Lauren Emery Bath Spa University

What does a neuroscience perspective offer Early Childhood Education and Care (ECEC) practitioners in supporting children with emotion regulation?

Introduction

This literature review examines the influence of neuroscience on Early Childhood Education and Care (ECEC) practice in supporting children's emotion regulation. First, it highlights why it is important for practitioners to support children's emotion regulation and discusses the relationship between emotion regulation and children's cognitive and social development. Second, it discusses the benefits and limitations of neuroscientific research, explores the assumptions and understandings of children's emotion regulation and explains what neuroscience can offer ECEC.

The focus on children's emotion regulation in ECEC: Why is it important for practitioners to support children's emotion regulation?

There has been a vast increase in the amount of research into emotion regulation in the last decade (Chen et al., 2015; Eisenberg, Valiente and Eggum 2010; Gross 2007). Children's capability to regulate their own emotions has been said to emerge during preschool and early childhood (Carlson and Wang 2007; Simonds et al., 2007). Research indicates that children's inability to regulate emotions effectively may seriously affect their mental health (Bradley 2000, Kring and Werner 2004) and their ability to learn and achieve in school (Bahman and Maffini 2008). This implies that effective emotion regulation is a foundation of a healthy child's development (Cole, Martin and Dennis, 2004; Shonkoff and Phillips, 2000) and an essential part of social and emotional learning (Denham, Bassett and Zinsser, 2012; Hourigan, Goodman and South-Gerow, 2011). A significant amount of empirical research (Bulotsky-Shearer and Fantuzzo, 2004; Daunic et al., 2013; Dryfoos, 1997; Hajdukova, Hornby and Cushman, 2015; Howse et al., 2003; Trentacosta and Izard 2007) indicates that children with low emotion regulation skills are prone to additional stress, anxiety and depression. Watson, Clark and Tellegen (1988) argue that children who have difficulties recognising and regulating their emotions often feel emotions such as fear, sadness and anger, which can lead to children developing negative feelings and attitudes in their peer and adult relationships (Bahman and

Maffini, 2008; Hajdukova, Hornby and Cushman, 2015; Watson, Clark and Tellegen, 1988). Whereas children with competent emotion regulation skills are able to recognise and manage their own emotions effectively, empathise with others and make sensible decisions concerning their behaviour and social interaction (Denham, Bassett and Zinsser, 2012; Garner 2010, Jones and Bouffard 2012; Kress and Elias, 2006). Effective emotion regulation can also help children to sustain their positive mood in a variety of social situations (Ciarrochi, Forgas and Mayer 2001; Mayer and Salovey, 1997) due to their ability to regulate emotions appropriately (Salovey and Mayer, 1990).

Studies have suggested that children who are successful at regulating their emotions adjust to school more easily due to competent emotion regulation and control of their behaviour (Blair, 2002; Paris and Paris, 2001). Research concerning young children and emotion regulation suggest that preschool children who are inexperienced in managing their impulses and can find adapting to the emotional demands of a school classroom difficult (Birch and Ladd, 1997; Herndon, Bailey, Shewark, Denham and Bassett, 2013; Shields et al., 2001). It is becoming increasingly evident that emotion plays a fundamental role not only in processes like motivation for learning but also in moment-to-moment problem solving and decision making. That is, emotion forms the rudder that steers learners' thinking in effect helping them call up information and memories that are relevant to the topic or problem at hand (Immordino-Yang and Damiso, 2007). The pressure in supporting children's emotion regulation comes from the school readiness discourse that focuses on preparing them to succeed later in school life (Gormley, Phillips and Gayer, 2008; Pinata et al., 2009). It promotes a deficit model of children's development, suggesting that the child is at fault if their emotion regulation skills are low, they are deemed to struggle not only with this but other aspects of learning. However, this is clearly not the case when considering the work of Bailey (2015) who found that an important contributor to children's emotion regulation skills is positive school adjustment, it was only in classrooms where teachers were less emotionally and organisationally supportive that children's emotion regulation skills were low.

