffering severe concussion, possibly changing the neurochemistry of his

brain or unlocking the function of his right brain (Harris 2013). The condition has been named Acquired Savant Syndrome (Harris 2013).

The question arises whether creativity and brain disorders could be linked in any way. While such speculations are interesting and have led to much debate within the medical field (for example, Abraham 2015), one has to acknowledge that, since many of these people have passed away and there is so much difference of opinion, it remains speculation. One might argue, however, that for these individuals, their afflictions had not always caused impairment of function, but at times may have enhanced creativity and perhaps given them the energy to accomplish extraordinary creative feats. In other cases, traumatic circumstances and tragic events may have given composers and performers an insight and depth that they might not otherwise have been capable of achieving. Very often unique talent or 'genius' was built on some degree of highly adaptive compensation for an existing pathology (for example, Hildesheimer 1982; Mai 2007).

The creative process itself does not have to be pathological and has been explained in terms of ego boundaries. Federn clarifies the mechanism that could explain Wolfgang Amadeus Mozart's accounts of how a whole musical score 'suddenly and simultaneously presented itself to his mind' (Federn 1952c, 223). This is an example of how the mental ego boundary enlarges to conceptualise ideas that were preconscious, but which might have become conscious at a previous stage (Federn 1952c, 223). Federn also explains that the last associations (pictures, ideas and conclusions about certain topics) that enter consciousness form the mental ego boundary for new associations. He says that 'the greatest and most complicated production is done unconsciously' (Federn 1952c, 223). The unconscious mind became indelibly linked to implicit memory processes as associated with the right brain (Schore 2012, 121). It is a role of creative artists to stretch or challenge existing boundaries (Swart 2015). Furthermore, the composer's ability to visualise (or 'audiolise') a musical work in an instant in its initial conception, or by the performer during the stage of learning, probably depends on an ability of the ego boundaries to become malleable. Giovacchini explains that in the creative process, ego boundaries can become fluid and permeable, even though they have been firmly developed and are well structured in other activities. He explains that these processes frequently reach 'primary-process-oriented parts of the self' (Giovacchini 1991, 187). This would be associated with early right-brain maturational processes and functioning. Giovacchini also says that, as a not fully understood feature of the creative process, this broad spectrum of functioning has often been confused with psychopathology (Giovacchini 1991, 187; see also Giovacchini 1965, 1971, 1981). Stein links music specifically to primary process experience, which he defines as the characteristic of music to be felt or perceived without necessitating additional elaboration or involving executive cognition in order to appreciate its meaning (Stein 2012, 555).

On the other side of the spectrum, some researchers do argue for an association between 'madness' and creativity. In psychometric research, Eysenck's psychoticism

personality traits were associated with originality and creativity. Yet these traits differed from features associated with psychosis in that it did not manifest in its pathological form but enabled such individuals to make constructive use of remote associations (Eysenck 1995, 244). It seems that there might be some overlap between mental processes associated with creativity and novelty and those associated with psychosis (Fink, Benedek, Unterrainer, Papousek and Weiss 2014, 2). The crucial importance of cognitive control in guiding the processing, organisation, evaluation and elaboration of novel information and ideas must never be neglected (Fink et al. 2014, 2). In fact, it may be one of the most important factors in determining outcomes of these mental and cognitive processes.

CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH

The more that is understood about the factors impacting on brain development and brain function in musicians, the more empowered teachers can become to unlock each learner's full potential. The significance of the right brain in both attachment trauma (affecting previously disadvantaged music learners at a high frequency) as well as in emotional communication involved in music interpretation was discussed. The healing potential of music was shown to lie in its communicative and relational nature, and in its ability to process emotion in terms of either intensifying or releasing emotion, through its ability to bypass the conscious mind and access the emotional centres of the brain directly. The importance of intersubjective processes in neurodevelopment and regulation of affect was highlighted. The development of ego boundaries and self-esteem was shown to be related and their functioning in musicians highlighted. Psychodynamic concepts such as ego, id and superego, defence mechanisms such as repression, denial, projection, displacement and sublimation, and psychodynamic phenomena such as transference and counter-transference were briefly explained. Effects of trauma on the brain and how this could predispose learners to patterns of behaviour not optimally conducive to healthy functioning were discussed, also taking into account dissociative responses and fear. Instilling a sense of safety optimises effective learning, while motivating learners through fear could jeopardise learning. It was shown how, even though many creative individuals are thought to have suffered from illnesses involving the brain, the creative process itself is not pathological, but a function of the expansion of the mental ego boundary and of novel associations.

