

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,100

Open access books available

116,000

International authors and editors

125M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Therapy for ADHD Directed Towards Addressing the Dual Imbalances in Mental Effort and Reward as Illustrated in the Mental Effort-Reward Imbalances Model (MERIM)

Alison Poulton

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/60814>

Abstract

In this chapter we describe a clinical model for ADHD: the Mental Effort Reward Imbalances Model (MERIM). We use this model to explain some of the behaviour commonly observed in children with ADHD and to guide approaches to treatment. The MERIM views the behaviour associated with ADHD as an outcome of two unfavourable imbalances: 1. Imbalance of the level of mental effort required for achievement. 2. Imbalance in the level of reward experienced. These imbalances each contribute to lower levels of achievement and fewer rewarding experiences in ADHD. This results in a poorer mood with less tolerance for frustration, together with seeking rewards that do not involve high levels of effort. The concept of ADHD as dual imbalances in mental effort and reward gives a useful framework for understanding the behaviour and the strategies that individuals use to compensate and improve their mood.

Keywords: attention deficit hyperactivity disorder, oppositional defiant disorder, mental effort reward imbalances model, emotional self regulation, reward deficiency syndrome

1. Introduction

In this chapter we describe a clinical model for ADHD: the Mental Effort-Reward Imbalances Model (MERIM) [1]. We use this model to explain some of the behaviour commonly observed in children with ADHD and to guide approaches to treatment. The MERIM is a clinical model which we have found useful for explaining some of the more difficult behaviour observed in individuals with ADHD. This is particularly valuable for parents and teachers because a better insight into the reason the behaviour works for the child helps promote understanding and empathy.

The MERIM views the behaviour associated with ADHD as an outcome of two unfavourable imbalances:

1. Imbalance of the level of mental effort required for achievement
2. Imbalance in the level of reward experienced

These imbalances each contribute to lower levels of achievement and fewer rewarding experiences in ADHD. This results in a poorer mood with less tolerance for frustration, together with seeking rewards that do not involve high levels of effort. The concept of ADHD as dual imbalances in mental effort and reward gives a useful framework for understanding the behaviour and the strategies that individuals use to compensate and improve their mood.

This chapter is structured with some clinical descriptions and some sections which outline the background and evidence. As much of the descriptive information is based on observation, it cannot be fully referenced. It is therefore up to the readers to draw on their own observations, experience and intuition for validation.

2. Background

2.1. What is ADHD?

ADHD is a common condition with an estimated population prevalence of between 2.6% and 11% in children [2-5], being higher in boys and younger children. It is also common in adults, with estimates varying from 2.8% to 4.7% [6-8]. People with ADHD have impaired functioning due to difficulties with sustaining attention and with controlling impulsive behaviour [9]. They also often have a high level of physical activity.

There is evidence that individuals with ADHD have functional deficits in the prefrontal cortex, which is the part of the brain most involved in executive functioning [10]. Executive functions include working memory, reasoning, planning and resisting distractions [11]. ADHD is also associated with reduced motivation attributable to deficits in the striatum affecting the dopamine reward pathway and it may impact on the functioning of the amygdala, which is associated with the experience of emotions [12, 13]. The stimulant medications used in the treatment of ADHD increase the levels of the neurotransmitters noradrenaline and dopamine, and lead to improvement in the executive functioning deficits and the mood [14, 15].

ADHD is a clinical diagnosis and depends on an individual showing the behavioural features to a greater extent than would be expected for their age or developmental level and having associated problems in functioning. The features of ADHD are not specific, also occurring within the normal population but not with sufficient severity to cause significant impairment. ADHD typically results in difficulty completing tasks, which leads to underachievement and a less rewarding existence. A popular misconception is that individuals with ADHD will tend to be similar in their behaviour. However, within the normal population there is substantial variation in personality types, skills and abilities. When a diagnosis such as ADHD is superimposed, it adds a further source of variability. ADHD can occur in people of all levels of intellectual ability. Intellectual ability is one of the most important personal attributes that modifies the expression of ADHD.

2.1.1. Inattention

People with ADHD have more difficulty than others for tasks that involve sustained attention, particularly if the task is mentally demanding. Therefore, they would cope better for tasks that are shorter, easier or have a particular interest that stimulates attention. Individuals with ADHD may be able to concentrate for prolonged periods of time on electronic games. These typically do not involve the effort of independent or creative thought and also provide constant stimulation that catches and keeps the attention.

One characteristic of people with ADHD is that they are easily distracted. This may occur while they are talking and may lead to forgetting what they were going to say or losing the point while telling a story. Alternatively, becoming distracted during a task and then forgetting to go back and get it finished can lead to a person being inefficient and disorganised. People with ADHD often have difficulty ignoring distractions and this may make them particularly intolerant to background noise while trying to concentrate. Losing focus on schoolwork may lead to disruptive behaviour in class as a response to the boredom that comes with having nothing to do. Lack of attention predisposes to missing instructions and making careless mistakes. A child with ADHD may have difficulty with age appropriate play, quickly losing concentration and moving on to the next task or looking around for something more entertaining to relieve boredom.

ADHD is more disabling in children who have learning difficulties. This is because they have to concentrate longer and harder to acquire the same skills. The more difficult the task is for them, the more quickly they will fatigue mentally and give up. Conversely, an able child with ADHD may have no difficulty achieving at school during the early years. However, as the work becomes more demanding in high school, intellectual ability by itself may no longer be sufficient; and if they are unable to concentrate in class and study consistently, their grades may decline. Once a person leaves school, they usually have more opportunity to follow their interests and strengths and ADHD may therefore be less of a problem. However, lack of organisational ability may become more disabling when an individual has to contend with the complexities of functioning in society as an adult.

2.1.2. *Hyperactivity*

Hyperactivity is common in ADHD and is the most easily recognised feature. The hyperactivity often reflects the changing focus of attention as a child moves rapidly from one distraction to another. The restless energy may make it difficult to remain seated for any length of time, increasing the challenge for table-based activities. A child with ADHD may also be excessively talkative, sometimes apparently talking just for the sake of it and may lack the patience to stop talking and listen. Hyperactivity tends to diminish with age [16] and although some adults with ADHD may be still hyperactive, a hyperactive young child may develop into an underactive, unmotivated adolescent.

2.1.3. *Impulsivity*

People with ADHD often have quick reactions that occur without having time to stop, think and make a decision. Impulsivity can have an adverse effect on peer relationships as a child may unintentionally hurt or offend or repeatedly get into trouble for the same misdemeanour, such as impulsively calling out in class. Because of the lack of any active decision-making, these unregulated actions may be considered accidental by the child who may be inclined to deny responsibility. The lack of impulse control can lead to anxiety and low self-esteem as the child may suddenly be in trouble without any prior warning or intent.

2.1.4. *Oppositional Defiant Disorder (ODD)*

ODD is very frequently associated with ADHD. It is a common condition, with a community sample in the United Kingdom showing a prevalence of 2.2% in children aged 8–19 [2]. Among children with ADHD, about 38–52% also meet diagnostic thresholds for ODD [2, 17, 18], and of the remainder many will have symptoms of ODD but not of sufficient severity or consistency to meet the diagnostic criteria. People with ODD typically overreact with anger in response to minor frustrations [9]. The lack of control over impulsive behaviour in ADHD becomes even worse when associated with anger as such children may incorrectly interpret another child's actions as hostile [19]. For example, if accidentally pushed, a child may automatically react by hitting. This can make individuals prone to involvement in physical fights and they may show no fear, even fighting with children who are much older and stronger. Other children may find this loss of control amusing and may deliberately provoke or bully such a child for a reaction. ODD is also associated with deliberately annoying people and sometimes with planned acts of spite. ODD is therefore a risk factor for bullying, either as the perpetrator, or the victim, or both. Children with ADHD sometimes consider the features of ODD to be an intrinsic part of their ADHD identity and may view the threat to their peers of their uncontrolled aggression as a source of power or strength rather than a weakness [21]. ODD is also associated with a negative attitude and a tendency to blame others and deny responsibility, argue and oppose authority.

2.1.5. *Functional impairment in ADHD*

The key to diagnosis of ADHD is not simply a matter of expressing the symptoms but, more importantly, it relates to the consequent impairment in functioning. When assessing the extent of functional impairment, it is useful to consider the level of achievement in the following

modalities: academic achievement in relation to ability; peer relationships; ability to function at home and/or at school without generating unreasonable levels of stress or disruption and level of self-esteem.

2.2. Why is ADHD different from normal functioning? – The Mental Effort-Reward Imbalances Model (MERIM)

The most fundamental problem in ADHD is the inability to achieve consistently at a level appropriate to a person's ability. The individual would therefore be intellectually capable of higher achievement and have no physical disability sufficient to explain their level of achievement. For normal people, getting through their daily routine involves a constant stream of tasks that require effort and lead to a series of achievements, most of them small. These achievements are each associated with the satisfaction of task completion – the feeling of a job done well – which all help to sustain a stable and amicable mood. Therefore, for example, you get up in the morning, you put some effort into getting dressed and ready to go. Your assessment is that you look presentable in your clothes. You have achieved and you feel good about yourself and ready to put further effort into the next challenge. Achievement therefore involves some level of effort and is associated with a feeling of satisfaction (reward) which contributes to a good mood and a readiness to attempt the next task. Good mood is important for normal functioning and it has been shown that individuals who have a greater tendency to react with positive emotions have better emotional, psychological and social well-being [22]. They have better physical health and fewer days off work. The cycle of achievement, reward, good mood and further achievement is represented in Figure 1.

