Informing educational decisions in the early years: can evidence for improving pedagogy for children with autistic spectrum disorder be found from neuroscience?

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It is possible that many benefits may be found for all concerned in education and child development in understanding how knowledge of the brain and its development can inform early years practice. This article, written by Brenda Peters and Chris Forlin, both from the Hong Kong Institute of Education, reviews literature based on neuroscience to establish potential links with teaching and learning, in an attempt to identify the most appropriate pedagogical support for children with autistic spectrum disorder (ASD). Two key themes have emerged: firstly, neuroscience and education and translation between these disciplines, and secondly, the relevance of these developments for specific groups of learners. This article focuses on early educational intervention and how emerging evidence from neuroscience and collaboration with educators may support future developments for practice for these young learners with ASD.

***Key words:* ASD, neuroscience, early intervention.**

Since psychology was first recognised as a science, a fascination with the brain and how it works has influenced teaching and learning. Origins of cognitive psychology stemmed from a broad base of knowledge that included the works of Piaget and Vygotsky, who continue to receive attention in literature with reference to developmental psychology (Zittoun, Gillespie, Cornish & Psaltis, 2007), co-operative learning theory (Fore, Riser & Boon, 2006) and inclusion (Daniels, 2009). As further educational interest develops in neuroscientific evidence, Katzir and Pare-Blagoev (2006) suggest that cognitive psychology might provide a middle ground between neuroscience and education, in much the same way that, in the early 1980s, cognitive psychology used additional information and research from neuroscience and saw an amalgamation of the two disciplines to form a new branch of psychology in the form of cognitive neuroscience (Pennington, Kelly, Snyder & Roberts, 2007).

While tentative attempts to embrace neuroscience in education were explored in the early 1990s, there was little information available for teachers on how to improve classroom practice for learning. Programmes claiming to be brain-based and educational came to the fore, often with very little supporting evidence or sufficient theory (Goswami, 2006; Spaulding, Mostert & Beam, 2010). Despite this, educational interest in brain development has grown with particular regard to improving pedagogy and support for those children with atypical development (Bailey, 2008; McGregor, Nunez, Cebula & Gomez, 2008). Indeed, evidence from recent studies suggests that teachers in the UK, for example, are keen to embrace neuroscience as it implies that important contributions may be gained in educational programme design for all children (Goswami, 2006; Pickering & Howard-Jones, 2007), and further suggests that educators should examine and investigate how this information may support learning (Hinton, Miyamoto & Della-Chiesa, 2008; Goswami, 2008a). Difficulty arises, however, in translating such complex literature into usable interventions at the classroom level.

Evidence suggests that pupils with autistic spectrum disorder (ASD) offer significant challenges in mainstream settings described as inclusive, due to the particular nature of the condition (Jordan, 2008; Humphrey, 2008; Peters & Forlin, 2011). It is important to consider how teaching can be better directed to meet and enhance the unique and individual learning needs of such pupils, to enhance inclusion, and to employ a more informed and sensitive stance in meeting perceived behavioural concerns. Neuroscience offers information concerning biological difference, thus adding to a deeper professional and integrated understanding that may affect an individual's success and achievement. This article, therefore, focuses on children with ASD and considers current thinking and research in neuroscience and the impact this is beginning to have on identifying best practices for learning.

ASD

ASD is a developmental disorder (Rutherford, 2007) that affects approximately 1% of the population (Goswami, 2008b). In children with a diagnosis of ASD, brain function has been shown to have a 'deviant growth trajectory, which leads to a disruption of the established patterns of functional connectivity during development' (Lewis & Elman, 2008). There is a general acceptance that ASD is a life-long

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condition (Shea, 2004) and genetic links have been established (Bailey, 2007) and are being extensively researched (Autism Genome Project, 2011). Under the *Diagnostic and Statistical Manual of Mental Disorders Fourth Edition* (DSM-IV-TR) (APA, 2000), the core features of ASD are: 1) qualitative impairment in social interaction; 2) qualitative impairment in communication; 3) restricted repetitive and stereotyped patterns of behaviour, interests and activities; 4) delays or abnormal functioning with onset prior to the age of three; and 5) the disturbance is not better accounted for by Rett's disorder or childhood disintegrative disorder.