Research however, should be interpreted with caution (Djambaziva-Popordannoska, 2016) many studies in this literature review lack clarification of what is defined as

emotion regulation, and because there is not a single comprehensive understanding it can be difficult to ensure that results are generalisable. The majority of studies concerning children's emotion regulation derive from neuroscience. Neuroscience is the multidisciplinary scientific study of the nervous system (Conkbayir, 2017); neuro scientists who study emotion regulation are interested in the brain's interaction within the nervous system and the influence this system has upon the child's emotions and behaviour (Conkbayir, 2017). It is key to note that neuroscientific studies reviewed within this literature review that the results can be challenging due to the difficulty of interpreting the emotions of others (Robson, 2016; Adolphs and Damasio, 2001; Caine and Caine, 1997; Ciarrochi, Forgas and Mayer, 2001; Forgas 2000; McCain, Mustard and Shanker, 2007). Despite this, neuroscience informs much research, policy and strategies in regards to 'supporting' children's emotional development (Allen, 2011; Conkbayir, 2017). This highlights the need for ECEC research in understanding the role of neuroscience in influencing the support of young children's emotion regulation and the implications it may have upon practice.

The emergence of neuroscience in ECEC: What can practitioners learn from neuroscience in understanding how to support children's emotion regulation?

Scientific understanding of the influence of emotions on thinking and learning has undergone a major transformation in recent years (Bradley 2000, Kring and Werner 2004; Bahman and Maffini 2008; Gormley, Phillips and Gayer, 2008; Pinata et al., 2009). Like most disciplines, neuroscience has taken decades to be readily accepted as a science which can reliably contribute to influencing education, particularly early childhood education (Bruer, 2011). Whilst attempts have been made to use some evidence derived from neuroscience in ECEC these have been generally erroneous. Neuroscience does offer insights concerning the young brain and the vital role adults play in helping to shape it, which can be applied both short and long term in practice (Spitzer, 2012; Howard-Jones, 2010; OECD, 2007). Neuroscience and educational researchers are "undoubtedly producing worthwhile evidence concerning the integration of neuroscience in education", but some argue a similar approach is now needed in ECEC (Conkbayir, 2017, p.32).

According to Rose, Gilbert and Richards (2016. p.73) emotion regulation is a "complex process that involves accommodating an increasing myriad of emotional states." Emotions are very much both physical and mental experiences that provoke different behaviours. The polyvagal theory (Porges, 1995) emphasises the link between the brain, heart and emotions and is concerned with the processes of the brain nerves in emotion. Central to this process is the limbic system, it responds to stimuli perceived as dangerous causing feelings of fear, anger, resulting in a stress response which increases hormones such as adrenaline and cortisol. These hormones stimulate physiological changes in the body, for example increased heart rate and blood pressure, rapid breathing and many other symptoms which are associated with anxiety and panic. This is known as the fight or flight reflex in action (Rose, Gilbert and Richards, 2016). This response is thought to have a role in children's emotional outbursts, due to the immaturity of the stress response system in children who are neurologically underdeveloped in the limbic system which signals danger, so it is natural for children to automatically enter fight or flight response (Krystek-Walton 2019). Polyvagal theory is not without its critics (Grossman and Taylor, 2007), it should be recognised as one of many systems contributing to emotion regulation (Porges, 2007).

Emotion regulation processes are often thought to impact on other brain processes which is often why correlations between emotion regulation and cognition are found (Robson, 2016; Adolphs and Damasio, 2001; Caine and Caine, 1997; Ciarrochi, Forgas and Mayer, 2001; Forgas 2000 and McCain, Mustard and Shanker, 2007). In their review of extensive research on brain development Caine and Caine (1991) and Forgarty (2009) asserted the influential role of emotions in the process of learning, stressing the notion that intense emotions compete for space in the active working memory of the brain, hence interfering with the learning process (Goleman, 2004). The reasoning for this is that the emotional region of the brain situated in the amygdala (involved in processing emotional information) is closely linked to the learning region of the brain, which is located in the neocortex (involved in higher cognitive functions such a conscious thinking and language development) (Adolphs and Damasio, 2001). According to Zins et al., (2004), the neocortex is pivotal in the

process of learning and when children feel overwhelmed by emotion, the learning regions of the brain are temporarily inhibited, focusing on the negative feelings (Elias et al., 1997). If the child has low emotion regulation skills it can cause ongoing negative emotions and if prolonged can have a detrimental effect on children's learning capacity. This comprehensive body of research indicates that emotion and cognition are intertwined. Arguably, emotion regulation is holistically interconnected with many areas of learning and development.

