COGNITIVE INTERVENTIONS FOR CHILDREN WITH ACQUIRED BRAIN INJURY

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Previous chapters have detailed what is known about the prevalence of childhood acquired brain injury (CABI), along with the varied aetiologies and markedly heterogeneous presentations that can complicate intervention planning and research. Chapters in this text have also described the emotional, behavioural, and other psychosocial consequences of CABI. This chapter, therefore, focuses on interventions that specifically address impairments in cognitive systems such as, attention, executive functioning, memory, and learning.

Before embarking on a description of potential interventions and approaches, it is important to note that it is not yet clear how best to treat the cognitive impairments associated with CABI. Despite techniques such as, errorless learning and mnemonic strategies having a long history in psychological research with adults (Wilson and Moffat, 1984), for children, we lack a robust evidence-base of what works for whom, and when different interventions are most appropriate (Catroppa & Anderson, 2009; Limond & Leeke, 2005; Laatsch et al., 2007; Slomine, 2009; Ross, Dorris, & McMillan, 2011; Diamond & Lee, 2011). This is compounded byindividual differences in levels of development and maturation (Crone & Ridderinkhof, 2011). This is the case whether the target is cognitive, emotional, or a more general psychosocial impairment and all reviews emphasise the importance of developing effective models for guiding neuropsychological rehabilitation, and methods of evaluation, to ensure high quality health care outcomes. To date, however, such models have been largely absent from the literature. What is needed, therefore, is a conceptual framework that: guides formulation; takes account of the heterogeneity of CABI sequelae as well as crucial developmental factors that can complicate assessment and intervention; and shows which cognitive

rehabilitation techniques should be considered when, in what order they should be applied, how they relate to psychosocial needs, and how these interventions can be evaluated.

This chapter will describe such a model, will introduce interventions for which an evidence-base is emerging, and will use case examples to illustrate how to apply the model in routine clinical practice (for a more detailed description of the model see, Limond, Adlam, & Cormack, 2014). It is beyond the remit of this chapter to classify and describe every neurocognitive rehabilitation technique or strategy that may be employed, and instead, the main techniques or classes of technique are described, along with references that signpost readers to further information. Furthermore, although the model focuses on cognitive rehabilitation, it also highlights the fundamental need to address psychosocial issues such as challenging behaviour, emotional difficulties, physical and sensory needs, as well as wider environmental issues. Thus the model provides a conceptual framework for addressing psychosocial need prior to, or in conjunction with, cognitive interventions.

Basic principles underlying the PNI model

The paediatric neurocognitive intervention (PNI) model (Limond, Adlam, & Cormack, 2014) is based on literature related to typical and atypical cognitive development, and thus considers the role of development and maturation in the planning of rehabilitation. The PNI model is not a list of techniques classified by system or sub-system, but a description of how the cognitive systems that we can support develop or nest together, such that lower level skills are foundations or pre-requisites for higher level skills. The PNI model consists of four hierarchical levels: Level A describes intensive, supported interventions to help develop semantic knowledge, adaptive functioning and specific cognitive skills such as memory. Level B describes potential remediation of cognitive process such as inhibitory control, working memory and attention. Level C describes interventions to develop metacognitive and supervisory processes, to increase skills such awareness, problem-solving and propsective memory. Level D described compensatory strategies that can be used independently by an individual with ABI, addressing cognitive difficulties such as episodic memory, visual processing, language and high level attention executive functions. The evidence-base for this hierarchy is based on adult and paediatric neuropsychology research, and is detailed in Limond et al. (2014). Specifically, the PNI model assimilates the evidence-base to make hypotheses concerning the order in which different cognitive skills should be optimised to maximise independent functioning. It provides a framework for treatment decisions based on individualised neurocognitive case formulation (Figure 1).