In recent years neuroscientific research has sought to identify potential causes of ASD. In July 2008, geneticists made significant progress by identifying specific genes that contribute to brain connectivity in ASD (Morrow, Yoo, Walsh, Ertelt, Greenberg & Partlow, 2008). In particular, genes were identified relating to the brain's ability to regulate and create connections in response to the child's social and physical surroundings; specifically the on-off switches of the genes that activate in typical development (Morrow et al., 2008). The behavioural responses of the genes affect the way the child's learning ability develops, which in turn is affected by interaction with the environment. Morrow concluded that the cellular processes of brain plasticity and the ways in which neurons become interconnected were different in the development of children with ASD. The term 'brain plasticity' relates to the brain's ability to adapt and form new connections and/or dendrites between neurons. This happens throughout life (National Scientific Council on the Developing Child, 2005). Other factors affecting development are the interplay of brain chemistry together with gene influence, plus the individual's interaction with the environment; this affects how brain regions become specific and how they become interconnected (Pennington et al., 2007; Karmiloff-Smith, 2008; Thomas & Johnson, 2008).

A number of interventions have been employed to improve outcomes for children with ASD. The interest in behavioural approaches accelerated after Lovaas's (1987) study on Applied Behaviour Analysis (ABA) and operant conditioning, which has led to specific programmes for children with ASD, involving Early Intensive Behavioural Intervention. There are particular therapy interventions which have become associated with the specific category of need (Davis & Florian, 2004) and many teaching approaches and strategies that specifically target children with ASD have been developed. These approaches include ABA, Picture Exchange Communication System, Treatment and Education of Autistic and Communication related handicapped Children, Floor-time, video modelling and social skills intervention (Davis & Florian, 2004; Brunner & Seung, 2009). These approaches, nonetheless, mostly focus on providing therapy to address behavioural and functional deficit rather than directly linking to teaching strategies to improve learning. According to Norwich and Lewis (2007), a degree of uncertainty exists between teaching strategy and learning-based therapeutic interventions, and further evidence suggests that the promotion of specific intervention strategies to support learning for children with ASD has not yet had sufficient or objective examination (Parsons, Guldberg, MacLeod, Jones, Prunty & Balfe, 2009; Prizant, Wetherby, Rubin & Laurent, 2010). In addition, both expert and empirical strands of evidence concerned with ASD demonstrate that no single intervention meets best practice criteria for these children, and established therapeutic interventions have yet to be challenged for efficacy and as long-term strategies for improving learning (Parsons et al., 2009; Prizant et al., 2010).

The social context of educating children with ASD

The work of developmental psychologists such as Piaget and Vygotsky has historically offered educators important knowledge and techniques about teaching in a developmentally and socio-culturally appropriate manner. From a theoretical basis Vygotsky (1978) was concerned that disability effectively alters the way in which a child develops and interacts within the environment and how he or she will interact with others. In particular it has been emphasised by Daniels (2009) that the developmental cognitive growth of a child with special educational needs is facilitated through collaborative activity. Daniels has stressed the importance of the teacher's role in mediating social consequences when they arise and not just dealing with the organic nature of the disability.

While children identified as having ASD have tended to be educated in special schools or in resource classes with peers exhibiting similar difficulties, this has begun to change in recent years (Forlin, 2008; Humphrey, 2008). There is an emerging theme that rather than providing individual support away from peers, children with ASD need extensive opportunities to experience inclusive practices that provide the socio-cultural stimulation needed to enable appropriate cognitive growth (Humphrey, 2008). Recent developments in education have seen a paradigm shift towards social models of inclusive education on the grounds of ethics and morality and the right of all children, including those with special educational needs, to be educated together (Forlin, 2010a). While similar themes have emerged, caveats remain, which continue to challenge models of inclusive practice; these include issues of access, debates on teaching strategies, and the use of evidence-based practice. However, as Jordan (2008) states, 'Education can be, and perhaps should be, an effective "treatment" for Autistic Spectrum Disorders'.

