Spotlight

Neuroscience-Based Approaches to Teaching Students on the Autism Spectrum

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Abstract: An understanding of the relationship between emotions, cognition, and learning can provide insight into learning needs for children with autism spectrum disorder (ASD). This article discusses current research and new theories on ASD from three different perspectives: the behavioral sciences, neuroscience, and education. The rapid increase of ASD diagnoses in children worldwide, and an understanding of autism as one of the developmental disorders affecting a spectrum of neural networks in a growing brain, indicates that educational implications from the combined insights may strengthen the development of strategies and interventions not only for ASD individuals, but for neurotypical children as well.

Keywords: autism spectrum disorder, emotions, cognition, neuroscience, education

Learning and communication deficits in children with autism spectrum disorders (ASD) are often associated with difficulties in interpreting emotional cues or with constructing a Theory of Mind (ToM; Baron-Cohen, 1997), including social reciprocity and perspective taking for other human beings. The Theory of Mind Blindness (Frith, 2001) builds upon ToM, postulating that difficulties in understanding the social world cause individuals to lose social motivation and withdraw, leading to an even greater social deficit. In a related theory, the Central Coherence Theory of Autism, Frith (2003) suggests that, in neurotypical individuals, attention and memory for details may suffer as a person focuses on the meaning and “gestalt” of the situation. In contrast, those with ASD may have an incredible memory for details, but miss the “big picture” entirely.

Recent neuroscientific findings have increasingly emphasized the interconnections between emotions, cognition, and learning (Immordino-Yang, 2011). Emotional processing is a component in higher cognitive functions such as judgment, reasoning, and problem-solving. Multiple researchers have shown that emotional awareness of both self and others is important in the development of not only social competency, but also knowledge acquisition (Herwig, Kaffenberger, Jäncke, & Brühl, 2010; Jerusalem & Klein-Heßling, 2002; Shuck, Albornoz, & Winberg, 2007).

Interaction of Emotional, Sensory, and Cognitive Processing in Neurotypical Populations

Connections between emotions and learning begin in the earliest days of life, when emotions prevail as the source of learning and cognitive development (Csibra & Gergely, 2006). A young infant, limited to emotional communication, cries out in hunger, and the caregiver’s response provides the child’s first lesson in meeting physical needs. An innate visual focus on faces and face-like patterns orients a baby to relevant cues needed for social cognition (Valenza, Simion, Cassia, & Umiltà, 1996).

As babies grow and mature, the range of visual emotional cues is expanded. Emotional cues are conveyed visually not only through facial expressions, but also through body language and the integration of nonverbal expressions (Apicella, Sicca, Federico, Campatelli, & Muratori, 2012). Even after language skills develop, socioemotional experiences play a large role in learning and cognitive development.

Neurophysiological studies (e.g., Pessoa, 2008) have highlighted the multifunctionality of networks of neural connectivity, demonstrating that neural regions are not dedicated to emotional or cognitive processing exclusively, but rather can be used as computational components in multiple neural processes. For example, all sensory input

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initially is processed in early visual areas such as the V2 and middle temporal areas. After the first processing, Pessoa (2008) suggests, more advanced processing takes place in central "hubs" such as the amygdala, portions of the prefrontal cortex, the anterior cingulate cortex, and the hypothalamus. These hubs appear to connect and disperse emotional and cognitive information.

To give another example, some studies suggest that neurotypical individuals process emotional cues through an automatic left-hemisphere network used to detect social intent (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). In functional magnetic resonance imaging (fMRI) studies, Breiter and his colleagues (1996) measured adult amygdala activity during presentation of happy, fearful, and neutral faces. Findings indicated that the human amygdala was activated in response to both positive and negative emotions. This activation of the left portion of the amygdala was significantly stronger for fearful and happy expressions than for neutral expressions. In addition, fronto-temporal areas were highly activated during a task dealing with social interaction (Abell et al., 1999).

Interaction of Emotional, Sensory, and Cognitive Processing in Autism Spectrum Disorder Populations

Individuals with autism spectrum disorder (ASD) miss elements of socio-emotional learning early in life. As babies, these individuals do not easily establish eye contact, limiting the first steps of social cognitive growth (Boutot & Myles, 2011). A subsequent delay in language and pragmatic development creates a cumulative communication deficit, and the social gap widens as these children age. In our previous studies of brain electrical responses (electroencephalogram, EEG) to emotional facial and body cues, neurotypical participants showed highly articulated early neural responses to fearful and angry faces and body postures. As early as 100–200 ms after seeing the cues, sensory processing of visual information in neurotypical participants differed between congruent and incongruent cues of anger and fear as they viewed combinations of facial and body expressions. In contrast, ASD participants showed little difference in EEG responses, suggesting that their early visual processing networks may not be picking up the important facial cues (Malaia, Bates, Seitzman, & Coppers, 2016; Malaia, Cockerham, & Rublein, 2016). Functional neuroimaging data on processing of visual emotional cues suggests that individuals with ASD may depend upon pattern recognition for deducing visual meaning, rather than engaging the limbic (emotion-related) left-hemisphere amygdala network, as do neurotypical individuals. Functional magnetic resonance imaging (fMRI) studies have shown that ASD individuals activate frontal cortical networks much less than neurotypical controls do, and may not activate the amygdala at all (Abell et al., 1999).