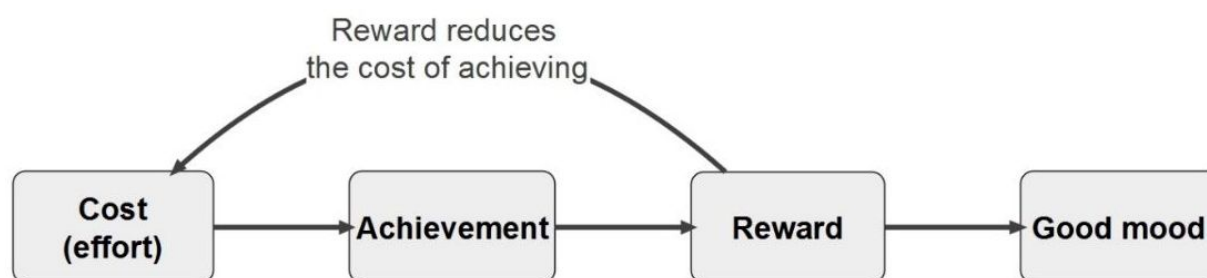


Figure 1. Schematic representation of the achievement and reward sequence

In ADHD the sequential pathway shown in Figure 1 does not work as effectively as it should. According to the MERIM, there are two places where it can malfunction. The first is if the cost or effort required to achieve is disproportionately great, as occurs in association with executive functioning deficits leading to less efficient thought processes in ADHD. The second is if a person experiences an inadequate level of reward. The MERIM views ODD as a deficit in the experience of reward, caused by neurochemical underactivity in the reward pathway. The impact of these two deficits on achievement and reward is illustrated in Figure 2.

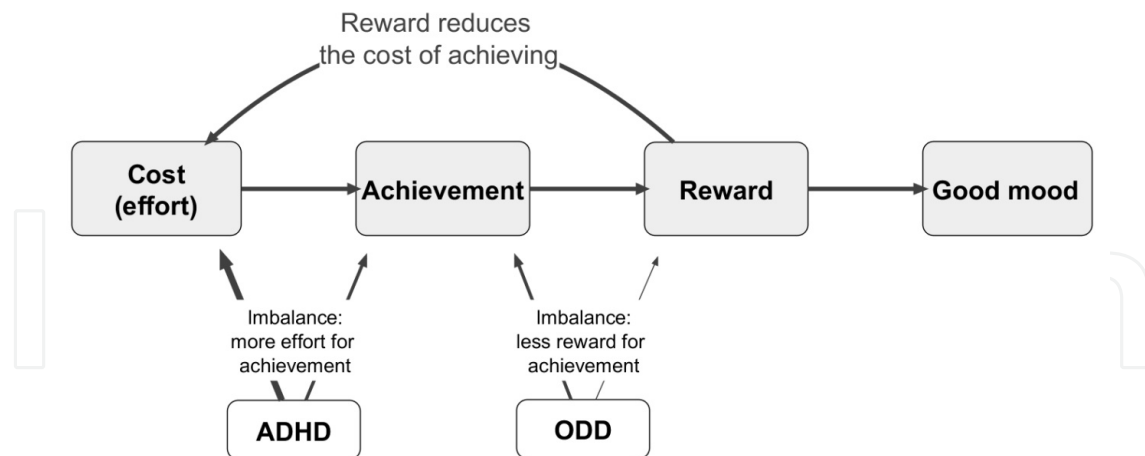


Figure reproduced with permission by Australasian Psychiatry [1]

Figure 2. Mental Effort-Reward Imbalances Model (MERIM)

2.2.1. Inefficient mental processes in ADHD leading to higher cost for achievement

In ADHD, mental processes (executive functions) are less efficient and therefore achievement requires more mental effort. This is like a runner who has to run uphill. It is not that running is a task that is too difficult for him, but he will tire more quickly than others who are running along level ground. He will either keep going but run more slowly, or he will try and run as fast as the others and then have to stop to rest. It is like this for mental tasks for people with ADHD. The mental fatigue is genuine and may affect academic functioning, social interactions and managing the daily routine at home. Children with ADHD often develop various ways of disguising or adapting to it. Some of these could be considered as 'taking mental short-cuts'.

2.2.1.1. Schoolwork

A child with ADHD may rush to get work finished within a time span for which he can concentrate. Alternatively, he may work for a bit and then stop working and appear to daydream, as if his mind is going blank like a computer on standby. Some just limit their rate of mental effort to a manageable level by working slowly. This may be disguised by giving too much attention to neatness and therefore doing very little of the more cognitively demanding aspects of the work. Creating a distraction may also be an effective work avoidance strategy. For example, a little girl developed the pattern of turning around and giving her mother a cuddle whenever she felt under too much pressure to concentrate on her homework. Other more common avoidance strategies include changing the subject or asking an irrelevant question.

2.2.1.2. Social interactions

Conversation demands mental effort, both for listening and for thinking and formulating the sentences required for a response. Children with ADHD often use strategies which conserve

their mental effort. If a child is asked about who they have played with at school, this involves the effort of thinking back to an earlier part of the day and it may be easier to respond: 'I don't remember'.

2.2.1.3. Routine tasks

Children with ADHD often have difficulty carrying out instructions, particularly if given several together. A child may try to look as though he is listening, keeping his eyes on the speaker but not fully concentrating and therefore unable to follow an explanation or instruction. Sometimes a child may only listen to part of a sentence and guess the rest. Remembering several instructions often involves the effort of repeating them mentally. Rehearsal strategies and recall may be less efficient in ADHD [23]. If a person is not putting in adequate mental effort or is distracted by other thoughts, instructions may easily be forgotten.

If a person is achieving less on account of the disproportionate or unsustainable effort they have to put into completing a task, they will experience less satisfaction. They may be less ready to put further effort into the next task, with a tendency to give up easily. Inefficient mental processes therefore contribute to the underachievement associated with ADHD and consequent low self-esteem. Some individuals attempt to preserve their self-esteem by reducing their goals in life to a level that is more achievable. This may lead to dropping out of school into unskilled work or state benefits. This may be framed as a deliberate choice rather than failure to achieve.

2.2.2. Inadequate experience of reward from achievement leading to symptoms of ODD

Getting pleasure from the little things in life is important as this helps to maintain a good mood and amicable outlook [24]. However, if the subjective experience of reward is inadequate, a person is likely to feel negative and dissatisfied. The resultant low mood may lead to lack of motivation stemming from the perception that tasks are not worth the effort. Alternatively, a person may compensate by seeking activities that are more highly rewarding or that give reward for less effort. The dissatisfaction associated with inadequate experience of reward predisposes to the characteristic behaviour of ODD.

In this chapter, the term ODD is being used to include all the disruptive, impulse control and conduct disorders (ODD, intermittent explosive disorder, antisocial personality disorder, disruptive mood dysregulation disorder, conduct disorder) [9]. These conditions are associated with temper outbursts (problems in emotional regulation) and with behaviour problems including rule breaking and antisocial acts, with the specific diagnosis designated according to the main symptoms and the relative balance of the mood versus the behavioural dysfunction.

Deficits in reward do not only occur in ADHD/ODD but are also associated with other conditions such as addictions and obesity [25]. These are sometimes termed reward deficiency syndromes and are characterised by the strategies that people use to compensate for their inadequate experience of reward [26]. These may include comfort eating, compulsive gambling, internet or gaming addiction and drug abuse.

2.3. Relating the MERIM to the DSM and other models of ADHD

A formal diagnosis of ADHD is usually made in accordance with specific diagnostic criteria, such as those published by the American Psychiatric Association in their Diagnostic and Statistical Manual of Mental Disorders (DSM), the current edition being DSM-5 [9]. The diagnosis is based on meeting a sufficient number of the DSM-5 criteria for inattention, hyperactivity and impulsivity, with associated impairment in functioning. ADHD is classified as combined type (meets sufficient criteria for inattention and for hyperactivity–impulsivity), predominantly inattentive ADHD (meets criteria for inattention but not for hyperactivity–impulsivity), or hyperactive–impulsive ADHD (does not meet criteria for inattention). The diagnosis of hyperactive–impulsive ADHD tends only to be made in preschool children, who are at a stage of life in which the lack of ability to sustain concentration may be less evident. A diagnosis of hyperactive–impulsive ADHD may therefore be revised to ADHD combined-type as a child matures [27].

Several of the DSM-5 diagnostic criteria for ADHD are outcome-based and relate to lack of achievement in task completion. These do not dictate the causal mechanism and are therefore not specific to underachievement due to executive functioning deficits. Children who underachieve due to inadequate experience of reward would also qualify. According to the MERIM, the dual deficits in executive functioning and reward experience contribute independently to the lack of achievement associated with ADHD (Figure 2). Because these two mechanisms are both highly prevalent and are additive in their effects on achievement, most people diagnosed with ADHD using the DSM are likely to have some degree of deficit in each. This provides an explanation for the substantial levels of diagnosable ODD among children with DSM-diagnosed ADHD. The MERIM would therefore consider the negative attitude and outlook that is frequently associated with ADHD as evidence of some degree of reward deficiency syndrome contributing to the symptoms of ADHD.