Neuroscience and education

Neuroscience and education, however, have yet to forge a common understanding that would indicate which way neuroscience can effect development and change in educational practice. With the rapid expansion of research of typical brain development, there also arises the opportunity for teaching and learning to develop new understandings in pedagogy and practice, based on neuroscientific evidence. Careful mapping of the brain, generating new knowledge about child behaviour, learning acquisition and the social nature of learning, is providing additional essential biological and neurological information on development (Stern, 2005; Bailey, 2008). Whether this information can be applied to children with an atypical trajectory will need further exploration.

Blakemore and Frith (2005, p. 1) postulated that:

> 'understanding the brain mechanisms that underlie learning and teaching could transform educational strategies and enable us to design educational programmes that optimize learning for people of all ages and of all needs'.

The most recent neuroscientific studies have shown areas of the brain associated with social brain networking and connectivity, and social deficit behaviours may indicate a lack of connectivity in these areas (Lewis & Elman, 2008). This links closely to the traits of social interaction impairment for ASD identified in DSM-IV-TR (APA, 2000). In addition, children with ASD often have pervasive sensory disorders that are also multi-modal (Leekam, Nieto, Libby, Wing & Gould, 2007). This verifies earlier research done by McAlonan, Daly, Kumari, Critchley, Amelsvoort, Suckling and Murphy (2002), whose initial findings indicated significant neurological differences in the areas of the brain associated with obsessive language and thought. Additional variance in sensory gating and responses to sensory stimuli were also found. The research also identified that although underlying differences in neurodevelopment exist, environmental factors such as isolation further inhibit the individual's sensory response and may result in an experience of greater isolation. In a subsequent study, McAlonan, Cheung, Cheung, Suckling, Lam, Tai and Chua (2005) found differences in the volume of grey matter in the brain affected the person's ability to read the intentions of others and social communication. The specific areas identified are the prefrontal cortex, the temporal regions and the cerebellum (McAlonan, Suckling, Wong, Cheung, Cheung, Lienenkaemper & Chua, 2008). When combined with deficient sensory gating, children with ASD experience difficulties in self-regulation. According to Tager-Flusberg (2007), this is also an indication of the brain's impaired executive function.

Identification of the affected biological systems in people with ASD helps account for the impact on social, emotional and communicative behaviour and executive function skills, the latter playing a significant role in affecting success and achievement at school (Greenberg & Rhoades, 2008). Research investigating executive function for cognitive development through teaching strategy development has targeted early literacy skills in pre-school-aged children, where teaching skills through the use of cultural tools and mediation was a major focus (Bodrova & Leong, 2001). Greenberg and Rhoades (2008) identify potential areas for future development and empirical research in curriculum-based strategies for improving executive function skills at later school levels. Moreover, a focus on constructive and cumulative educational approaches with accompanying strategies to emphasise cognitive development, a systems approach (Baron-Cohen, 2008) and the brain's executive function skills, may be more effective for these learners.

Frith (2005) actively looked at ways in which concepts from brain science were relevant to education, as well as undertaking investigations into the atypical developing brain. Rather than focusing on deficits in brain function in individuals, Frith (2005) emphasised the educational focus needed to consider the individual and his or her response to the environment. The ways in which a child with ASD perceives the environment is closely linked to how the child interacts with it, which in turn affects his or her ability to internalise the experience and develop emotional responses but, as suggested by Connolly (1993, p. 942):

> 'We would do better to look for strengths and recognize that these will be different for different children. Differences offer hope because they provide the possibility of alternative routes for development, educational and personal fulfillment'.