Insert Figure 1 about here

As an example, consider a case presenting with episodic memory impairment: the individual frequently forgets information, loses personal possessions, and standardised assessment confirms a memory problem. It is tempting to just recommend that the individual learns to use mnemonic strategies; but the success or failure of this advice will really depend on whether the techniques are developmentally appropriate, whether prerequisite attentional and information-processing skills are in place, and the motivation, engagement, and psychological adjustment of the individual or their carers, among other factors. As mentioned above, it is also essential that the wider context of a child's experiences is considered. Factors such as a chaotic family environment, and caregivers' ability to adapt new strategies and implement advice and recommendations, will affect the successful use of intervention strategies (e.g., Reis, Potter,& Llorente, 2007). *It is therefore crucial to support these wider issues as described in other chapters in this text.* We do not, therefore, assume that cognitive rehabilitation must immediately focus on explicit rehabilitation strategies. We recommended that underlying cognitive processes are comprehensively assessed and considered in the context of cognitive development and the individual's wider psychosocial needs and environment, to generate an appropriately individualized intervention programme.

It is not, however, proposed that every patient presenting for neurocognitive rehabilitation receives a comprehensive assessment covering every cognitive system and sub-system. If an individual presents with a higher level impairment and shows no evidence of core deficits at lower levels, it is clearly sensible to try and intervene at the higher level as indicated. However, if that initial intervention is unsuccessful, then it may be necessary to assess further and consider shifting to interventions targeting lower levels of the model. This is, therefore, a stepped care model, allowing resources to be deployed sensibly.

A more detailed case study is presented at the end of this chapter, but it may be helpful to consider some generic examples here by way of introduction to the principles of the PNI model. A child or adolescent presenting with episodic memory problems could benefit from Level D interventions, if they were independent and able to self-regulate, whereas a young or dependent child might need to start at Level A, receiving prompting and support with strategy choice and use. Where strategies are unsuccessful, clinicians need to establish whether the child is unable to learn the strategy, or has learnt it but is unable to utilise it (Bjorklund, 2012). This exploration can help to pinpoint whether the difficulty is related to problems in core functions such as attention, working memory, processing speed, or higher-order functions such as, cognitive flexibility, metacognitive awareness. These hypotheses can be confirmed by more detailed neuropsychological investigation,

and rehabilitation strategies can then be applied that are appropriate for a lower level in the PNI model.

The four levels of the PNI model are next described in more detail, identifying rehabilitation programmes and techniques that have an emerging evidence-base in CABI, cognitive psychology, education, or other relevant literature, and have theoretical applications that may still need to be evaluated specifically in CABI. We then present a case study to demonstrate how the model has supported our clinical decision-making in the context of community-based rehabilitation for CABI.

In terms of applying this assessment and intervention approach in a clinical setting, this approach has been developed in the context of working within multi-disciplinary teams within community settings. In this context the clinical neuropsychologist provides detailed assessment and formulation, and guidance on cognitive intervention priorities. The clinical neuropsychologist's role is primarily to introduce and evaluate interventions using their collaboratively developed formulation, with individual sessions to develop the core skills and programme elements, and then working with the wider team, school staff, and carers to support everyday implementation of the interventions.

Establishing a Semantic Knowledge Base, Supporting Core Skills and Supporting Adaptive Functioning (Level A of the PNI Model)

At this level the primary objective is to ensure optimal development of academic attainments i.e., literacy and numeracy skills, and critical knowledge (e.g., focusing on safety and foundation knowledge). Ideally, children will be supported become fluent (i.e., accurate and quick) in these processes. At Level A, strategies are not expected to be applied independently. Instead, they will rely on significant prompting, cueing, and support from care-givers and teachers (or teaching assistants) to help the child know when and where to apply the strategy, and to keep the child on track (Schwenck, Björklund & Schneider, 2007). Cognitive strategies can be supplemented by environmental modifications and other levels of support in the school or home environment.

Dynamic assessment (see Box 1) can help to test and review what is working and what is needed for a strategy to work, but it is important to: i) consider what strategies are most likely to be effective for the child at various stages in their development; and ii) provide a clear rationale and comprehensive support for the care-givers and education team that is supporting the child in day-to-day life.