The MERIM is not the only model for ADHD that competes with that described in the DSM. The MERIM is probably the simplest model as it does not attempt to relate the symptoms of ADHD to specific testable modalities of executive functioning. Instead, it starts from the premise that unspecified executive functioning deficits mean that cognition is less efficient in ADHD and therefore requires more mental effort. It also does not really provide any explanation for the hyperactivity or the impulsivity. It has similarities with the model put forward by Douglas, which considers ADHD to be a result of four predispositions: the desire for immediate gratification, reluctance to invest mental effort, impaired impulse control and impairment in modulating arousal or alertness [28]. However, although it does not address arousal and impulse control, in the area of gratification the MERIM goes further than Douglas in that the desire for reward is explained as being an intrinsic deficit that reduces the individual's subjective experience of reward and interacts with the motivation for mental effort.

Barkley postulated the primary problem in ADHD to be inadequate response inhibition [27]. He gave this as the underlying cause for deficits in executive functions that include working memory, inner speech and verbal reasoning, analysis of behaviour and also for deficits in emotional regulation. According to this model, the symptoms of ODD would be explainable as manifestations of the emotional dysregulation associated with ADHD. Therefore, with

Barkley's model there is also no need for any additional diagnosis of ODD. However, although Barkley's model includes ODD in the overall symptomatology of ADHD, unlike the MERIM it does not explain the observation that the main emotional component of ADHD should be negative.

2.4. Striving for happiness: The balance between adequate reward and manageable effort

According to the MERIM, the clinical presentation of a child with ADHD will vary according to the severity of the imbalances in the level of mental effort required for achievement and the level of reward experienced. The particular clinical problems depend partly on the behavioural outcomes resulting from the underlying neurochemical deficits and partly on the strategies an individual develops to compensate and cope with these deficits.

People who have deficits in their experience of reward may feel miserable and moody. However, many develop strategies that make their life more rewarding and result in improving their mood and feeling happier. The particular strategies depend partly on the relative balance of deficits in executive functioning and reward experience and also on a person's intellectual strengths and weaknesses. Symptoms of reward deficit include arguing, deliberately annoying people and being spiteful or vindictive. Although these strategies might not initially appear to be obviously rewarding, there are study data that suggest otherwise. A study of adolescents with aggressive conduct disorder found that they showed an atypical response when observing inflicted pain, with activation in areas of the brain associated with pleasure [29]. Clinical observations also provide intuitive support: why would a child be deliberately spiteful if this were not pleasurable in some way? Humans are a social species and even more fundamental than communicating with language is communication that involves influencing and manipulating others' emotions. This can be done in a positive way, for example, telling a good joke that makes people laugh or giving someone a pleasant surprise that makes them happy. However, positive experiences can be difficult to organise and it is often easier to hurt or upset someone. Parents sometimes say that their child with ADHD will argue that black is white. This implies that arguing may not be a rational debate but rather an end in itself. Perceptive parents may observe that their child would start out in an angry mood but after a prolonged argument that frustrates or even hurts and upsets the parent, the child's mood may have improved. Therefore, the strategy works for the child, but clearly not for the parent. Winning is also a rewarding experience and older teenagers or adults may actively look for opportunities for starting an argument that they think they can win. Alternatively, children may become skilled at annoying or upsetting other family members, or playing one parent off against the other, and then quietly smiling at the resulting chaos. Children with less sophistication may simply resort to unprovoked physical violence when they feel irritable. Eliciting a negative social response by being deliberately difficult may therefore be an effective strategy that compensates for deficits in the subjective experience of reward. In the present context, any such activity that is carried out with the intention of causing pain or distress to another person has been classified as bullying. Therefore, a child may bully a parent or a teacher. The positive impact of bullying on mood is shown in Figure 3.

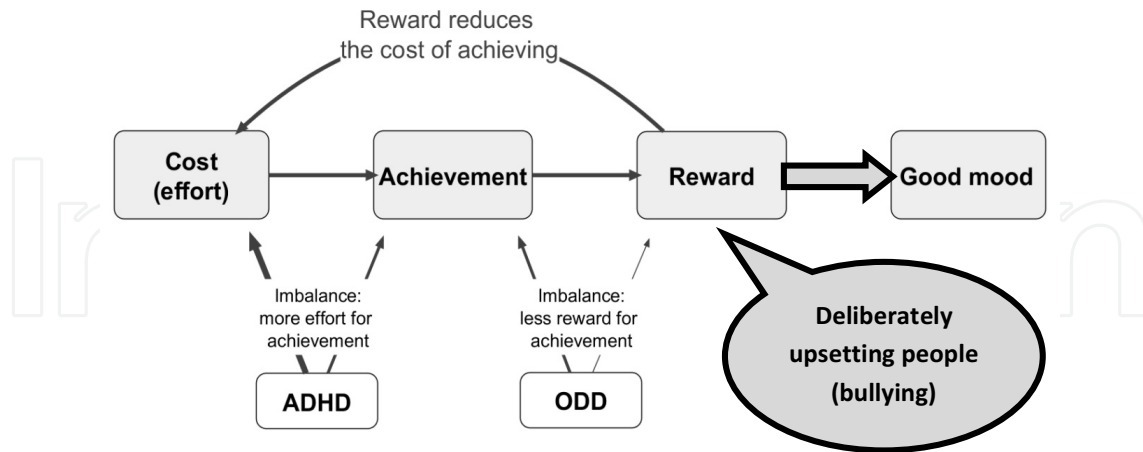


Figure 3. Oppositional behaviour that compensates for lack of reward

Although the behaviour that is typically associated with ODD may be effective for compensating for deficits in reward experience, there are other strategies that can also enhance reward. Figure 4 shows a range of tasks, strategies and achievements that vary in the amount of effort they require and the level of reward experienced. For individuals with the most severe deficits in executive functioning and reward, the level of reward has to be particularly high in relation to the level of effort to make the activity worthwhile.

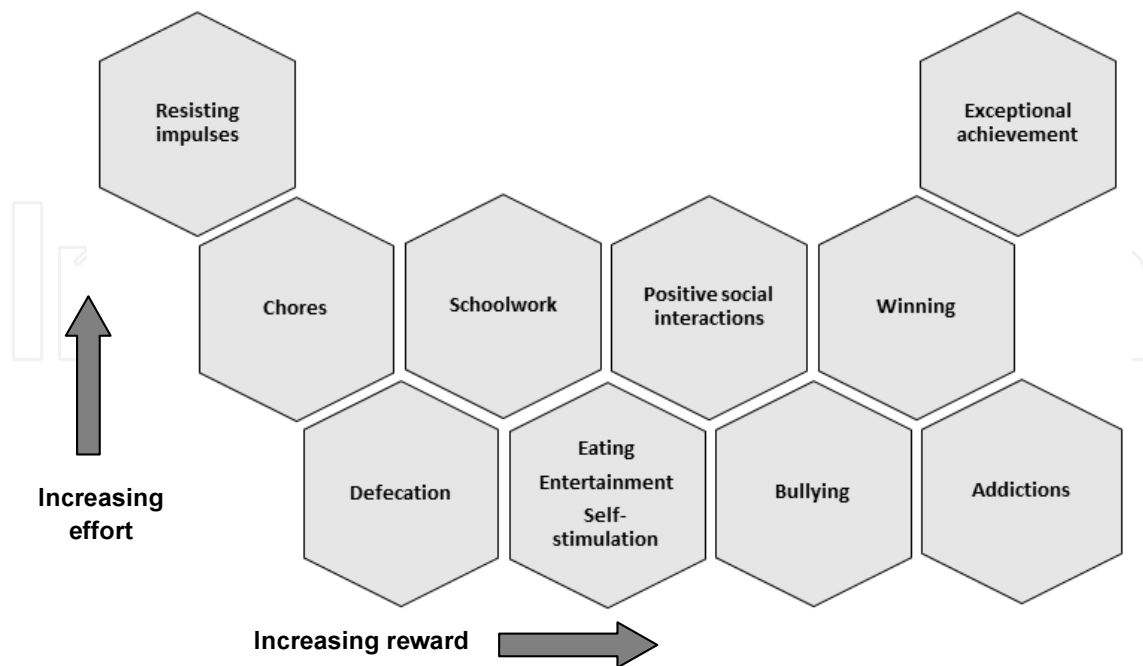


Figure 4. Hypothetical balance of effort and reward for various tasks and pastimes.

Intellectual capacity and tenacity determine an individual's capability for achievement. Individuals with severe ADHD, ODD and intellectual disability may find that going to the toilet for defecation is not sufficiently rewarding to be worth the effort [30]. An individual may indulge in self-stimulation as this provides reward and is not mentally demanding. Eating is also easy and rewarding, which may explain the recognised association of ODD with obesity [31, 32]. Individuals with ODD are particularly susceptible to addictions to substances such as nicotine or illicit drugs [33, 34]. Conversely, resisting impulses requires substantial effort and is not particularly rewarding. An aggressive and irritable child may therefore have no meaningful incentive for putting effort into foregoing the satisfaction of hitting a sibling.