Taking into consideration the variance in neuro-diversity among people with ASD and the associated behaviours with impaired executive function, it becomes important to reconsider pedagogy for children with ASD, and how they may have access to learning for cognitive development (Bailey, 2008). Further sensitive exploration is needed, which must take careful consideration of input from all stakeholders and give greater attention to the voice from the community of those with ASD.

Neuroscience, education and evidence

Evidence from cognitive neuroscience suggests that learning occurs as a synergistic process by building neurons through active representation of events initially through sensory channels (Goswami, 2008a). As observed by Piaget, windows of opportunity exist during the child's first decade when the brain is positively primed to receive sensory input. This allows for more complex and advanced neural pathways to develop, which further supports advanced learning schemes. As sensory input is crucial for experiential learning, this should happen within the first few years after birth to avoid inhibiting neural growth (Howard-Jones, Pollard, Blakemore, Rogers, Goswami, Butterworth & Frith, 2007; Nelson, 2007; Thomas & Johnson, 2008). The early years are the most crucial time for learning as some abilities are acquired more easily during sensitive periods. These periods for neuro-development are related to two main factors: firstly, the child's stage of development, and secondly, the brain area involved (Thomas & Johnson, 2008). Although there is a lack of literature that helps identify sensitive periods of brain growth in either typical or atypical development, Johnson and Munakata (2005) emphasise the simple mechanisms underlying sensitive growth periods rather than the periods themselves. This has instigated a general move in developmental psychology toward understanding 'error-driven and self-organizing learning mechanisms'. Underpinning the development of neural pathways and brain regions, these mechanisms activate as the individual interacts within his or her environment. When this is combined with language, the experience becomes integrated as it is represented across the regions of the brain within the developing person (Goswami, 2008a).

Additionally Oberman and Ramachandran (2007) propose that mirror neuron stimulation is key to several areas of development, including imitation and language. Mirror cells, located in Broca's area of the brain, have been found to activate when observing others (Aziz-Zadeh, Koski, Zaidel, Mazziotta & Iacoboni, 2006) and are implicated in the difficulties experienced by children with ASD (Hadjikhani, Joseph, Snyder & Tager-Flusberg, 2007). While sensitive periods vary between children, a child with ASD is more likely to be at a different stage than typically developing peers; what is known and utilised in providing interventions for young learners with ASD is that engaging in simple learning during sensitive periods can yield critical effects. A qualitative approach, therefore, with good knowledge of child developmental processes (Gindis, 2003) and how learning may proceed, is essential for endeavouring to identify the type of interventions that may be applicable at any given time for a particular individual. To date, much of early years education is founded upon the key theory and strategies of assimilation, discovery, child centeredness, and hands-on learning, employing the deliberate use of scaffolding for learning and the construction of concrete learning opportunities. Furthermore, Vygotsky's theory on instruction being the means for active cognitive development plays a significant and proactive role within the Zone of Proximal Development (Daniels, 2009).

The importance of early intervention

As gaps in academic performance widen as a child progresses through the school years (Mustard, 2008), it is suggested that early intervention for all children has definite positive outcomes for educational services as well as health care services (Knudsen, Heckman, Cameron & Shonkoff, 2006). The known malleability and plasticity of the brain has placed great importance on early intervention and particularly the type of programmes that will positively affect a child's development and learning trajectory. Early intervention has paramount importance for children with ASD; however, it is only within the last 20 years that technology has advanced to capture neurological and biological factors related to ASD (Nelson, 2007) that could help direct the most relevant types of interventions (Bailey, 2008).

Linking neuroscience and education: providing the best support for learners with ASD

In response to the need for appropriate school-based interventions for children with ASD, research in neuroscience identifies and maps the biology and areas of the brain. There is the potential to identify optimum learning times for maximizing potential learning of both academic and social skills for children with ASD. McGregor et al. (2008) posit an integration of research disciplines for future educational development, as there is a need to move away from causal explanations of ASD towards developmental responses to a developmental disorder.