Recent advances in the neuroscience of emotions are highlighting connections between cognitive and emotional functions that have the potential to revolutionise our understanding of learning in the context of schools (Immordino-Yang, 2016). In order for new information about the brain, learning and emotion to influence the design of learning environments, practitioners and others involved in education policy need to know about the newest findings about the brain and learning (Immordino, 2016). Sharing good practice and working in a multidisciplinary manner can help practitioners broaden their knowledge about their role in supporting early brain development in regards to emotion regulation (Immordino-Yang, 2007). It is suggested that embedding neuroscience at a policy level can also help to ensure that evidence obtained from neuroscience can be filtered down to practice (Conkbayir, 2017). The neuroscientific findings could lead to "innovations in practice and policy, to discover these, findings must be presented for theoretical and philosophical debate between and across disciplines" (Immordino-Yang, 2016, p.74). Neuroscience is applied across diverse professions to help reinforce and enhance practice (Evan, 2015; Cozolino, 2013; Royal College Midwives 2012; Immordino-Yang and Damiso, 2007). According to Immordino-Yang (2016, p.80) "neuroscientists must now investigate phenomena that are relevant to real-world learning and development to ensure implementation of research into ECEC" such as the relationships between play, emotion and the brain.

However, this does not mean that neuroscience is a panacea; capable of contributing insights into all educational problems (Immordino-Yang, 2016). Challenges of implementing neuroscience into practice include applicability, implications, and limitations of neuroscience research methods in answering educational questions. Neuroscientists now have to learn about the problems,

issues and processes of education to promote transferability of neuroscientific research (Immordino-Yang, 2016).

The danger of neuroscience in ECEC: Why practitioners need to be cautious in applying findings from neuroscience into practice when supporting children's emotion regulation?

All too often there is a sincere desire to help children but it is important to maintain a cautious stance when considering neuroscience within ECEC (Fischer et al., 2007). Practitioners use strategies based on misunderstandings of misapplications of neuroscience. It is important that new advances in neuroscience be carefully examined in light of psychological, developmental and pedagogical theory and research, to ensure that the field proceeds with caution as well as optimism toward educational innovation (Immordino-Yang, 2016). It is important to note that the impact of neuroscience goes beyond these practical applications and extends towards a broader societal influence (Fias, 2017 cited in Vanderbroeck, 2017). In the past, neuroscientific ideas of children's development has led to the formation of neuromyths which are oversimplified, misunderstood, or misapplied notions whose integration into educational contexts is unjustified and, in some cases, detrimental or even dangerous (Goswami, 2006). Issues of research ethics concerning the use of brain imaging techniques with children and over-extrapolation of findings loosely based on neuroscience have not only led to this gap but also resulted in apprehension in grappling with knowledge that is neuroscience-based (Ansari et al., 2011; Devonshire and Dommett, 2010; Goswami, 2006; Jolles et al., 2005).

Neuroscience supports the conclusion that emotional control is essential to school learning (Gormley, Phillips and Gayer, 2008; Pinata, Barnett, Burchinal and Thornburg, 2009). It is increasingly recognised that effective learning does not take place when the learner is experiencing fear or stress. The main emotional system within the brain is the limbic system, a set of structures incorporating the amygdala and hippocampus. The 'emotional brain' (LeDoux, 1996) has strong connections with the frontal cortex (the major site for reasoning and problem solving). When a learner is stressed or fearful, connections with the frontal cortex become impaired, with a negative impact on learning (Goswami, 2004). Although these findings may inform

reasons why children with low emotion regulation skills could achieve worse in school, emotion regulation does not necessarily occur in a “linear way, nor should it be assumed that all children will transition through the different phases of emotional development in a similar way” (Conkbayir, 2017, p.41). While some are enthusiastic about the educational benefits to be gained from neuroscience (Greenleaf 1999; Clark, 2001), others have expressed reservations and urged caution. Importantly, many of these criticisms have come from within neuroscience itself, where several recent and authoritative publications have presented concerns that neuroscience itself is being discredited by some of the classroom strategies (Goswami, 2006). The recent neuro-argument prevailing early childhood education is, raising the misleading expectations that neuroscience is a panacea to understanding children’s development (De Vos and Pluth, 2016). Neuroscience and brain images are increasingly appearing in documents where policy makers advocate for investments in the early years. The Allen (2011) report is one example which showed a misleading image of a shrunken brain on its cover, implying that a lack of care in the early years could cause such a deteriorated brain (Vanderbrook et al., 2017). The most critical aspect of the persuasiveness of neuroscience is the continuity in presenting children as the object of policy – saving the world, one child at the time. In bringing neuroscience to inform education, this updating of educational theory is often neglected.