Having a higher level of intellectual ability opens the possibility for higher levels of achievement. Within the broad categories of chores, schoolwork and social interactions, different activities will vary in their level of interest and difficulty for the individual, with some chores and schoolwork being experienced as less arduous and more rewarding than others. The level of effort required for social interaction is often underestimated. Children generally demand a high level of attention from their friends, and even though play and conversation are rewarding, a child with ADHD may find the intensity of the mental effort unsustainable. The child may consequently withdraw to a less demanding pastime, perhaps playing alongside their friend. A child may find relaxation from a low-level, repetitive activity, which can lead to an incorrect diagnostic label of autism spectrum disorder. Alternatively, a child with ADHD may be more comfortable playing with a younger or less intellectually demanding child, or an older child who can make allowances or entertain.

Some individuals with reward deficit may be intensely competitive, striving for the high rewards that accompany high achievement. Those who are intellectually able may appear 'driven' to exceptional achievement, combating their general dissatisfaction by striving for higher levels of reward. Failure may lead to hostility and antagonism towards those who are more successful. In other words, after not managing exceptional achievement, their reward deficit may be addressed by the less exacting activity of bullying. Some children use competition to maintain motivation during play by making every activity into a win-lose situation. Such children may be unable to tolerate losing. However, being competitive may be used adaptively to enhance the reward associated with routine tasks or chores, for example, a child trying to break their record for how quickly they can get dressed.

With the exception of addiction, the higher rewards depend for their value on social recognition or an emotional response from one or more other people. Even exceptional achievement needs a social frame of reference in order to designate its value. The higher rewards associated with more positive achievements tend to require higher levels of effort and aptitude. By contrast, negative behaviour such as bullying has a high balance of reward for the mental effort and is therefore easier for those who are less able. However, the rewards that are associated with low levels of effort and achievement may be associated with low self-esteem. This could negate some of the reward experienced from activities such as bullying. Attributing blame to the victim may reduce this negative effect on the bully's self-esteem[19].

The above figure and paragraphs classify a range pastimes and achievements with a model that assigns to each a comparative level of effort and reward. This model predicts the strategies

and behaviours that are likely to characterise deficient internal reward processes. It is important to recognise the function that such behaviours serve for the individual in generating the sense of satisfaction that they crave. An individual's prevailing mood gives a measure of the success of their strategies for achieving adequate reward within a manageable level of effort.

3. Management

Management of ADHD may involve medication, non-pharmacological treatment or a combination of both.

3.1. Non-pharmacological management of ADHD

Non-pharmacological approaches to management usually focus on the areas of functioning which are causing the most problems. This may involve additional learning support or other assistance related to the executive functioning deficits, such as help with organisation. However, the main emphasis is usually on behaviour management strategies. The conventional behavioural strategies used in ADHD are not specific for this condition, but aim to take good parenting and good classroom management to a higher level. Therefore, strategies may be applied to the whole family or to the entire class or even the whole school. An additional but less well utilised modality of non-pharmacological management targets the emotional issues. We suggest a larger role for emotional self-regulation as a means of promoting and maintaining a positive mood and outlook in ADHD.

3.1.1. *Addressing the imbalance of the level of mental effort required for achievement*

3.1.1.1. *Additional learning support*

This is designed to address specific problems exacerbated by the executive functioning deficits, for example, additional support with reading, so that this skill becomes easier and accomplished with a more manageable level of effort. Reading is a complex skill that involves several components. Each component requires attention. Therefore, the individual has to recognise the letters, relate them to their sounds and blend the sounds together to decipher the word. The words then have to be remembered so that the sentences can be derived. The sentences have to be understood and their meaning remembered long enough to make sense of the passage. The main reward of the task is in the interest from the information contained in the passage.

When a child is learning to read, the process is slow and laborious and the reward from the information may be lost unless the sentence is very simple. With practice, the child starts to recognise common words without having to sound out each one individually and reading becomes easier and more fluent. This allows more attention to be focussed on the meaning. The information is received at a faster rate and the balance of effort to reward improves. As reading becomes more rewarding, the child may start to read books for pleasure and thereby further practice and develop their skills.

If a child has ADHD, their attention span for concentrating will be less than other children. The learning process may be more laborious and the child may be inclined to give up easily. It may be harder for the child with ADHD to attend to the meaning while simultaneously deciphering the individual words, which reduces the interest of the task for the child. At this stage, additional one-to-one teaching may accelerate the rate at which the child develops reading fluency. As reading is a prerequisite for success in almost every area of schooling, good skills that enable a child to read without putting all their attention and effort into the process will be beneficial in all areas of academic learning.

3.1.1.2. Modifying the tasks and expectations

A child with ADHD is likely to need a higher level of parent or teacher attention and the tasks may need to be modified to make them achievable. Management often involves looking at the particular problems to find modifications that may make the required tasks more manageable within a child's limited attention span. Such strategies may include keeping tasks short and varied and moving on to a new topic before boredom sets in. Instructions need to be easily understood and repeated if necessary, perhaps with a written task list. A child with ADHD may need to be reminded to remain on task. Breaks may be factored in, such as sending the child out on an errand.

3.1.1.3. Teaching organisational strategies

Organisational skills can also be taught. These can include strategies to keep track of homework, including structuring the tasks, using checklists and long-term planning of tasks with their completion dates [20, 35].

3.1.2. Addressing the imbalance in the level of reward experienced: increasing the external rewards with conventional behaviour management

Behaviour management strategies are generally used by the parent or teacher and are designed to make favourable behaviour more rewarding and negative behaviour less rewarding for the child. These strategies usually involve a combination of rewarding desired behaviour and negative consequences for behaviour that is being discouraged. They depend on the individual being able to evaluate in advance the consequences of their behaviour. The particulars of the behavioural strategies have to be carefully thought out.

Conventional behaviour management has the drawbacks that because the rewards and consequences are external and often tied to particular tasks and situations, they may not carry over to other tasks and settings. Conventional behavioural strategies often use emotional rewards, with the parent or teacher praising the child and showing delight if the child has achieved or put considerable effort into the task. The child may respond by trying harder in order to gain the satisfaction of making another person happy. Therefore, it is frequently observed that a child will work better for a teacher who cares and takes more interest in him, but works less well following a change of teacher. The long-term aim of behaviour management is that the behavioural change should become generalised as the child matures [36].

A review evaluating psychological interventions has demonstrated sufficient evidence to consider behaviour management to be an established and effective intervention for ADHD, either when administered by the parent following training or when used in the classroom [36].

In order for behaviour management to be effective, a number of prerequisites must be met.

1. The child must be capable of carrying out the target behaviour.

This means that the goals should be realistic. It is important that goals are not too difficult such that the child gives up. Targeting small, manageable tasks is often the more effective approach. In children with a lot of behaviour that is perceived as problematic, goals need to be prioritised. For example, if a child regularly refuses to do any homework, rewarding the child for concentrating for 5 minutes and writing a single sentence and gradually working up to completing their entire half hour of homework may be more successful than choosing homework completion as the initial goal.

2. The child must understand the rewards and consequences and be able to relate these to their behaviour.

The child needs to have sufficient capacity to be able to comprehend that there will be consequences. The child also has to make an emotional connection with the consequences. It has been shown that children with ADHD may choose immediate small rewards over larger, delayed rewards [37]. The relevance of this to the clinical setting is that children with ADHD may appear to 'live for the moment'. The child may at be able to recite the consequences for a particular misdemeanour; but at the moment of making a decision, the consequences appear to have little relevance to the child. Afterwards, the child may show no interest in the reason for their punishment, experiencing it only as a frustration. It may not be that the child is intellectually incapable of understanding the connection between an activity and its consequence, but that what is important or relevant to the child is the present.

3. The rewards and consequences need to be meaningful and appropriate.

Rewards and consequences should be chosen carefully. A child might be rewarded with time to play on a computer; a meaningful punishment might be taking away the child's favourite toy or game. Rewards and punishments that are small and repeatable are often more effective than larger ones. For example, if a parent is very angry with a child, there may be a temptation to extend the duration of the punishment, perhaps taking away the favourite toy or banning the child from watching television for a week. If the child subsequently misbehaves during that week, the parent has lost one valuable option for punishment. Alternatively, if the punishment is milder, for example, the child is prevented from watching just one show, or loses their game for only five or ten minutes, the same punishment can be repeated as often as necessary. Prolonged punishment with restoration of the item made dependent on good behaviour may be even less effective. To a child with ADHD, a week may be such a long time that they consider the item lost forever; furthermore, it may be unrealistic to expect the child to behave well for a whole week. Withdrawal of attention from a child who has misbehaved can also be effective.

4. The strategies should be applied consistently.

Effective behaviour management requires consistent effort from the parent or teacher. If there is any leeway a child may become skilful in picking the time when they can get away with breaking a rule.