Compiled from a range of sources (for example, Goswami & Bryant, 2007; Mustard, 2008; Stern, 2005; Timmons, 2007), Table 1 is a summary of seven key aspects that have emerged from neuroscientific research that can inform educational programmes and would be pertinent for supporting the inclusion of students with ASD.

It can be seen from Table 1 that early educational experiences need to include a rich, supportive environment that is sensitive and responsive to the child's needs. For this to be possible a qualitative view of the whole child should inform daily encounters and learning opportunities. Teachers, therefore, can ensure the child's access, activity and participation, and provide a balance of good pedagogical and developmental knowledge, scaffolded experiences, and clear mediation in cumulative and constructive approaches.

Conclusion

There is a clear need to ensure that the most effective teaching and learning approaches are used to enhance all aspects of inclusive provision, in the increasingly diverse classrooms of today's schools. Indications from research suggest that teachers and parents are keen to know the factors that make for successful inclusion (Waddington & Reed, 2006) and the best ways to support the children who face some of the most difficult challenges within a school environment. Education is ultimately the most widely available intervention for children with ASD (Bailey, 2008).

As the movement towards inclusive education continues to grow in significance and importance, challenges face schools and policy makers (Forlin, Keen & Barrett, 2008). These challenges include both curricular and pedagogical issues that relate to how a school can cater for the specific cognitive, emotional and behavioural learning needs of children with ASD.

Two key areas have emerged regarding potential links between neuroscience and education that need further research. The importance of neuroscience to education and the translation between the two disciplines is under-investigated. The relevance of developing a bond between neuroscience, cognitive psychology and education for supporting specific groups of learners also needs greater research. As a result of developments in unobtrusive brain imaging technology, greater understanding has been reached. There has already been a vast amount of research on the general question of children's cognitive development and learning (for example, Goswami & Bryant, 2007). New knowledge generated from neuroscientific input, though, is now helping to reform current thinking about the ways in which children learn and the type of pedagogies that are needed to engage them in their learning. There is sufficient discourse to suggest that neuroscience is important to future pedagogical development, for example, by adding empirical value to the earlier works of Piaget and Vygotsky.

Although the widespread paradigm shift in education towards inclusion has already been noted (Forlin, 2010a), many teachers and parents are still unsure about a fully

Table 1: Alignment of education practices with indicators from neuroscience

Indicators from neuroscience	Suggested educational interventions
Optimum conditions for individual development positively enhance the process of learning. The brain grows in an integrated way that demands a rich environment which addresses the multiple aspects of development of all children.	A rich, stimulating and nurturing environment; child-centred, emotional stability; personal attachment; regulated sensory stimulation; use concrete experiences, problem-based learning, discovery learning, direct teaching and scaffolding all within supportive social settings.
Learning is optimised during developmental sensitive periods.	Early interventions from birth to age five, dependent upon age, social and emotional development, interest and prior experiences; involve parents and learning opportunities based on observation and good pedagogical knowledge and practice.
Sensory processing difficulties: touch and vision will not reach full potential once the sensitive period has passed.	Provide multi-modal sensory-based and exploratory approach to learning including a range of stimulating hands-on activities and variety of visual inputs with appropriate problem-solving opportunities in an inclusive setting.
People are positively wired for social encounters and social cognition develops from cross-modal sensory input during infancy. Development is dependent on complex social interactions with significant others	Teaching Theory of Mind to enhance empathy, self-regulation, executive functioning, joint attention, gaze following and pointing. Provide opportunities to watch and participate in events, listen to language and eclectic sources of sounds. Have active experiential learning.
Early concept formation and symbolisation in play is a precondition for language development. Children learn by imitation and observation as well as through analogy. Feelings and empathy are important for social and emotional development.	Provide more inclusive opportunities for children to learn alongside typically developing peers; non-verbal play, gesturing, imitation, socio-dramatic play, pretend play, creative or symbolic play with minimal direction, to help develop joint attention. Focus on language and communication, working in collaboration with parents to ensure home/school continuity of intervention. Include listening experiences, story telling, book sharing, role playing etc.
Learning involves developing a range of motor tasks using fine and gross motor skills and this is supported by language acquisition.	Provide opportunities for active learning, activity and construction, hand/eye co-ordination, deliberate discussion and collaborative work.
Learning is influenced by emotion and memory, which is established early, and is difficult to modify later in life. If there is an undue amount of stress and anxiety then learning acuity is significantly decreased.	Provide supportive environments that reduce stress and anxiety. Employ child-centred learning with individualised programmes in inclusive settings.