The value of neuroscience in early childhood is “undermined by a lack of understanding and inaccuracy in which it is presented which is then exacerbated by enthusiastic but misinformed practitioners who consequently disseminate erroneous information” (Conkbayir, 2017, p.31). Attempting to move directly from brain research to educational innovation without passing through the theory-building stage limits the generalisability of the research and is sometimes even dangerous for children (Hirsh-Pasek and Bruer, 2007). Take for example the Mozart effect, the finding of relation between spatial ability and music was misrepresented and misapplied in education. For education to truly benefit from these neuroscientific findings, educators must examine closely the theory on which good practice is built, to reconcile the new and exciting evidence with established educational models and philosophies (Immordino-Yang, 2016). Future research and theory in education should attempt to understand

how best to capitalise on the emotional and social dimensions of learning (Immordino-Yang, 2016).

While ECEC can benefit from articles that highlight the consequences of misusing neuroscience in education, some articles are hyper-critical and almost dismissive of key theories of early childhood practice but also inform early childhood policies (Gerhardt, 2015; Williams, 2014). Such skepticism "serves to further distance contemporary early childhood issues and practitioners from neuroscience" (Conkbayir, 2017, p.31). Nevertheless, translation from neuroscience research to education is difficult. As Howard-Jones (2010) comments, no classroom-ready knowledge from neuroscience is ever likely to exist. This is due to the stigma surrounding neuroscience and child development with ECEC. Unless the ECEC sector becomes more accepting of neuroscience the integration of the two will always be challenging (Conkbayir, 2017). Moreover, the interaction of the disciplines of neuroscience, psychology and education has been characterised by competition rather than collaboration, and education researchers remain suspicious of the hype surrounding educational neuroscience (Micheal et al., 2019).

Conclusion

An integrated approach will require policymakers, neuroscientists, early childhood professionals and educational researchers to work together, with close effective coordination and monitoring from each field in order to ensure that the evidence produced can be interpreted in early childhood policies and used by practitioners at an international level (Immordino-Yang, 2016). Such a strategy would lend itself to raising awareness and understanding about the science underpinning the developing brain, and the implications of standardising this knowledge within ECEC (Howard-Jones, 2010). Difficulties and errors are an inevitable part of the process of incorporating neuroscience into ECEC provision, but on the whole it is a worthwhile endeavour because neuroscience not only confirms existing knowledge concerning good practice but also extends it by providing a scientific base from which to understand the developing brain (Conkbayir, 2017). In the United Kingdom in 2014, the Education Endowment Foundation and the Wellcome Trust launched an Education and Neuroscience scheme; with the aim to provide funding for

collaborative projects between educators and neuroscientists (Howard-Jones, 2014b).

However, much work is still needed around understanding the developmental trajectories taking into account how the social environment and education impact on these developmental trajectories (Kaufmann et al., 2015). Teaching ECEC practitioners about neuroscience will inspire better pedagogy (Carew and Magsamen, 2010; Coch and Ansari, 2009; Dehaene, 2009; Dubinsky, 2010; Eden and Moats, 2002; Gabrieli, 2009; Goswami, 2006; Katzir and Pare-Blagoev, 2006; McCandliss, 2010; Meltzoff et al., 2009; Pickering and Howard-Jones, 2007; Sigman et al., 2014). As Dehaene (2011) states, educators who can visualise how the child's brain works, will spontaneously conceive better ways of teaching.

Neuroscience is a rapidly and dynamically evolving field of research with new techniques allowing for continuous insight and progress. Efforts to translate neuroscience findings and theories need to be flexibly situated in a dynamic changing context of ECEC. With respect to the children's emotion regulation, the position of this review is not that neuroscientific observations should not play a role in thinking about childcare education. On the contrary, it can form an important source of relevant information. However, the important message that comes with this is that neuroscience should not be taken as a panacea that provides simple solutions to complex problems. (Fias, 2017, cited in Vanderbroeck, 2017). The divide between neuroscience and early childhood practice is gradually being eroded by knowledgeable and dedicated early childhood practitioners, lecturers and researchers. There is increasing evidence that shows the benefits of cross-disciplinary working (Almond and Currie, 2010; Kolata, 2007; Cunha et al., 2006) in early education and intervention (Howard-Jones, 2014). "This collaboration may prove highly effective for improving outcomes for young children in their learning and emotional development" (Conkbayir, 2017, p.135).