5. The child must choose to co-operate.

Co-operation is likely to depend on the child's own assessment of the balance of effort to reward. If the effort required is disproportionate due to the executive functioning deficits associated with ADHD, the child may insist on a reward that appears similarly disproportionate. For example, a small reward, such as adding a sticker to a chart for every task completed, may work for a few days until the child realises that the stickers are not worth the effort. At that stage, in order for the behaviour management to continue to be effective, a higher reward may be negotiated. This cycle may continue until the child will not even consider doing any homework unless rewarded with a very substantial sum of money. Alternatively, the child may perceive that he or she will experience greater satisfaction through non-co-operation. Figure 4 categorises bullying – behaviour designed to upset or hurt another person – as being more rewarding than schoolwork. Therefore, if a child can derive an alternative to co-operation that causes pain, this may appear an attractive option. If the child perceives that the parent or teacher is emotionally committed to their co-operation and genuinely wants to see the child carry out the task, this may provide an opportunity for bullying. This might take the form of deliberately destroying their work, for example, by scribbling on the page. Observing the resultant surprise, anger or frustration may be immensely satisfying for the child. Another very common strategy for non-co-operation is arguing. This may be a delaying tactic and a parent may be baffled that their child may spend twenty minutes and considerable effort arguing over ten minutes of homework, which ultimately still has to be done. To the child arguing may serve several purposes. Firstly, time spent arguing may be considered time well-spent because the homework is not actually being done. Secondly, the child may be negotiating a better deal, such as a higher reward or a reward in advance of the task. Winning such a concession would also be rewarding in itself (Figure 4). Thirdly, the child may be bullying the parent, enjoying the effect of the argument on their parent's emotions, for example, observing an increasing level of frustration or anger. It is important for adults to understand the value that a child may place on observing an emotional response. Withdrawing from the child to calm down may minimise the reward the child experiences for their negative behaviour.

3.1.3. Emotional self-regulation

Emotional self-regulation with the aim of improving the mood fits in with the logic of the MERIM because reward deficit resulting in a less positive mood is considered an intrinsic part of the symptomatology of the majority of individuals with ADHD. Although strategies that can lead to a higher level of task completion have merit, an important additional outcome is the effect on mood. Therefore, for example, if a child completes homework under protest and with the sole aim of gaining a tangible external reward, perhaps perceived as a bribe, this might be considered an acceptable outcome as the work is done. However, if the attitude towards

the work is poor, it is likely that the child will complete it to the lowest acceptable standard. Therefore, an important additional aim would be to teach the child to value their work and gain internal reward in the satisfaction of a job done well. In other words, the positive aspects of the task that has been undertaken would be used to enhance the mood. Emotional self-regulation could supplement conventional behaviour management based on rewards and punishment, but places less emphasis on targeting particular behaviour, instead focusing on generating a positive mood through achievement. The main aim of this approach is to enhance achievement by promoting the cycle of achievement leading to a feeling of satisfaction, a happier mood and a readiness to take on the next challenge to achieve. Although not directly addressing the reward mechanisms, we have also included in this section anger management strategies.

3.1.3.1. Potentiating the internal reward mechanisms for a positive mood

Individuals may use a number of strategies which regulate their emotions. These strategies are not simply learned in childhood and adolescence but continue to develop, usually in a positive way, over the course of adult life [38]. Self-regulation strategies may be helpful as a long-term intervention for generating and maintaining positive emotions. For example, an intervention study of meditation (Loving Kindness Meditation) found that 35% of participants continued to derive positive emotional benefit from meditation a year after ceasing therapy [39].

Unlike conventional behaviour management, emotional self-regulation aiming to promote positive emotions has a theoretical advantage that its techniques directly address the effects of the underlying reward deficit. Furthermore, it can be applied to all aspects of daily life, and once taught and adopted, it does not rely on any outside sources for reward as individuals evaluate and provide their own reinforcement for their positive behaviour, developing strategies for sustaining their mood and self-esteem. The long-term goal would be for the individual to become independent in using the techniques of emotional self-regulation. This might happen if the individual notices that these strategies are worthwhile because they make him or her feel better. Because the individual has the control, self-regulation in relation to mood promotes individual responsibility and independence.

Positive rumination

Rumination involves repetitive thoughts that can influence an individual's emotional state. Rumination is conventionally considered to be negative in both the content of the ruminant thoughts and the emotional outcome as it focuses on the causes and symptoms of distress without seeking any solution to the perceived problems [40]. Negative rumination not only exacerbates depression and anxiety but is also a risk factor for a range of mental health problems, including aggressive behaviour in boys [41]. However, we suggest that spending time reflecting on a positive achievement could increase the level of enjoyment or satisfaction obtained. We have termed this positive rumination. We suggest that positive rumination may be a strategy used by healthy individuals that helps them to sustain a positive, stable mood and amicable outlook. It is a cognitive process that would involve some mental effort and therefore may come less easily to individuals with ADHD. It also depends on a person being

able to recognise their emotions, which can be a problem in ADHD [42]. Therefore, positive rumination may need to be specifically taught and practised in order for a person with ADHD to be able to use it effectively and understand and recognise its value.

There is evidence that frequent small, positive emotional boosts are associated with enhanced physical and mental well-being [24]. Positive rumination might provide this, but to be a workable strategy it would depend on the individual taking time to consider the good points about a piece of work or an activity and then reflecting on the sense of satisfaction that is generated. For example, after doing a piece of work, even if the work is not perfect, some positive attributes may be identified. These could initially be pointed out by the parent or teacher, but ultimately the individual would be encouraged to identify for themselves the value in their work. Times of reflection may also be built into the daily routine, for example, at bedtime thinking of the positive and enjoyable experiences and achievements of the day. These might include some of the following pleasant activities that are often associated with positive emotions: being helpful, interactions with others, playing, learning, exercise and spiritual activities [24]. In positive rumination, the individual has to be able to pause and reflect and have awareness of their mood, together with mood changes following on from their positive reflection.

Positive re-appraisal

In therapeutic settings, emotional self-regulation has tended to be directed towards dealing with negative emotions, for example, in anxiety, depression and anger [43]. However, a more recent approach to emotional regulation aims to generate and promote positive emotions [39]. Some strategies, such as negative rumination, avoidance and suppression are associated with psychopathology, while re-appraisal, problem solving and acceptance are considered protective. [43]. Positive re-appraisal involves redefining an adverse event in terms of any possible positive aspects [38]. Initially, the parent or teacher would need to assist the child, perhaps with a response such as: 'Although you lost your temper, you only hit him once, you calmed down quickly and you've learned that you should avoid him in future'. With time, the child may learn to practise positive re-appraisal. If the child's mood and self-esteem can so be preserved in times of adversity, he or she may be less tempted to resort to bullying in order to feel better.

3.1.3.2. Anger management

The symptoms of ODD might indicate a valuable role for anger management techniques. Strategies that have been used successfully for anger management include emotion recognition, problem solving, cognitive re-appraisal and relaxation with controlled breathing [44]. Recognition of emotion involves developing an awareness of symptoms associated with physiological arousal, such as feeling hot and having a pounding heart. Cognitive re-appraisal is designed to counteract an aggressive individual's tendency to respond with anger or blame if they have difficulty interpreting another person's actions [19]. The tendency to blame or to attribute hostility to another person in ambiguous situations may be used to justify aggression and can be associated with poor problem solving skills [45]. Therapy may emphasise thinking of non-personal reasons to explain another's behaviour instead of taking offense (for example:

'she must be having a bad day') and also looking for positives in a social situation. Learning to delay responding impulsively while feeling angry or thinking of alternative responses may also be valuable, perhaps by using 'self-instructions', which may be rehearsed and practised [45]. Strategies for managing the arousal include firstly avoiding or moving away from the stimulus and then calming the physiological changes. This may be achieved by controlled breathing, concentrating on taking a deep breath and self-instructions such as 'calm down' or 'relax' during expiration, also imagining reducing the body temperature and heartbeat [45]. Large muscle exercise and relaxation may be beneficial for hyperactive impulsive children [46].

Self-regulation with the aim of promoting good mood would appear to be a logical and promising new approach that is worthy of consideration. If these strategies can be used effectively by people with ADHD, they could lead to improvements in mood, functioning and self-esteem, which would not be linked to specific tasks and situations. The lack of study of emotional regulation in ADHD does not necessarily mean that such strategies are not being used therapeutically and effectively. However, efficacy still needs to be established with further research.

3.2. Pharmacological management of ADHD

The aim of treatment of ADHD is to achieve normal functioning. Non-pharmacological interventions can be successful, but the individual may still have ongoing problems associated with the underlying deficits of ADHD. Therefore, they would still experience mental fatigue with tasks that require sustained concentration. The tendency to act quickly and impulsively without the opportunity for adequate decision-making can greatly reduce the efficacy of behavioural management strategies. This is because behaviour management depends on the child being in a position to make a rational decision based on the pre-determined consequences. Furthermore, the low mood that is associated with reward deficit will tend to reduce the inclination to co-operate. Children who have significant functional impairment due to ADHD are sometimes identifiable as those who do not respond to the management strategies that work well for their siblings or peers. Drug treatment can improve the deficits in executive functioning and reward.

The medical formulations used most frequently in ADHD are based on the stimulants dexamphetamine and methylphenidate. These enhance the levels of neurotransmitters and address the underlying neurochemical deficits. They result in improvements in cognitive functioning which increase as the dose is increased [47]. They also improve the mood and behaviour, which may be an effect of enhancing the activity of the dopamine reward pathway. In clinical settings, the dose is established not by the child's weight but by titration for optimal therapeutic effect [48]. The non-stimulant atomoxetine is also an effective treatment for ADHD [49].