As modern research sheds new light on the neural substrates of ASD, educators are challenged to update intervention practices and educational theories. The Extreme Male Brain (EMB) theory of autism (Baron-Cohen et al., 2001) is based on distinguishing between the mental processes of empathizing and systemizing. EMB theory posits that the need to empathize, or identify another person's feelings and thoughts, lies at one end of a continuum, and the need to systemize (analyze, predict, construct, and control a system) lies at the extreme other end (Wheelwright et al., 2006). Whereas neurotypical persons are capable of both, individuals diagnosed with severe ASD base their actions and decisions almost entirely on systemizing, deducing understanding from "if-then" rules and patterns, and attempting to apply system-based reasoning to the unpredictable, nonlinear social realm. This theory, which suggests that every person can be placed somewhere on the ASD continuum, underscores the need for educators to better understand ASD, incorporating ASD support strategies into teaching for *all* children. Recent research indicates that the developmental clinical picture of ASD might be more complicated, with problems in between-network connectivity at various spatial and temporal scales within the brain leading to significant differences in processing of incoming information (sight, sound, and physical stimuli).

Educational Implications

Evidence that individuals on the ASD spectrum may interpret emotional cues through systems, patterns, and deductive strategies, rather than through automatic emotional networks, supports the need to incorporate clear, direct, and interactive explanations of social communication skills into teaching. In the next paragraphs, we will discuss interventions, techniques, and strategies for the classroom that have demonstrated their effectiveness both for students with ASD and for their neurotypical peers.

Antecedent interventions help prepare and ease transition concerns for new situations. Priming techniques may include verbal descriptions, picture cues (Ogletree, Oren, & Fischer, 2007), and/or environmental changes (rearranging desks, placing a calculator within view, etc.). Social stories, which introduce a new setting through a written or pictorial guide, can acquaint ASD individuals with social expectations, logistics, or perspectives, and have been used effectively to introduce new situations to ASD individuals (Reynhout & Carter, 2006). For example, a child may read a social story entitled "Going into a Museum" or "What Will I See at the Smithsonian Natural History Museum?" to prepare for a visit to this museum. Proactive measures such as these may reduce or eliminate problem behaviors that can occur when transitions change the rules, environment, or expectations. Beginning an activity by designating a specific "job" for a student to complete can also provide a natural bridge for moving from one activity to another (Simpson, de Boer-Ott, & Myles, 2003).

The amygdala theory points to a need for incorporating *pattern-based techniques and deductive strategies* into learning. Specific, rather than general, terminology ("you've added these numbers correctly" vs. "good job") can help a child identify exactly which behaviors he has done well, providing a pattern for future success. Adult modeling of a calm, unemotional voice tone, fluid and deliberate body language, and appropriate actions and behaviors are important in helping the child understand expectations (Simpson et al., 2003). Video modeling (Ayres & Langone, 2005), in which a child watches a demonstration and then emulates the behavior, has been shown to help clarify understanding in elementary school students. Social robotics, using interactive robots such as Zeno (Ranatunga, Rajruangrabin, Popa, & Makedon, 2011), present another type of modeling for social skills. These robots can help ASD children overcome the anxiety that often accompanies live social interactions (Cardon, 2016).

Repetition and rehearsal are a vital part of intervention that helps ASD individuals form schema for new "systems." Behavioral rehearsal (role play in a structured setting) allows both ASD and neurotypical students to practice social skills (Gresham, 2002). Students might role-play everyday situations, such as answering the phone, helping a peer who has dropped a load of supplies, or ordering a meal at a restaurant. Difficult tasks may need to be introduced in a one-to-one setting before ASD students practice with a group, and variations in directions, environment, and strategies can help with generalizing skills to other settings. Frequent practice in a realistic setting (simulating a grocery store or restaurant) has been seen to increase skills in navigating the complexities of our social world (Boutot & Myles, 2011).

Positive reinforcement is important not only to provide feedback to the ASD child, but also to ensure him that the adult is supervising his behavior (Harrower & Dunlap, 2001). Simple reinforcers, including extra time on a favorite activity, attention from peers or adults, stickers, toys, or food, may be effective, but should be simple, natural, and related to the interests and needs of the child.

According to the United States Center for Disease Control (Centers for Disease Control and Prevention [CDC], 2014), 1 in 68 children now has ASD, a 30% increase over the 1 in 88 diagnoses 2 years ago. As new technologies and social changes increase the complexity of communicative interactions, interventions that increase the understanding of social and emotional communication are becoming more important for students in every classroom.

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