References

Adolphs, R., and Demasio, A. (2001) 'The Interaction of Affect and Cognition: A Neurobiological Perspective', in Forgas, J.P. (ed.) *The Handbook of Affect and Social Cognition.* Mahwah, NJ:Erlbaum.

Allen, G. (2011) *Early Intervention: The Next Steps.* Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/284086/early-intervention-next-steps2.pdf. Accessed: 17 December 2019.

Almond, D. and Currie, J. (2010) 'Human capital development before age five', *Handbook of Labour Economics*, 4, pp.1315-1486.

Ansari W., Stock, C.,UK Student Health Group, Snelgrove S, Hu X, Parke S, Davies S, John J, Adetunji H, Stoate M, Deeny P, Phillips C, Mabhala A (2011) 'Feeling healthy? A survey of physical and psychological wellbeing of students from seven universities in the UK', *Int J Environ Res Public Health*, 8 (5), pp. 1308-1323.

Bahman, S., and Maffini, H. (2008) *Developing Children's Emotional Intelligence.* New York: Continuum International Publishing Group.

Bailey, C. (2015) 'Emotional and Organisational Supports for Preschoolers' Emotion Regulation: Relations With School Adjustment', *American Psychologist Association,* 16 (2), pp.263-279

Birch, S.H. and Ladd, G.W. (1997) 'The Teacher-Child Relationship and Children's Early School Adjustment,' *Journal of School Psychology*, 35 (1), pp.61-79.

Blair, C. (2002) 'School Readiness. Integrating cognition and emotion in a neurobiological conceptualisation of children's functioning at school entry', American Psychologist, 57, pp. 111-127.

Bradley S.J. (2000) *Affect Regulation and the Development and the Development of Psychopathology.* New York: Guilford Press.

Bruer, J. (2011) *Revisiting The Myth of the First Three Years.* Canterbury: University of Kent, Centre of Parenting Culture Studies.

Bulotsky-Shearer, R. and Fantuzzo, J. (2004) 'Adjustment Scales for Preschool Intervention: Extending Validity and Relevance across Multiple Perspectives', *Psychology in the Schools,* 41, pp. 725-736.

Caine, R. and Caine, G. (1991) *Making Connections: Teaching and the Human Brain.* Alexandria, VA: Association for Supervision and Curriculum Development.

Caine, R. N., and Caine,G. (1997) *Education on the Edge of Possibility.* Alexandria, VA: Association for Supervision and Curriculum Development.

Carew, T.J. and Magsamen, S.H. (2010) 'Neuroscience and education: an ideal partnership for producing evidence-based solutions to Guide 21(st) Century Learning', *Neuron*, 67(5), pp.685-688.

Carlson, S.M, and Wang, T.S, (2007) 'Inhibitory Control and Emotion Regulation in Preschool Children, *Cognitive Development*, 22, pp. 489-510.

Chen, S. H., Zhou, Q., Main, A. and Lee, E. H., (2015) 'Chinese American Immigrant Parents' Emotional Expression in the Family: Relations with Parents' Cultural Orientations and Children's Emotion-related Regulation.' *Cultural Diversity and Ethnic Minority Psychology*, 21 (4), pp. 619–629.

Ciarrochi, J. V., Forgas, J. P. and Mayer J. D. (2001) *Emotional Intelligence in Everyday Life: A Scientific Inquiry.* Philadelphia, PA: Psychology Press.

Clark A. (2001) 'Reasons, robots and the extended mind', *Mind and Language*, 16, pp. 121-145.

Coch, D., & Ansari, D. (2009) 'Thinking about mechanisms is crucial to connecting neuroscience and education', *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 45*(4), pp. 546–547.

Cole, P. M., Martin, S. E., Dennis, T. A. (2004) 'Emotion Regulation as a Scientific Construct:Methodological Challenges and Directions for Child Development Research,' *Developmental and Psychopathology, 7*, pp. 1-10.