3.2.1. Mechanism of action of the stimulants

Methylphenidate and dexamphetamine increase the synaptic levels of dopamine and norepinephrine in the prefrontal cortex and in sub-cortical structures including the striatum and

nucleus accumbens (a part of the brain involved with appetite control). Dopamine and noradrenalin are neurotransmitters which are released into synaptic clefts and transmit impulses between nerve cells. Higher concentrations may assist with neurotransmission. The stimulants potentiate neurotransmission by three different mechanisms: enhancing neurotransmitter release, blocking reuptake by binding with the transporters and by direct stimulation of the receptors [50]. The actions of the stimulants on the different neurotransmitter systems depend on the amount of neurotransmitter and the affinities of the neurotransmitter receptors and transporters in the different regions of the brain [51]. The striatum is rich in dopamine; and although the dopamine transporter has high affinity for dopamine, it will also bind with noradrenalin. Conversely, noradrenalin is the principal neurotransmitter in the prefrontal cortex where it is taken up by the noradrenalin transporter. Dopamine is also present in the prefrontal cortex but at low levels and is taken up by the noradrenalin transporter, to which it binds with low affinity. Dexamphetamine and methylphenidate are both highly effective for reducing the reuptake of dopamine and noradrenalin, but dexamphetamine also enhances the release of stored dopamine and increases serotonin levels [52].

3.2.2. Clinical effects of the stimulants

The beneficial effect of stimulant medications for improving the functioning of children with ADHD was first recognised in the 1930s [53]. The stimulant medications dexamphetamine and methylphenidate have the effect of reducing the level of physical activity and enhancing the ability for sustained attention. They also suppress the appetite [54]. The efficacy of the stimulants for treating the symptoms of ADHD has been well established in placebo controlled trials [48, 55]. In the Multimodal Treatment study of ADHD (MTA Study), it was shown that for the core features of ADHD (inattention, hyperactivity and impulsivity), stimulant medication was more effective than behaviour therapy [18]. Behaviour management was better for comorbid conditions including ODD. Children treated only with stimulant medication required higher doses for optimal improvement than those randomised to a combination of medication and behaviour therapy, suggesting an interaction between behavioural strategies and medication, with differential effects on the different symptom types. The stimulants have been shown to be effective in reducing the symptoms of ADHD in pre-schoolers [56], school-aged children [18], adolescents [55] and adults [57].

Clinical trials treating children with ADHD plus ODD have shown symptomatic improvement on medication for both of these conditions, but children with clinically significant symptoms of ODD required higher doses [55, 58, 59]. This suggests that different types of symptoms respond to different doses of medication. Evidence of two distinct pharmacological effects, each with its own therapeutic window, comes from the work of Sprague and Sleator [60]. They treated children with ADHD on two doses of methylphenidate and found that on the lower dose there was more improvement in learning, suggesting that this dose was targeting executive functioning. The higher dose was associated with greater improvements in social behaviour, but was less good for learning and may therefore have been treating the difficult, negative and hostile behaviour associated with ODD. This suggests that the stimulant effects for improving the deficits in executive functioning and reward are pharmacologically distinct,

with different therapeutic windows that do not precisely coincide, reward deficit requiring higher doses for optimal treatment.

The main ongoing concern about the therapeutic use of stimulant medication in ADHD is the risk of abuse and diversion. Although methylphenidate is similar to cocaine in its affinity for the dopamine receptor, the addictive effect is the euphoria and this depends on a rapid rate of binding of the drug with the receptor [61]. Methylphenidate, particularly when taken orally, binds much more slowly than cocaine, which explains its far lower abuse potential. Atomoxetine is also used for treating ADHD. It is not a stimulant; it selectively inhibits noradrenalin reuptake and has minimal dopaminergic effect. It therefore lacks the abuse potential of the stimulants. It is also longer acting than the stimulants, giving a more consistent effect over the course of the day. However, the time taken for the levels to stabilise makes accurate dose titration more difficult.

Aside from their abuse potential, the most significant side effect of stimulant medication is the effect on appetite and weight, with a secondary effect on growth [62, 63]. It is as if the stimulant resets the appetite at a lower level. This results in initial weight loss. If a child remains on stimulant medication, the appetite recovers and weight gain resumes. After a year of treatment, the weight is usually approximately the same as it was at the time that medication was started. Appetite suppression appears to correlate closely with the therapeutic effect and a dose that does not affect weight is likely to be too low to be effective. Because weight gain is important for providing the resources necessary for growth in height, there is slowing of the height velocity, which gradually normalises over two to three years. Adult height appears not to be significantly affected by stimulant treatment, but there is some evidence that puberty may progress more slowly, with a later growth spurt [64, 65]. Stimulant medication also increases the heart rate and blood pressure [66]. Stimulant medications can also cause insomnia, irritability and feelings of sadness [67].

3.2.3. Practical issues of pharmacological treatment

The above section indicates that the actions of the stimulants are complex, that they have different effects in different parts of the brain and that the optimal doses for different aspects of functioning may not coincide. The dose–response curves for cognitive functioning and for mood and behaviour might look like Figure 5. This figure illustrates that the dose can be titrated to maximise either effect, but not both together. Alternatively, the dose giving the best overall effect might fall somewhere between the two peaks. Even if one effect is targeted, the selected dose may still lead to some improvements in the other effect. For example, a child with severe symptoms of ODD may function best on a relatively high dose of medication. Although this dose may be higher than his optimal dose for executive functioning, he may still concentrate substantially better than he would if unmedicated. This is likely to be related to some improvement in his executive functioning on the selected dose and also because his attitude towards cognitive tasks may be better when the deficits in his dopamine neurotransmission are addressed.

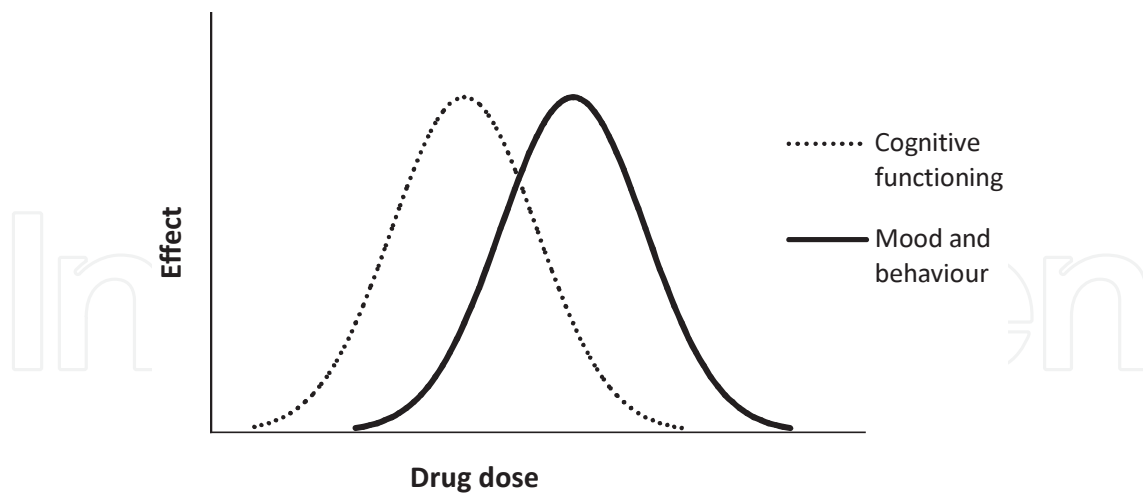


Figure 5. Hypothetical dose–response curves for the improvements in executive functioning and behaviour on stimulant medication

As children mature, they tend to improve in their behaviour [16]. They also outgrow their dose as they gain weight. Therefore, a dose initially selected for optimal improvement in the symptoms of ODD may, with time, gradually progress into a dose that is better for maximising the executive functioning deficits as the drug levels decline with the growth of the child.

The most important aspect of pharmacological management is to find the dose that works best for the individual. Careful dose titration while monitoring the changes in cognitive functioning and behaviour on medication and adjusting the dose to target those symptoms that are most impairing can be very effective. This is usually done by starting at a low dose and gradually increasing the dose while observing the changes in functioning. Behavioural rating scales may assist with comparing effects of different doses of medication. It is important that the rating scale includes items relating to cognitive functioning and to mood and behaviour, for example [68]. Dose titration and its effects are illustrated in Figure 6. Because the reward mechanisms also affect appetite control, the improvement in mood and behaviour correlates with weight loss. However, the dopamine reward pathway is only one of a series of mechanisms that affect energy balance and these other systems become activated as the weight drops, increasing the appetite and limiting further weight loss. [69]

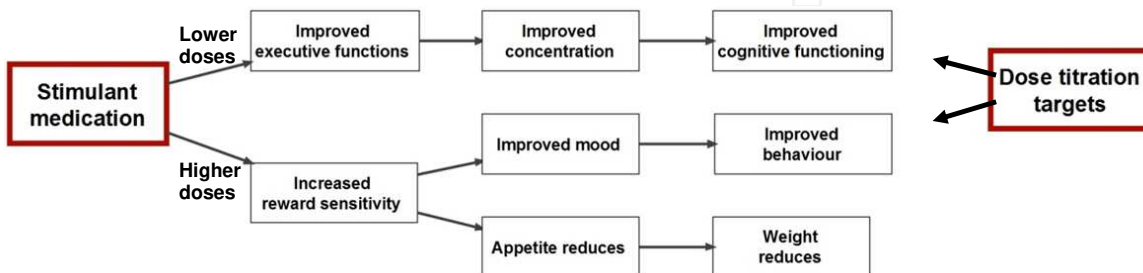


Figure 6. Stimulant medication and the effects of dose titration

The stimulant medications dexamphetamine and methylphenidate are short-acting, with an effect that lasts around 3–4 hours. In children who have significant hyperactivity or oppositional symptoms, the effect is usually obvious within 30 minutes of taking the dose. In children who only have inattention, the effect may be more subtle. As the effect wears off there may be rebound, with irritability and worsening of symptoms. The therapeutic effect may be prolonged by using formulations that release medication slowly over several hours. These may also wear off more slowly, reducing the rebound associated with rapidly falling levels. Because the stimulants can cause difficulty with settling to sleep at night, medication is often targeted to be effective earlier in the day while the child is at school, wearing off into the evening. Although the short duration of action of the stimulants can be inconvenient, it has the advantage that it allows a constant comparison of the child's functioning on and off medication. It is important to monitor the therapeutic effect and make dose adjustments whenever necessary as the dose usually needs to be increased periodically as the child grows.