While arguments for biological illness are interesting, many famous musicians have also suffered abuse. Beethoven was abused by an alcoholic father (Wolf 2001, 298) and Mozart was exploited by his father as a child prodigy (Crosby 2014, 135), to name only two examples. Therefore, it would be informative to examine the possible effects of traumatic neurodevelopment more seriously in the light of new

findings in neuropsychoanalysis as an alternative or additional explanation for these composers' fascinating pathologies.

More research is needed on how the understanding of brain processes can be used to the advantage of learners in the pedagogic process. Research specific to previously disadvantaged learners, focusing on their specific needs, is lacking. Applying psychodynamic insights to a culture of *ubuntu* or relatedness, where the group and not individual relationships take precedence (Department of Welfare, Republic of South Africa 1996, 12), could yield valuable insights. Such understanding could inform efforts to incorporate modules in psychology into the curriculum for music educators.

As neuro-imaging techniques constantly evolve, more possibilities become available for scanning musicians engaged in learning and performing music. While in the past functional magnetic resonance imaging (fMRI) scanning required that subjects remain still, newer techniques are now available (Bandettini 2009; Schlaug 2015). If sufficient parallel research continues to draw attention to the neuroscientific insights that could result from studying musicians, this could increase the likelihood of allocating funding to neuroimaging of musicians and increasing interdisciplinary collaboration. Involvement of the right brain in emotional communication could be researched through imaging music performers. Through refining such an investigation, screening musicians with known accurately documented histories of trauma (including ages at which trauma occurred as well as types of trauma) could lead to new insights on the impact of trauma on brain function and neural communication, as well as right brain involvement in this process.

ENDNOTES

1. Use of the standard terms 'previously disadvantaged' or 'economically disadvantaged' in the South African context refers to those individuals who have been discriminated against in the past under the apartheid system on the basis of 'race'.
2. In the *White Paper for Social Welfare*, *ubuntu* is described as a spirit of mutual support and a principle of caring for one another's well-being. It is an African philosophy and way of life that holds that each individual's humanity is ideally expressed through his or her relationship with others, and their humanity is in turn expressed through recognition of the individual's humanity (Department of Welfare, Republic of South Africa 1996, 12). According to the Department of Welfare, *ubuntu* means that 'people are people through other people' (Department of Welfare, Republic of South Africa 1996, 12).

REFERENCES

Abraham, A. 2015. Editorial: Madness and creativity – yes, no or maybe? *Frontiers in Psychology* 6 (1055). DOI: 10.3389/fpsyg.2015.01055

Altenmüller, E., and G. Schlaug. 2015. *Apollo's gift: New aspects of neurologic music therapy.* In *Music, neurology, and neuroscience: Evolution, the musical brain, medical conditions, and therapies*, ed. E. Altenmüller, S. Finger and F. Boller, 237–252. Amsterdam: Elsevier.

Amaducci, L., E. Grassi and F. Boller. 2002. Maurice Ravel and right-hemisphere musical creativity: Influence of disease on his last musical works? *European Journal of Neurology* 9: 75–82.

APA (American Psychiatric Association). 2013. *Diagnostic and statistical manual of mental disorders*. 5th ed. (DSM–V). Washington, DC: American Psychiatric Publishers.

Ashoori, A., and J. Jankovic. 2007. Mozart's movements and behaviour: A case of Tourette's Syndrome? *Journal of Neurology, Neurosurgery and Psychiatry* 78: 1171–1175.

Bandettini, P. A. 2009. What's new in neuroimaging methods? *Annals of the New York Academy of Sciences* 1156: 260–293.

Bäzner, H., and M. Hennerici. 2010. From sensibility to madness in nineteenth-century Romanticism – Neurosyphilis in German-speaking composers. In *Neurology of music*, ed. F. C. Rose, 315–334. London: Imperial College Press.

Crosby, J. F. 2014. *Sons and Fathers: Challenges to Paternal Authority*. New York: Routledge.

Department of Welfare, Republic of South Africa. 1996. *White Paper for Social Welfare. Government Gazette*, 02/02/1996, No.16943. Pretoria: Government Printer.

Eysenck, H. J. 1995. Creativity as a product of intelligence and personality. In *International handbook of personality and intelligence*, ed. D. H. Saklofske and M. Zeidner, 231–247. New York: Plenum Press.

Federn, P. 1952. *Ego psychology and the psychoses*. Ed. E. Weiss. New York: Basic Books.

Federn, P. 1952a. The awakening of the ego in dreams. In *Ego psychology and the psychoses*, ed. E. Weiss, 90–96. New York: Basic Books.

Federn, P. 1952b. Mental hygiene of the ego in schizophrenia. In *Ego psychology and the psychoses*, ed. E. Weiss, 184–206. New York: Basic Books.