Conkbayir, M. (2017) *Early Childhood and Neuroscience: Theory, Research and Implications for Practice*. London: Bloomsbury.

Cozolino, L. (2013) *The Social Neuroscience of Education: Optimising Learning and Attachment in the Classroom.* London: W.W. Norton and Co.

Cuhna, F., Heckman, J., Lochner, L. and Masterov, D.V (2006) 'Interpreting the Evidence on Life Cycle Skill Formation', *Handbook of the Economics of Education*, 1, pp. 697-812.

Daunic, A., Corbett, N., Smith, S., Barnes, T., Santiago-Poventud, L., Chalftant, P., Pitts, D. and Gleaton, J. (2013) 'Integrating Social-emotional Learning with Literacy

Instruction: An Intervention for Children at Risk for Emotional and Behavioural Disorders', *Behavioural Disorders,* 39 (1), pp. 43-49.

Dehaene, S. (2009) *Reading in the Brain: The New Science of How We Read.* New York: Penguin.

Dehaene, S. (2011) *The number sense: How the mind creates mathematics.* Oxford University Press.

Denham, A.S., Bassett, H.H. and Zinsser, K. (2012) 'Early Childhood Teachers as Socialisers of Young Children's Emotional Competence', Early Childhood Education Journal, 40, pp. 137-143.

Devonshire, I.M. and Dommett, E.J. (2010) 'Neuroscience: Viable Applications in Education?' *Neuroscientist*, 16, pp.349-356.

De Vos, J. and Pluth, E. (2016). 'Introduction' in J. De Vos and E. Pluth (eds.), *Neuroscience and critique: Exploring the limits of the neurological turn*. London: Routledge, pp. 1–8.

Djambazova-Popordanoska, S. (2016) 'Implications of emotion regulation on young children's emotional wellbeing and educational achievement', *Educational Review,* 68 (4), pp. 497-515. doi: 10.1080/00131911.2016.1144559

Dryfoos , J.G. (1997) 'The Prevalence of Problem Behaviours: Implications For Programs,' in Weissberg, R.P., Gullotta, T.P., Hampton, R.L., Ryan, B.A. and Adams, G.R., (ed.) Healthy Children 2010: Enhancing Children's Wellness. Thousand Oaks, CA: SAGE.

Dubinsky, J. (2010) '*Infusing Neuroscience Into Teacher Professional Development'*, Educational Researcher, 42(6), pp.317-329.

Eden, G.F. and Moats, L. (2002) 'The role of neuroscience in the remediation of students with dyslexia', *Nature Neuroscience, 5*, pp.1080–1084.

Eisenberg, N., Valiente, C. and Eggnum, D.N. (2010) 'Self-regulation and School Readiness'*, Early Education and Development* 21 (5), pp. 681-698.

Elias, M., Zins, J., Weissberg, R., Frey, K., Greenberg, M., Haynes, N., Kessler, R., Schwab-Stone, M., and Schriver, T. (1997) *Promoting Social and Emotional Learning: Guidelines for Educators.* Alexandria, VA: Association for Supervision and Curriculum Development.

Fischer, K.W., Berstein, J.H. and Immordino- Yang, M.H. (2007) *Mind, brain and education in reading disorders.* Cambridge, UK. Cambridge University.

Forgarty, R. (2009) *Brain Compatible Classrooms.* 3rd edn, Thousand Oaks, CA: SAGE.

Gabrieli, J. (2007) 'Cognitive Neuroscience of Dyslexia', *Language Speech and Hearing Services in Schools,* 49(4), pp.798-809.

Garner, P.W (2010) 'Emotional Competence and its Influences on Teaching and Learning', *Educational Psychology Review*, 22, pp. 297-321.

Gerthardt, S. (2015) *Why Love Matters.* London: Routledge.

Goleman, D. (2004) *Building Academic Success on Social and Emotional Learning.* New York: Teachers College Press.

Gormley, W.T., Phillips, D. and Gayer, T.(2008)'The early years: Preschool programs can boost school readiness', *Science*, 320, pp. 1723 - 1724.

Goswami, U. (2004) 'Neuroscience and education', *British Journal of Educational Psychology*, 74, pp.1-2.

