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Conduct problems, including bullying, remain a major behavioural management challenge in the school setting. Recent research that has identified neural mechanisms associated with conduct problems in childhood might have a crucial role to play in informing how schools manage conduct problems and bullying.

Tackling behavioural problems and bullying in schools

Antisocial behaviours at school have a significant impact on the wider learning environment, on the mental health of the victims, and on the perpetrators of such behaviours who could be excluded from educational provision at a great detriment to themselves and society at large [1]. Schools spend considerable resources managing disordered behaviour and many also have programmes aimed at promoting development of prosocial behaviour and empathy [2]. Alongside these programmes there has been a substantial expansion of mental health services for children in schools [3]. Maximising the potential of school-based interventions and preventative strategies is therefore of interest to policy makers across education, health and community contexts. There has also been recent interest in harnessing developments in the field of neuroscience to inform educational practice [4]. Here we provide a brief overview of the emerging evidence base for the cognitive neuroscience of conduct problems and consider whether this body of research has the potential to shed light on how difficult behaviours might be better managed in schools.

Not all children present with conduct problems for the same reasons. Researchers are becoming increasingly aware of different ‘pathways’ to similar problem behaviours. One pathway is characterised by genetic vulnerability, low responsiveness to other people’s distress and lack of empathy [5]. Children on this pathway are said to have ‘callous-unemotional’ traits and they share neurocognitive characteristics with adult psychopaths: reduced sensitivity to visual or vocal displays of distress emotions and poor modulation of behaviour in response to punishment [5]. A second pathway is characterised by environmental adversity and reactive aggression [5]. Children on this pathway are described as ‘non-callous’, have preserved empathic ability, can modulate behaviour in response to punishment and can be oversensitive to anger and punishment cues [5]. Neuroscience research is helping us to understand how these different subgroups of children with conduct problems have distinct neurocognitive vulnerabilities and might need different forms of intervention.

Functional magnetic resonance imaging (fMRI) studies of children and adolescents on the first pathway (those with conduct problems and callous-unemotional traits) have reported lower amygdala activity to others’ distress (fearful facial expressions) in this group as compared with typically developing adolescents and adolescents with attention deficit hyperactivity disorder [6,7]. Other studies have reported abnormal ventromedial prefrontal cortex response to punishment, and disrupted integration of amygdala, orbitofrontal cortex and caudate functioning during reinforcement learning in adolescents with callous-unemotional traits [8,9]. Overall, these findings indicate a functional neural basis for why adolescents with callous-unemotional traits and conduct problems lack empathy for others’ distress, make poor behavioural choices and have difficulty learning from their mistakes.

No studies to date have explicitly focused on children and adolescents on the second pathway (those with conduct problems who are ‘non-callous’). However, a series of fMRI studies have investigated a generic group of children with conduct problems of whom one would expect the majority to fall within this second pathway (see [10] for review). The studies reported reduced anterior cingulate activation to threatening emotional scenes under passive viewing conditions in these children (possibly reflecting poor emotional regulation). Increased amygdala activation to threatening emotional scenes, partly related to comorbid anxiety, has also been reported (consistent with heightened emotional reactivity for some children with conduct problems). In addition, a recent study reported heightened amygdala activity even to neutral faces in adolescents with conduct problems when compared with typically developing adolescents [11]. Overall these findings of aberrant activity in the brain’s basic emotion and emotion regulation regions indicate functional neural bases for why some adolescents with conduct problems can react aggressively even in the face of minimal provocation.
Cognitive neuroscience research therefore indicates that children on distinct conduct problem pathways are likely to be characterised by different patterns of neurocognitive vulnerability. From an educational perspective, this suggests that school-based interventions for behavioural problems should be tailored to meet the specific needs and neurocognitive limitations of children on these distinct pathways. Findings from parenting intervention studies for younger children support this notion [12]. Neuroscience findings indicate that it might be fruitful to intervene with school-aged children with callous-unemotional traits and conduct problems in ways that appeal to their self-interest, rather than through interventions that focus primarily on punishment-oriented strategies or attempts to induce empathy for victims [5]. Interventions that focus on anger management might be more effective for adolescents who have a long history of conduct problems but who do not exhibit callous-unemotional traits and seem to show problems with emotional regulation and threat perception [5,12]. In relation to bullying interventions in particular, there is a growing case for developing tailored approaches for adolescents with conduct problems and callous-unemotional traits because they are unlikely to be well served by the most commonly implemented approaches [13]. For example, educative approaches often aim to elicit empathy in the bully and focus on the distress they cause other children as a means to engender in them a motivation to change. The second commonly used intervention approach, exemplified by ‘zero-tolerance’ policies, is essentially punitive and involves exclusion from school and other high-level disciplinary sanctions. Neuroscience research indicates that neither of the above approaches is likely to work effectively in children with callous-unemotional conduct problems because they have difficulties empathising and are less responsive to punishment. A more successful approach could involve, for example, the establishment of a system of rewards for behaviour incompatible with bullying; in parallel there would be a need to ensure that rewards for bullying behaviour (e.g. gaining peer dominance, status and goods) were minimized, for example through close supervision by adults or peer mentors. Currently, however, schools rarely implement systemic and peer-supported approaches to bullying [14].