3.2.4. Changes in treatment requirements with maturity

As children mature, they usually develop more control over their behaviour and this may reduce their reliance on medication. For example, a young hyperactive child may generate so much stress in the family that he or she may need medication every day. As the child matures, the hyperactivity may start to settle and medication may only be needed for school. The school years are often the most difficult stage of life for the individual with ADHD. This is because schoolwork involves prolonged periods of concentration and many of the tasks may not be intrinsically interesting. Once a person is no longer studying, they may be able to cease medication.

Although executive functioning deficits generally persist into adult life, with maturity individuals often become better at developing strategies to help them to function. However, some have ongoing problems with irritability and anger. An understanding of the reward deficit associated with ADHD may encourage such people to practise emotional self-regulation strategies to help promote a better mood and more rewarding existence.

4. Directions for research

The main novel approach to treatment suggested in this chapter is the recommendation for strategies designed to enhance the positive emotional experiences in everyday life for individuals with ADHD. These would clearly need to be evaluated with randomised controlled studies that include a plausible comparison treatment. In young children, behaviour management strategies are generally taught to the parents who then implement them with the child. Therefore, groups of parents could be taught conventional behaviour management using external rewards and punishments or strategies designed to promote positive emotions in the child through their achievement. Outcomes would be assessed using standardised rating scales relating not only to achievement in terms of task completion but also any positive effects on mood. In older children and adults with ADHD, particularly those with anger or opposi-

tional features, there would be value in comparing anger management strategies that are intended to give more control over negative emotions, with strategies designed to enhance the positive experience of reward. Outcomes could be evaluated with standardised rating scales, both self-reported and observer-reported.

5. Conclusions

In this chapter we have described the MERIM, a new way of conceptualising ADHD that emphasises the importance of mood in the overall symptomatology. This naturally leads on to strategies specifically aiming to enhance a person's experience of reward in order to sustain a stable and amicable mood. Although medication can directly address the neurochemical deficits, self-regulation strategies may play a valuable role in enhancing reward, leading to long-term improvements in behavioural functioning.

Author details

Alison Poulton

Address all correspondence to: alison.poulton@sydney.edu.au

The University of Sydney - Sydney Medical School Nepean, Penrith, Australia

References

- [1] Poulton A, Nanan R. The attention deficit hyperactivity disorder phenotype as a summation of deficits in executive functioning and reward sensitivity: does this explain its relationship with oppositional defiant disorder? *Australas Psychiatry* 2014; 22 174-8.
- [2] Stringaris A, Goodman R. Mood lability and psychopathology in youth. *Psychol Med* 2009; 39 1237-45.
- [3] Amiri S, Fakhari A, Maheri M, Mohammadpoor Asl A. Attention deficit/hyperactivity disorder in primary school children of Tabriz, North-West Iran. *Paediatr Perinat Epidemiol* 2010; 24 597-601.
- [4] Dopfner M, Breuer D, Wille N, Erhart M, Ravens-Sieberer U. How often do children meet ICD-10/DSM-IV criteria of attention deficit-/hyperactivity disorder and hyperkinetic disorder? Parent-based prevalence rates in a national sample--results of the BELLA study. *Eur Child Adolesc Psychiatry* 2008; 17 Suppl 1 59-70.

- [5] Sawyer MG, Arney FM, Baghurst PA, Clark JJ, Graetz BW, Kosky RJ, Nurcombe B, Patton GC, Prior MR, Raphael B et al. The mental health of young people in Australia: key findings from the child and adolescent component of the national survey of mental health and well-being. *Aust NZ J Psychiatry* 2001; 35 806-14.
- [6] Caci HM, Morin AJ, Tran A. Prevalence and correlates of attention deficit hyperactivity disorder in adults from a French community sample. *J Nerv Ment Dis* 2014; 202 324-32.
- [7] Antshel KM, Faraone SV, Maglione K, Doyle A, Fried R, Seidman L, Biederman J. Is adult attention deficit hyperactivity disorder a valid diagnosis in the presence of high IQ? *Psychol Med* 2009; 39 1325-35.
- [8] de Zwaan M, Gruss B, Muller A, Graap H, Martin A, Glaesmer H, Hilbert A, Philipsen A. The estimated prevalence and correlates of adult ADHD in a German community sample. *Eur Arch Psychiatry Clin Neurosci* 2012; 262 79-86.
- [9] American Psychiatric Association DSMTF. *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*. Arlington, VA: American Psychiatric Association; 2013.
- [10] Rubia K, Smith AB, Halari R, Matsukura F, Mohammad M, Taylor E, Brammer MJ. Disorder-specific dissociation of orbitofrontal dysfunction in boys with pure conduct disorder during reward and ventrolateral prefrontal dysfunction in boys with pure ADHD during sustained attention. *Am J Psychiatry* 2009; 166 83-94.
- [11] Pennington BF, Ozonoff S. Executive functions and developmental psychopathology. *J Child Psychol Psychiatry* 1996; 37 51-87.
- [12] Del Campo N, Chamberlain SR, Sahakian BJ, Robbins TW. The roles of dopamine and noradrenaline in the pathophysiology and treatment of attention-deficit/hyperactivity disorder. *Biol Psychiatry* 2011; 69 e145-57.
- [13] Hulvershorn LA, Mennes M, Castellanos FX, Di Martino A, Milham MP, Hummer TA, Roy AK. Abnormal amygdala functional connectivity associated with emotional lability in children with attention-deficit/hyperactivity disorder. *J Am Acad Child Adolesc Psychiatry* 2014; 53 351-61.e1.
- [14] Gamo NJ, Wang M, Arnsten AF. Methylphenidate and atomoxetine enhance prefrontal function through alpha2-adrenergic and dopamine D1 receptors. *J Am Acad Child Adolesc Psychiatry* 2010; 49 1011-23.
- [15] Sinita E, Coghill D. The use of stimulant medications for non-core aspects of ADHD and in other disorders. *Neuropharmacology* 2014; 87: 161-72.
- [16] Biederman J, Mick E, Faraone S. Age-dependent decline of symptoms of attention deficit hyperactivity disorder: impact of remission definition and symptom type. *Am J Psychiatry* 2000; 157 816-8.
- [17] Greenhill L, Kollins S, Abikoff H, McCracken J, Riddle M, Swanson J, McGough J, Wigal S, Wigal T, Vitiello B et al. Efficacy and safety of immediate-release methyl-

- phenidate treatment for preschoolers with ADHD. *J Am Acad Child Adolesc Psychiatry* 2006; 45 1284-93.
- [18] MTA Cooperative Group. A 14-month randomized clinical trial of treatment strategies for attention-deficit/hyperactivity disorder *Arch Gen Psychiatry* 1999; 56 1073-86.
- [19] Fondacaro MR, Heller K. Attributional style in aggressive adolescent boys. *J Abnorm Child Psychol* 1990; 18 75-89.
- [20] Langberg JM, Epstein JN, Graham AJ. Organizational-skills interventions in the treatment of ADHD. *Expert Rev Neurother* 2008; 8 1549-61.
- [21] Singh I. A disorder of anger and aggression: children's perspectives on attention deficit/hyperactivity disorder in the UK. *Soc Sci Med* 2011; 73 889-96.
- [22] Keyes CL. Promoting and protecting mental health as flourishing: a complementary strategy for improving national mental health. *Am Psychol* 2007; 62 95-108.
- [23] O'Neill ME, Douglas VI. Rehearsal strategies and recall performance in boys with and without attention deficit hyperactivity disorder. *J Pediatr Psychol* 1996; 21 73-88.
- [24] Catalino LI, Fredrickson BL. A Tuesday in the life of a flourisher: the role of positive emotional reactivity in optimal mental health. *Emotion* 2011; 11 938-50.
- [25] Volkow ND, Wang GJ, Fowler JS, Telang F. Overlapping neuronal circuits in addiction and obesity: evidence of systems pathology. *Philos Trans R Soc Lond B Biol Sci* 2008; 363 3191-200.
- [26] Downs B, Oscar-Berman M, Waite R, Madigan M, Giordano J, Beley T, Jones S, Simpatico T, Hauser M, Borsten J et al. Have We Hatched the Addiction Egg: Reward Deficiency Syndrome Solution System. *Journal of genetic syndrome & gene therapy* 2013; 4 14318.
- [27] Barkley RA. Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychol Bull* 1997; 121 65-94.
- [28] Parry PA, Douglas VI. Effects of reinforcement on concept identification in hyperactive children. *J Abnorm Child Psychol* 1983; 11 327-40.
- [29] Decety J, Michalska KJ, Akitsuki Y, Lahey BB. Atypical empathic responses in adolescents with aggressive conduct disorder: a functional MRI investigation. *Biol Psychol* 2009; 80 203-11.
- [30] Johnston BD, Wright JA. Attentional dysfunction in children with encopresis. *J Dev Behav Pediatr* 1993; 14(6): 381-5.
- [31] Pauli-Pott U, Neidhard J, Heinzl-Gutenbrunner M, Becker K. On the link between attention deficit/hyperactivity disorder and obesity: do comorbid oppositional defiant and conduct disorder matter? *Eur Child Adolesc Psychiatry* 2014; 23 531-7.