At this Level, approaches described in the education literature such as precision teaching (see Table 1) that have been shown to be helpful in specific learning disabilities (e.g., reading,

Hughes, Beverley, & Whitehead, 2007) and global developmental delay (Spooner, Knight, Browder, & Smith, 2012), are very likely to be effective for children with ABI. Strategies (Table 1) that have been successfully applied in childhood populations include errorless learning (e.g., Warmington et al, 2013; Mueller, Palkovic, & Maynard, 2007), elaborative encoding (e.g., Oberg & Turkstra, 1998), structuring processes such as individualised step-by-step templates, and standardised processes such as PQRST (e.g., Franzen, Roberts, Schmidts, Verduyn, & Manshadi, 1996), or rehearsal strategies (e.g., Harris, 1996). These can ensure the development of a secure knowledge base.

These strategies are likely to be most beneficial for young children learning something for the first time, or for children with global developmental delay, specific learning difficulties, or semantic memory impairments. This approach is also likely to be needed at the early-stages of recovery from CABI. Strategy selection will depend on the child's level of cognitive maturity, and older children and adolescents might benefit from support to utilise additional complex strategies (which are also applicable at Level D of the PNI model) such as mind maps, essay templates, and mnemonics (e.g., Rankin & Hood, 2005). As children mature, or if they have specific strengths and weaknesses in other areas, they may progress to higher levels of intervention.

Compensatory aids (e.g., Wilson et al., 2009a) can also be helpful for academic learning but are primarily seen to improve adaptive functioning. Prompted and supported use of compensatory aids is also highly appropriate at this level of intervention (see O'Neill and Limond chapter XX, for more information about assistive technology systems). For example, training in the effective use of diaries (Kerns & Thomson, 1998), computer-based diary systems (e.g., Flannery et al, 1997), prompting devices such as neuropage (Wilson et al, 2009) and more recent technology such as Vicon Revue (previously known as Sensecam; Pauly-Takacs et al, 2011).

Environmental adaptations and additional strategies that may be incorporated at this level with cueing and support include: random cueing to support sustained attention (O'Connell, Bellgrove, Dockree, & Robertson, 2006) and environmental compensations to assist with distractability (Zentall, 2005) or aids to support impaired episodic memory (e.g. Kerns & Thomson, (1998). It is important to note that children with ABI who consequently meet criteria for a diagnosis of intellectual disability (i.e. impaired IQ and adaptive functioning) are predicted to have average or close to average abilities in memory functioning (Cohen, 1997), and therefore low IQ should not of itself prevent the consideration of these additional strategies if significant impairment in episodic memory is also identified.

Table 1: some examples of Level A interventions

PNI strategy	Brief description and key references

Precision teaching	Precision teaching involves identifying a specific skill difficulty (e.g., reading numbers), then providing daily sessions of teaching, frequency building, monitoring and evaluating progress, and adapting to this evidence to optimise learning (Lindsley, 1992). Key components include finding an approach that the child engages with; focusing on observable behaviours (so that these can be easily monitored); using frequency measures to monitor performance (e.g., number correct); and using standard graphical displays to record responses and guide recommendations. For detailed description see White & Neely (2004).
Errorless learning	Errorless learning refers to conditions where errors are eliminated during the learning process. In PNI errors can be avoided by: i) breaking down the targeted task into small, discrete steps or components; ii) providing sufficient models before the child is asked to perform the target task; iii) encouraging the child to avoid guessing; v) immediately correcting errors; and iv) carefully fading prompts or cues (Sohlberg et al., 2005). For a detailed review see Clare & Jones (2008)
Elaborative encoding	Elaborative encoding is based on the levels-of-processing theory (Craik & Tulving, 1975) and involves the child making explicit links between new information and information already stored in memory. Two examples of using this technique include: the child defining concepts in their own words, and thinking of their own examples for the concepts. See Oberg & Turkstra (1998) for use of this technique in CABI.
PQRST	PQRST is an elaborative encoding technique that improves comprehension and memory. It involves the child reading through the material to be learnt (Preview), identifying a Question to ask the material, Reading the material in detail to answer the questions, Stating the information in the material in relation to the question, and Testing memory for the material. See Franzen, Roberts, Schmits, Verduyn, & Manchadi, 1996 for use with CABI.
NeuroPage/NeuroText	NeuroPage (and NeuroText) is a paging service which provides individuals with reminders for specific activities at the required time (e.g., remember to take medicine). The individual informs the operator of their schedule and the reminders are sent at pre-specified times. This service is effective at improving memory for everyday activities in individuals with ABI, including CABI (see Wilson, Emslie, Evans, Quirk, Watson & Fish, 2009). For information on how to access this service, see http://www.neuropage.nhs.uk/.
Vicon Revue	Vicon Revue (previously SenseCam) is a portable camera that can be worn around the neck to capture scenes. The scenes can then be reviewed to prompt autobiographical memory for the daily events (Hodges, Berry & Wood, 2011). For examples of using this technique with CABI, see Pauly-Takacs, Moulin, & Estlin (2011).