New directions: a future interdisciplinary framework

The dialogue between cognitive neuroscience and education has only recently begun but it offers the potential to provide a helpful framework for some of the common social and behaviour management challenges in the educational domain. Schools are uniquely positioned to create a social milieu through their policies and practice that can support children with particular neural vulnerabilities that result in behavioural problems and pose real challenges for educators and peers. The future research agenda in this area should include the formal testing of the impact of school-wide initiatives, such as social-emotional learning curricula, on neurocognitive functioning in children by using experimental neuropsychology tasks alongside well-designed neuroimaging studies. For the most vulnerable students with conduct problems, neuroscience findings offer specific guidance on the development of differentiated interventions targeted according to specific neurocognitive profiles. Again, formal intervention studies in the school setting, informed by social neuroscience findings, should be the subject of future research.

We envisage that the cognitive neuroscience evidence base on children, current research on school social context and educational practice, and findings from child mental health research will form the ‘building blocks’ for future research integrating education and cognitive neuroscience (Figure 1). The current challenge is to generate a set of relevant research questions that fruitfully bring together these building blocks and set the research agenda for cognitive neuroscience in schools. Ultimately the set of research questions should inform intervention, prevention and policy.

The strategy for achieving the integration of cognitive neuroscience and education research is likely to evolve as findings accumulate. However, we would propose the following initial steps. Systematic reviews of the literature

![Diagram](http://example.com/diagram.png)

**Figure 1.** There is a need to integrate findings from neuroscience, education and mental health research in establishing a research agenda to generate a new evidence base for the promotion of socioemotional development in schools.
are a crucial starting point in identifying common themes and priorities in child and adolescent cognitive neuroscience, educational research and mental health. The emergent integration of findings across these domains will provide a solid basis to generate a useful and meaningful research agenda. There are also longer-term strategic goals. Drawing on proposals for translating epidemiological findings for policy use [15], we believe that training ‘brokers’ who have in-depth expertise in both cognitive neuroscience and research/practice in educational contexts would help considerably in the meaningful integration of these fields. Such individuals would be ideally placed to facilitate effective communication between policy makers, neuroscientists, educationalists and mental health practitioners in helping to shape the longer term strategic goal of developing priority research agendas in which neuroscience research meets the needs of schools and pupils, including pupils with socioemotional vulnerabilities.

We think that new insights from cognitive neuroscience can already provide a framework, as well as practical guidance, for educationalists and policy makers. However, substantive translational efforts in this area will be realised only when specific efforts are made to integrate findings and advance a research agenda incorporating neuroscience, education and mental health research.

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**Letters**

Further notes on testosterone as a social hormone

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Further notes on testosterone as a social hormone

The hormone testosterone has a bad reputation in terms of how it influences our social behavior. According to the general public, testosterone induces violence and aggression [1], and in the scientific literature the hormone is victimized as the chemical source of antisocial and immoral behavior, with high-testosterone individuals having psychological profiles that compare to sociopaths [2]. In their passionate and insightful book, *Heroes, Rogues and Lovers: On Testosterone and Behavior* [3], James and Mary Dabbs show that these views are mistaken. Dabbs and Dabbs argue that testosterone can in certain conditions motivate rebellious, aggressive and violent behavior but these conditions will mostly involve social dominance competition. However, in other conditions, testosterone can motivate behaviors that are extremely prosocial and altruistic, especially in individuals holding socially protective positions in society, such as firefighters, police officers and soldiers [3]. The effects of the steroid hormone testosterone heavily depend on the social situation, and it is unlikely that this natural bodily fluid has instant antisocial or prosocial properties. Similarly, the peptide hormone oxytocin, popularly known as the ‘love-drug’, is not unconditionally a prosocial hormone. Oxytocin promotes ethnocentrism: its