Goswami, U. 92006) 'Neuroscience and education: From research to practice?', *Nature Reviews Neuroscience,* 7(5), pp. 406-411.
Greenleaf, R. (1999) 'It's Never Too Late! What Neuroscience Has to Offer High Schools', *NASSP Bulletin*, 83, pp.81-89.

Gross, J.J. (2007) *Handbook of Emotion Regulation.* New York: Guilford Press.

Grossman, P. and Taylor, E.W (2007) 'Toward understanding respiratory sinus arrhythmia: Relations to cardiac vagal tone, evolution and biobehavioral functions', *Biological Psychology*, 74, pp. 263–285.

Hajdukova, E.B., Hornby, G. and Cushman, P. (2015) 'Bullying Experiences of Students with Social, Emotional and Behavioural Difficulties (SEBD)', *Educational Review,* 68, pp. 207-221.

Herndon, K.J., Bailey, C.S, Shewark, E.A, Denham, S.A. and Bassett, H.H. (2013) 'Preschoolers' Emotion Expression and Regulation: Relations with School Adjustment,' *The Journal of Genetic Psychology*, 174 (5-6), pp. 642-663.

Hirsh-Pasek, K. and Bruer, J. (2007) ,The brain/education barrier', *Science*, 317, pp. 1293.

Hourigan, S.E., Goodman, K.L. and Southam-Gerow, M.A. (2011) 'Discrepancies in Parents' and Children's Reports of Child Emotion Regulation', *Journal of Experimental Child Psychology*, 110, pp. 198-212

Howard-Jones, P., Pickering, S. and Diack, A. (2007) *Perceptions of the Role of Neuroscience in Education.* London: Innovation Unit.

Howard-Jones, P. (2010) *Introducing Neuroeducational Research: Neuroscience, Education and the Brain from Contexts to Practice.* Abingdon: Routledge.

Howard-Jones, P.A. (2014b) *Neuroscience and education: A review of educational interventions and approaches informed by neuroscience.* London: Education Endowment Foundation.

Howse, R.B., Calkins, S.D., Anastopoulos, A.D, Keane, S.P. and Shelton, T.L. (2003) 'Regulatory Contributions to Children's Kindergarten Achievement' *Early Education and Development*, 14 (1), pp. 101-120.

Immordino-Yang, M.H. (2016) *Emotions, Learning and the Brain.* London: W.W. Norton and Company.

Immordino-Yang, M.H. and Damasio, A.R. (2007) 'We feel, therefore we learn: The relevance of affective and social neuroscience to education', *Mind, Brain and Education*, 1(1), pp. 3-10.

Jolles, J., De Groot, R.H.M., Van Benthem, J., Dekkers, H., De Glopper, C. and Uijlings, H. (2005) *Brain Lessons.* Maastricht:Neuropsych.

Jones, S.M. and Bouffard, S.M (2012) 'Social and Emotional Learning in Schools from Programs to Strategies', *Sharing Child and Youth Development Knowledge,* 26 (4), pp. 1-33.

Kaufmann, A., Xia, M., Fosco, G., Yaptangco, M., Skidmore, C. and Crowell, S. (2015) 'The Difficulties in Emotion Regulation Scale Short Form (DERS-SF): Validation and Replication in Adolescent and Adult Samples', Journal of Psychopathology and Behaviour Assessment, 38 (8), pp.443-455.

Kolata, G. (2007) 'A surprising secret to a long life: Stay in School.' New York Times, 3 January 2007 Avaialable at https://www.nytimes.com/2007/01/03/health/03aging.html Accessed 27 February 2020.

Kress, J.S. and Elias, M.J. (2006) 'School-based Social and Emotional Learning Programs', in Renninger, K.A and Sigel, I.E. (ed.) *Handbook of Child Psychology.* New York: Wiley, pp. 592-618.

Kring, A. M., and Werner, K.H. (2004) 'Emotion Regulation in Psychopathology,' in Philippot, P. and Feldman, R.S., (ed.) *The Regulation of Emotion.* Mahwah, NJ:Lawrence Erlbaum Associates, pp. 359-385.

Krystek-Walton,U. (2019) *Neuroscience in the Early Years: EYFS TV.* Available at: https://www.earlyyears.tv/episode/ursula-krystek-walton-on-neuroscience-in-the-early-years/ Accessed 17 Decemeber 2019.