Level A interventions are highly reliant on the skills, commitment and organisation of carers. Whatever the strategies deployed, they are only likely to bring benefits or be maintained if the family and other carers are able to understand and implement them effectively. Of particular

importance is the cost-benefit analysis within the context of the child's daily life. If the strategy or aid requires very high levels of effort on the part of the helper and the child, and/or the gains are perceived as minimal or even moderate, it is highly likely that the intervention will not be maintained by these individuals. The importance of considering this issue is clearly illustrated by the following example of an errorless learning approach using backward chaining, taken from the Brain Injury Association of Washington:

Teacher (T): I am going to teach you your phone number. I will teach you to say "My phone number is 671-1369. " You finish what I say. My phone number is 671-136 ni…..?
Student (S): 9
T: Good. My phone number is 671-136…?
S: 9
T: Good. My phone number is 671-13…?
S: 69
T: Good. My phone number is 671-1
S: 369
T: Good. My phone number is 671-
S: um….
T: 1 th….?
S: 1369
T: Good. My phone number is 67…?
S: 1-1369
T: Good. My phone number is 6…?
S: 71-1369
T: Good. My phone number is …?
S: 671-1369
T: Very Good. What is your phone number? My pho…?
S: My phone number is 671-1369.
T: Very good. It's a lovely day today, isn't it? What do you like to do on a day like this?
S: I like to walk my dog in the park.
T: That sounds nice. I'd like to check something you were learning a moment ago. What is your phone number?
S: My phone number is, um…
T: 6…
S: 671-1269
T: Very good. What is your phone number?
S: My phone number is 671-1269.

Errorless learning can be a powerful and effective teaching tool, but imagine being an English teacher who is asked to teach a child to read in this way and estimate how much time, effort and resources would be required to generate the materials for that individual's needs and deliver

the teaching required, as well as the level of motivation from the child to sustain this approach through lessons that may last up to one hour. Similar, but perhaps less obvious considerations apply to all Level A strategies and it is, therefore, important to consider a range of potential strategies and how they may be appropriately applied for different materials and settings. It is also important to be available to carers and teachers for feedback and review, so that appropriate tools can be built up over time. Schools do not have the resources to develop specialist materials and programmes, and require expertise and input from the clinical neuropsychologist and rehabilitation team to achieve this.

Improving Core Cognitive Skills which support all 'higher' level Cognitive Activity (Level B of the PNI Model)

Based on developmental cognitive psychology research (e.g., Diamond, 2013) and adult cognitive psychology models (e.g. Shallice & Cooper, 2010), Limond, Adlam & Cormack (2014) suggest that optimising core skills such as sustained and selective attention, working memory, inhibitory control, sequencing skills (the ability to recognise and learn sequential patterns) and processing speed will serve to improve the child's functioning as well as supporting interventions aimed at higher level skills such as executive functioning and independent strategy use. For example, impairments in working memory and attention are likely to have an impact on the development of literacy and numeracy, limit the acquisition of new skills, and will affect performance on all cognitive 'on-line' tasks (Baddeley, 2003; Daneman & Carpenter, 1980; Engle, Tuholski, Laughlin, & Conway, 1999).