Federn, P. 1952c. Ego psychological aspect of schizophrenia. In *Ego Psychology and the Psychoses*, ed. E. Weiss, 210–226. New York: Basic Books.

Freud, S. 1962. The neuro-psychoses of defence. In *The Standard Edition of the Complete Psychological Works of Sigmund Freud, Volume III (1893–1899): Early Psycho-Analytic Publications*, ed. J. Strachey, 41–61. London: Hogarth Press.

Gabrielsson, A. 2011. *Strong experiences with music: Music is much more than just music.* Trans. R. Bradbury. Oxford: Oxford University Press.

Gärtner, H., M. Minnerop, P. Pieperhoff, A. Schleicher, K. Zilles, E. Altenmüller and K. Amunts. 2013. Brain morphometry shows effects of long-term musical practice in middle-aged keyboard players'. *Frontiers in Psychology* 4(636). DOI: 10.3389/fpsyg.2013.00636

Giovacchini, P. L. 1965. Some aspects of the ego-ideal of a creative scientist. *Psychoanalytical Quarterly* 34: 79–101.

Giovacchini, P. L. 1971. Characterological factors and the creative personality. *Journal of the American Psychoanalytic Association* 19: 524–542.

Giovacchini, P. L. 1981. Creativity, adolescence and inevitable failure. *Adolescent Psychiatry* 9: 35–60.

Giovacchini, P. L. 1991. The creative person as maverick. *Journal of the American Academy of Psychoanalysis* 19(2): 174–188.

Gomez, L. 1997. *An introduction to object relations*. London: Free Association Press.

Gordon, R. M. 1997. Handling transference and countertransference issues with the difficult patient. *Pennsylvania Psychologist Quarterly* 1: 20–24.

Grocke, D. 2005. A case study in the Bonny Method of Guided Imagery and Music (BMGIM). In *Case study designs in music therapy*, ed. D. Aldridge, 97–118. London: Jessica Kingsley.

Gunderson, J. G., and L. Choi-Kain. 2012. Personality Disorders. MSD Manual Professional Edition. http://www.msdmanuals.com/professional/psychiatric-disorders/personalitydisorders/personality-disorders (accessed October 12, 2015).

Hamilton, M. G. 1990. *Self and others: Object Relations Theory in practice*. Lanham, MD: Rowman and Littlefield.

Harris, N-E. 2013. Derek Amato becomes musical genius after brain injury: What is acquired savant syndrome? Medical Daily. http://www.medicaldaily.com/derek-amato-becomesmusical-genius-after-brain-injury-what-acquired-savant-syndrome-video-260369 (accessed July 20, 2015).

Hebb, D. O. 1949. *The Organization of behavior*. New York: Wiley.

Hildesheimer, W. 1982. *Mozart*. Trans. M. Feiber. London: J. M. Dent.

Huguelet, P., and N. Perroud. 2005. Wolfgang Amadeus Mozart's psychopathology in light of thecurrent conceptualization of psychiatric disorders'. *Psychiatry* 68 (2): 130139.

Jensen, E. 1998. *Teaching with the brain in mind*. Alexandria, VA: ASCD.

Katz, G. 2014. *The play within the play: The enacted dimension of psychoanalytic process*. Hove: Routledge.

Klein, M. 1948. *Contributions to psychoanalysis, 1921–1945*. Honolulu: Hogarth Press.

Lamont, A. 2002. Musical identities and the school environment. In *Musical identities*, ed. R. R. MacDonald, D. J. Hargreaves and D. Miell, 41–59. Oxford: Oxford University Press.

LeDoux, J. 2002. *Synaptic self. How our brains become who we are*. London: Macmillan.

Levitin, D. J. 2006. *This is your brain on music: Understanding a human obsession*. London: Atlantic Books.

Levitin, D. J. 2014. *The organized mind: Thinking straight in the age of information overload*. London: Viking.

Library of Congress. 2000. 'Project of the Decade of the Brain (1990–1999)'. http://www.loc.gov/loc/brain/ (accessed July 20, 2015).

Mai, F. M. 2007. *Diagnosing genius: The life and death of Beethoven*. Montreal: McGill Queens University Press.

Martin, R. 2000. *Beethoven's hair. An extraordinary historical odyssey and a scientific mystery solved*. London: Bloomsbury.

Miller, A. 1997. *The drama of the gifted child: The search for the true self*. New York: Basic Books.

Miller, M. 2013. *Das wahre Drama des begabten Kindes: Die Tragödie Alice Millers: Wie verdrängte Kriegstraumata in der Familie wirken*. Freiburg: Verlag Kreuz.