LeDoux, J. E. (1996) *The emotional brain: The mysterious underpinnings of emotional life.* Simon & Schuster.

Mayer, J. D., and Salovey, P. (1997) 'What is Emotional Intelligence?', in Mayer, P. (ed.) *Emotional Development and Emotional Intelligence*. New York: Basic Books, pp. 3–31

McCain, M., Mustard F., and Shanker, S. (2007) *Early Years Study 2: Putting Science into Action.* Available: http://www.founders.net/fn/news.nsf/.pdf Accessed 17 December 2019.

Mccandliss, B. (2010) '*Educational neuroscience:The early years*', Proceedings of the National Academy of Sciences, 107(18), pp.8049-8050.

Meltzoff, A.N., Kuhl, P.K., Movellan, J. and Sejnowski, T. (2009) 'Foundations for a New Science of Learning', *Science,* 17, pp.284-288.

Paris, S.G. and Paris, A.H. (2001) 'Classroom applications of research on self-regulated learning.', *Educational Psychologist,* 36, pp. 89 - 101.

Pianta, R.C., Barnett, W.S, Burchinal, M. and Thornburg, K.R. (2009) 'The effects of preschool education: What we know, how public policy is or is not aligned with the evidence base and what we need to know, *Psychological Science in the Public Interest,* 10, pp. 49 - 88.

Porges, S.W. (1995) 'Orientating in a Defensive World: Mammalian Modifications of Our Evolutionary Heritage. A Polyvagal Theory', *Psychophysiology*, 32, pp. 301-318.

Porges, S.W. (2007) 'The Polyvagal Perspective', *Biological Psychology*, 74 (2), PP. 116-143

Robson, S. (2016) 'Are there differences between children's display of self-regulation and metacognition when engaged in an activity and when later reflecting on it? The complementary roles of observation and reflective dialogue roles of observation and reflective dialogue', *Early Years* 36(2), pp. 179–194.

Rose, J., Gilbert, L. and Richards, V. (2016) *Health and Well-being in Early Childhood.* London: SAGE.

Royal College of Midwives (2012) *Maternal Emotional Wellbeing and Infant Development: A Good Practice Guide for Midwives.* London: Royal College of Midwives Trust.

Salovey, P., and Mayer, J. D. (1990) 'Emotional Intelligence', *Imagination, Cognition, and Personality,* 9 (3), pp. 185–211.

Shields, A., Dickstein, S., Seifer, R., Gusti, L., Magee, K. D. and Spritz, B. (2001) 'Emotional Competence and Early School Adjustment: A Study of Preschoolers at Risk', *Early Education and Development,* 12 (1), pp. 73–96. doi:10.1207/s15566935eed1201_5.

Shonkoff,J.P, and Phillips, D., (2000) *From Neurons to Neighbourhoods: The Science of Early Childhood Development.* Washington, DC:National Academy Press.

Sigman, M., Pena, M., Goldin, A.P. and Ribeiro, S. (2014) 'Neuroscience and Education: Prime Time to Build the Bridge', Nature Neuroscience 17(4), pp.497-502.

Simmonds, J., Kieras, J.E., Rueda, M.R., Rothbart, M.K. (2007) 'Effortful Control, Executive, Attention, and Emotional Regulation in 7-10 year old Children.' *Cognitive Development*, 22, pp. 474-488.

Trentacosta, C.J., and Izard, C.E. (2007) 'Kindergarten Children's Emotion Competence as a Predictor of their Academic Competence in First Grade', *Emotion* 7 (1), pp.77-88.

Vanderbrook, M., De Vos, J., Fias, W., Olson, L.M., Penn, H., Wastell, D. and White, S. (2011) *Constructions of Neuroscience in Early Childhood Education.* London: Routledge

Watson, D., Clark, L.A. and Tellegan, A. (1988) 'Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales', *Journal of Personality and Social Psychology,* 54 (6), pp. 1063-1070.

Williams, E. (2014) 'Out of the Ordinary: Incorporating Limits with Austin and Derrida', *Educational Philosophy and Theory*, 46(12), pp.1337-1352.

Zins, J.E, Bloodworth, M.R., Weissberg, R.P. and Walberg, H.J (2004) *The Scientific Base Linking Social and Emotional Learning to School Success.* New York: Teachers College Press.