- [32] Mustillo S, Worthman C, Erkanli A, Keeler G, Angold A, Costello EJ. Obesity and psychiatric disorder: developmental trajectories. *Pediatrics* 2003; 111 851-9.
- [33] Harty SC, Ivanov I, Newcorn JH, Halperin JM. The impact of conduct disorder and stimulant medication on later substance use in an ethnically diverse sample of individuals with attention-deficit/hyperactivity disorder in childhood. *J Child Adolesc Psychopharmacol* 2011; 21 331-9.
- [34] Modesto-Lowe V, Danforth JS, Neering C, Easton C. Can we prevent smoking in children with ADHD: a review of the literature. *Conn Med* 2010; 74 229-36.
- [35] Abikoff H, Gallagher R, Wells KC, Murray DW, Huang L, Lu F, Petkova E. Remediating organizational functioning in children with ADHD: immediate and long-term effects from a randomized controlled trial. *J Consult Clin Psychol* 2013; 81 113-28.
- [36] Evans SW, Owens JS, Bunford N. Evidence-based psychosocial treatments for children and adolescents with attention-deficit/hyperactivity disorder. *J Clin Child Adolesc Psychol* 2014; 43 527-51.
- [37] Sonuga-Barke EJ, Taylor E, Sembi S, Smith J. Hyperactivity and delay aversion--I. The effect of delay on choice. *J Child Psychol Psychiatry* 1992; 33 387-98.
- [38] Samson AC, Wells WM, Phillips JM, Hardan AY, Gross JJ. Emotion regulation in autism spectrum disorder: evidence from parent interviews and children's daily diaries. *J Child Psychol Psychiatry* 2014.
- [39] Cohn MA, Fredrickson BL. In search of durable positive psychology interventions: Predictors and consequences of long-term positive behavior change. *The journal of positive psychology* 2010; 5 355-66.
- [40] Nolen-Hoeksema S, Wisco BE, Lyubomirsky S. Rethinking Rumination. *Perspectives on Psychological Science* 2008; 3 400-24.
- [41] McLaughlin KA, Aldao A, Wisco BE, Hilt LM. Rumination as a transdiagnostic factor underlying transitions between internalizing symptoms and aggressive behavior in early adolescents. *J Abnorm Psychol* 2014; 123 13-23.
- [42] Conway F. The use of empathy and transference as interventions in psychotherapy with attention deficit hyperactive disorder latency-aged boys. *Psychotherapy (Chic)* 2014; 51 104-9.
- [43] Aldao A, Nolen-Hoeksema S, Schweizer S. Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clin Psychol Rev* 2010; 30 217-37.
- [44] Fuller JR, Diguseppe R, O'Leary S, Fountain T, Lang C. An open trial of a comprehensive anger treatment program on an outpatient sample. *Behav Cogn Psychother* 2010; 38 485-90.

- [45] Feindler EL. Ideal treatment package for children and adolescents with anger disorders. *Issues Compr Pediatr Nurs* 1995; 18 233-60.
- [46] Klein SA, Deffenbacher JL. Relaxation and exercise for hyperactive impulsive children. *Percept Mot Skills* 1977; 45 1159-62.
- [47] Douglas VI, Barr RG, Amin K, O'Neill ME, Britton BG. Dosage effects and individual responsivity to methylphenidate in attention deficit disorder. *J Child Psychol Psychiatry* 1988; 29 453-75.
- [48] Rapport MD, Denney C. Titrating methylphenidate in children with attention-deficit/hyperactivity disorder: is body mass predictive of clinical response? *J Am Acad Child Adolesc Psychiatry* 1997; 36 523-30.
- [49] Michelson D, Faries D, Wernicke J, Kelsey D, Kendrick K, Sallee FR, Spencer T. Atomoxetine in the treatment of children and adolescents with attention-deficit/hyperactivity disorder: a randomized, placebo-controlled, dose-response study. *Pediatrics* 2001; 108 E83.
- [50] Arnsten AF, Rubia K. Neurobiological circuits regulating attention, cognitive control, motivation, and emotion: disruptions in neurodevelopmental psychiatric disorders. *J Am Acad Child Adolesc Psychiatry* 2012; 51 356-67.
- [51] Madras BK, Miller GM, Fischman AJ. The dopamine transporter and attention-deficit/hyperactivity disorder. *Biol Psychiatry* 2005; 57 1397-409.
- [52] Kuczenski R, Segal DS. Effects of methylphenidate on extracellular dopamine, serotonin, and norepinephrine: comparison with amphetamine. *J Neurochem* 1997; 68 2032-7.
- [53] Bradley C. The behavior of children receiving benzedrine. *Am J Psychiatry* 1937; 94 577-85.
- [54] Greenhill LL, Halperin JM, Abikoff H. Stimulant medications. *J Am Acad Child Adolesc Psychiatry* 1999; 38 503-12.
- [55] Spencer TJ, Abikoff HB, Connor DF, Biederman J, Pliszka SR, Boellner S, Read SC, Pratt R. Efficacy and safety of mixed amphetamine salts extended release (adderall XR) in the management of oppositional defiant disorder with or without comorbid attention-deficit/hyperactivity disorder in school-aged children and adolescents: A 4-week, multicenter, randomized, double-blind, parallel-group, placebo-controlled, forced-dose-escalation study. *Clin Ther* 2006; 28 402-18.
- [56] Greenhill L, Kollins S, Abikoff H, McCracken J, Riddle M, Swanson J, McGough J, Wigal S, Wigal T, Vitiello B. Efficacy and safety of immediate-release methylphenidate treatment for preschoolers with ADHD. *J Am Acad Child Adolesc Psychiatry* 2006; 45 1284-93.
- [57] Jain U, Hechtman L, Weiss M, Ahmed TS, Reiz JL, Donnelly GA, Harsanyi Z, Darke AC. Efficacy of a novel biphasic controlled-release methylphenidate formula in

adults with attention-deficit/hyperactivity disorder: results of a double-blind, placebo-controlled crossover study. *J Clin Psychiatry* 2007; 68 268-77.

- [58] Blader JC, Pliszka SR, Jensen PS, Schooler NR, Kafantaris V. Stimulant-responsive and stimulant-refractory aggressive behavior among children with ADHD. *Pediatrics* 2010; 126 e796-806.
- [59] Newcorn JH, Spencer TJ, Biederman J, Milton DR, Michelson D, Newcorn JH, Spencer TJ, Biederman J, Milton DR, Michelson D. Atomoxetine treatment in children and adolescents with attention-deficit/hyperactivity disorder and comorbid oppositional defiant disorder. *J Am Acad Child Adolesc Psychiatry* 2005; 44 240-8.
- [60] Sprague RL, Sleator EK. Methylphenidate in hyperkinetic children: differences in dose effects on learning and social behavior. *Science* 1977; 198 1274-6.
- [61] Volkow ND, Wang GJ, Fowler JS, Gatley SJ, Logan J, Ding YS, Hitzemann R, Pappas N. Dopamine transporter occupancies in the human brain induced by therapeutic doses of oral methylphenidate. *Am J Psychiatry* 1998; 155 1325-31.
- [62] Poulton A, Briody J, McCorquodale T, Melzer E, Herrmann M, Baur LA, Duque G. Weight loss on stimulant medication: how does it affect body composition and bone metabolism? - A prospective longitudinal study. *International journal of pediatric endocrinology* 2012; 2012 30.
- [63] Poulton A, Cowell CT. Slowing of growth in height and weight on stimulants: a characteristic pattern. *J Paediatr Child Health* 2003; 39 180-5.
- [64] Harstad EB, Weaver AL, Katusic SK, Colligan RC, Kumar S, Chan E, Voigt RG, Barbaresi WJ. ADHD, stimulant treatment, and growth: a longitudinal study. *Pediatrics* 2014; 134 e935-44.
- [65] Poulton AS, Melzer E, Tait PR, Garnett SP, Cowell CT, Baur LA, Clarke S. Growth and pubertal development of adolescent boys on stimulant medication for attention deficit hyperactivity disorder. *Med J Aust* 2013; 198 29-32.
- [66] Stiefel G, Besag FM. Cardiovascular effects of methylphenidate, amphetamines and atomoxetine in the treatment of attention-deficit hyperactivity disorder. *Drug Saf* 2010; 33 821-42.
- [67] Efron D, Jarman F, Barker M. Side effects of methylphenidate and dexamphetamine in children with attention deficit hyperactivity disorder: a double-blind, crossover trial. *Pediatrics* 1997; 100 662-6.
- [68] Pelham W, Milich R, Murphy D, Murphy H. Normative data on the IOWA Conners teacher rating scale. *J Clin Child Psychology* 1989; 18 259-62.
- [69] Cummings DE, Overduin J. Gastrointestinal regulation of food intake. *J Clin Invest* 2007; 117 13-23.