Montello, L. 2002. *Essential musical intelligence. Using music as your path to healing, creativity, and radiant wellness*. Wheaton, IL: Quest Books.

Olson, I. R., Plotzker, A. and Ezzyat, Y. 2007. The enigmatic temporal pole: A review of findings on social and emotional processing. *Brain. A Journal of Neurology* 130(7): 1718–1731. DOI:10.1093/brain/awm052

Palombo, D. J., M. C. McKinnon, A. R. McIntosh, A. K. Anderson, R. M. Todd and B. Levine. 2015. The neural correlates of memory for a life-threatening event: An fMRI study of passengers from flight AT236. *Clinical Psychological Science.* DOI: 10.1177/2167702615589308.

Perry, B. D. 1999. Memories of fear. How the brain stores and retrieves physiologic states, feelings, behaviours and thoughts from traumatic events'. In *Splintered Reflections: Images of the body in trauma,* ed. J. Goodwin and R. Attias, 3–28. New York: Basic Books.

Pruneau, L. 2013. Personal communication on 5 December.

Rajmohan, V., and E. Mohandas. 2007. Mirror neuron system'. *Indian Journal of Psychiatry* 49(1): 66–69.

Rizzolatti, G., and L. Craighero. 2004. The mirror-neuron system. *Annual Review of Neuroscience* 27: 169–192.

Rosen, P. 2004. *Rubinstein remembered: Legendary visions*. BMG Classics [DVD Video Documentary]

Sacks, O. 2008. *Musicophilia: Tales of music and the brain*. Rev. ed. London: Picador.

Sándor, G. 1981. *On piano playing: Motion, sound and expression*. New York: Schirmer.

Scaer, R. C. 2005. *The trauma spectrum: Hidden wounds and human resiliency*. London: Norton.

Schlaug, G. 2015. Musicians and music making as a model for the study of brain plasticity. *Progress in Brain Research* 217: 37–55.

Schlaug, G. L., Y. Huang, J. F. Staiger and H. Steinmetz. 1995. Increased corpus callosum size in musicians. *Neuropsychologia* 33 (8): 1047–1055.

Schore, A. N. 2003. *Affect regulation and the repair of the self*. New York: Norton.

Schore, A. N. 2012. *The science of the art of psychotherapy*. New York: Norton.

Schore, A. N. 2015. Personal email communication on 30 May.

Schore, J. R., and A. N. Schore. 2014. Regulation theory and affect regulation psychotherapy: A clinical primer. *Smith College Studies in Social Work* 84 (2–3): 178–195.

Siegel, D. J. 2010. *The mindful therapist. A clinician's guide to mindsight and neural integration*. New York: Norton.

Siegel, D. J. 2012. *The developing mind: How relationships and the brain interact to shape who we are*. 2nd ed. New York: Guilford.

Stein, A. 2012. Psychoanalysis and music'. In *Textbook of psychoanalysis*, ed. G. O. Gabbard, B. E. Litowitz and P. Williams, 551–565 . 2nd ed. Arlington, VA: American Psychiatric Publishing.

Stein, A. 2007. Music and trauma in Polanski's *The Pianist* (2002). *Psychoanalytic Inquiry* 27 (4), 440–454.

Sutton, J. P. ed. 2002. *Music, music therapy and trauma: International perspectives*. London: Jessica Kingsley.

Swart, I. 2010. The influence of trauma on musicians. DMus diss., University of Pretoria.

Swart, I. 2014. Overcoming adversity. Trauma in the lives of music performers and composers. *Psychology of Music* 42 (3): 386–402.

Swart, I. 2015. Ego boundaries and self-esteem: Two elusive facets of the psyche of performing musicians. *Psychology of Music*. DOI: 10.1177/0305735615590283.

Taylor, J. B. 2008. *My stroke of insight. A brain scientist's personal journey*. London: Hodder and Stoughton.

Tondo, L. 2011. Interview with John Bowlby, M. D. *Clinical Neuropsychiatry* 8: 159–171.

Treffert, D. A. 2009. The savant syndrome. An extraordinary condition: A synopsis: Past, present, future. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364: 1351–1357.

Veenhoven Guidarian, L. 2014. Creative application: A way to include music composition and improvisation in the general music curriculum'. In *The musical experience: Rethinking music teaching and learning*, ed. J. R. Barrett and P. R. Webster, 183–204. Oxford: Oxford University Press.

Welbel, J. 2009. Personal communication on 10 September.

Wohlitz, H. 2013. Personal communication on 13 December.

Wolf, P. 2001. Creativity and chronic disease: Ludwig von Beethoven (1770–1829). *Western Journal of Medicine* 175(5): 298.