inclusive education for children with ASD, because of the nature of the difficulty. However, there now appears to be neurological evidence supporting inclusion as research suggests the brain is positively wired for social encounters (Aziz-Zadeh et al., 2006). Neuroscience also confirms the importance of early intervention and the specific use of approaches embedded within a social and inclusive context.

At the moment, while there is a dearth of evidence to support the principle that pedagogy can be informed by neuroscientific research, there are a number of researchers who are suggesting that this is an important aspect and should be reviewed further (Bailey, 2008; Blakemore & Frith, 2005; Frith, 2005; Goswami, 2008a). It would therefore seem prudent for educationalists to look to neuroscience for support to make better informed decisions on educational programmes, specifically in the early years regarding the needs of children with ASD. Accessing this body of research literature, however, is complex, and it may be difficult to determine its usefulness in relation to classroom practice. Closer links between neuroscientific researchers and educationalists would seem to be critical if it is going to be possible to develop the connection between these two areas. Neuroscientific findings need careful and empathic translation into pedagogy within common frameworks of understanding and shared language if their true value is to be capitalised upon.

Educators have begun to take cautious steps towards embracing neuroscience and how it may inform practice. Even so, there is still a lack of published collaborative work between neuroscientists, teachers and educational researchers (Willis, 2008). Effectively this is creating a knowledge gap that needs to be filled by empirical research data, working towards a common language of understanding. The next pressing step is for educational systems and teachers to be pragmatic in developing programmes that not only respond to this neuroscientific evidence, but make it manageable within early childhood settings/schools, and to set a future integrated research agenda with education at its centre.

By involving evidence from neuroscientific research and following a similar relationship path that cognitive neuroscience has with psychology, teachers may begin to collaborate with neuroscientists and gain an important affiliation to substantiate brain-based knowledge for effective education. As the role of neuroscience has emerged as a complementary discipline to cognitive neuroscience, it is apparent that teachers do not need to ignore established theory such as Piaget's and Vygotsky's work. They do, however, need to develop a translation between these to establish a strong partnership that considers both theoretical and scientific perspectives.

Education appears to be on the cusp of a future exciting research relationship with neuroscience. It is important to seize this opportunity and explore ways to develop this alliance further, so that a dynamic and collaborative relationship between educational theory and neuroscientific research to improve curricula and pedagogical practice may be constructed. Educational psychologists already employ cognitive neuroscience to inform much of the work they do with children in schools (Forlin, 2010b). It would seem plausible that educational or school psychologists could well become the bridge between the emerging neuroscientific research findings and how this can support teachers in enhancing pedagogical practice.

From the research of neuroscientists it has been possible to indicate avenues for educators to consider regarding appropriate support for children with ASD. For example, the seven areas highlighted in Table 1 focus on a range of good practices for supporting these learners, including the importance of the environment; that interventions should acknowledge simple learning mechanisms within sensitive periods; use multi-modal forms of sensory approaches; develop social understandings; use early play; enhance motor skills; and enable social inclusion. There are questions that remain, concerning the effectiveness and implementation of favourable conditions for the most advantageous development; however, neuroscience has the potential to clarify whether future educational programmes are developmentally appropriate and are really targeting the emergent needs of children, while identifying the most sensitive period to ensure optimum development. Educators are best placed to develop and implement appropriate curricula and pedagogies to enable children to access the most pertinent forms of learning. Together neuroscientists and educators could be instrumental in developing the best practice in supporting the learning of children with ASD.

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