Various authors have identified the potential for improvement, not just compensation, of attention, working memory and episodic memory skills (see Table 2). A combined programme of two computerised attention programmes (Rehacom and Attentzione e Concentrazione) and non-computerised tasks involving interpretation of pictures and vignettes focusing on management of attention are described by Galbiati et al. (2009) with moderate effect sizes reported (Ross et al, 2011). Areas targeted are described as focusing on: selective attention, focused attention, sustained attention, divided attention, inhibition, shifting, and meta-attention (i.e., awareness of attention skills).

Table 2: some examples of Level B interventions

PNI strategy	Brief description and key references
Rehacom	RehaCom is a computerised cognitive training programme targeting attention, memory, visual-spatial processes, and executive functioning. The program contains several modules with difficulty

	levels automatically increasing as the individual successful completes tasks. See Galbiati et al. (2009) for use with CABI. For more information see www.rehacom.co.uk.
AMAT-C	Amsterdam Memory and Attention Training-for Children (AMAT-C) is based on process drill training, such that the child practices tasks repeatedly with the aid of a coach. Unlike process-only training, the coach helps the child to identify strategies to support performance and facilitates the child's (metacognitive) awareness of the learning strategies, including how and when to apply these strategies to novel tasks. The training involves one-to-one coaching (at school or home), for approximately 30-minutes per day, for approximately 20-weeks. For studies demonstrating efficacy in CABI see van't Hooft, Anderson, Sejersen, Bartfai, & von Wendt (2007) and Sjo, Spellerberg, Weidner, & Kihlgren (2010).
Cogmed	Cogmed is a computerised working memory training programme (Pearson Clinical) involving repeated practice of tasks for approximately 30-minutes per day for approximately 25-days. The level of difficulty is adjusted according to the child's performance, ensuring that the child is working to their maximum capacity. A coach contacts the child and family once a week via the telephone to review progress and provide feedback. The tasks are designed to be motivating and engaging, using a game-like platform. For more information, including current research studies evaluating Cogmed, see www.cogmed.com.

Another programme that involves a specified programme of tasks and activities provided by a clinician over 15-20 weeks is the Amsterdam Attention and Memory Training for Children (AMAT-C; Table 2) where skills are systematically addressed, with good reported outcomes (e.g., Van't Hooft et al., 2005; 2007; Sjo, Spellerberg, Weidner, & Kihlgren, 2010). AMAT-C is currently being translated into English and evaluated (Catroppa, personal communication). Cogmed computerised working memory training is also being used clinically in various CABI groups (e.g., Adlam, Dunning, Gracey, Holmes, & Gathercole, *in preparation*). It was originally developed for children with attention deficit disorder (e.g., Klingberg 2002) and whilst there have been mixed findings for this intervention, there is also some emerging evidence to support positive outcomes for premature children (e.g., Lohaugen et al., 2011) and children who have survived a brain tumour (e.g., Hardy, Willard, Allen, & Bonner, 2013).

In terms of interventions for inhibitory control there is currently limited research within CABI (Feeney, 2010), however, there is promising evidence in the wider developmental literature. Youngc hildren have difficulty with inhibiting a prepotent response, and this can be improved if a delay is imposed (Simpson et al., 2012) and mainstream activities such as martial arts have been identified as improving this core skills (e.g., Diamond & Lee, 2011).

Slow processing speed can have similar impact to the difficulties described above but can also introduce a level of frustration in immediate social interactions and a high level of negative feedback for the individual concerned. Evidence to support improvements in processing speed are limited but there are some studies emerging for older adults (Willis et al., 2006), for children, through the use of board games encouraging speeded responses,in foster care due to abuse or neglect (Mackey, Hill, Stone, & Bunge, 2011), and following CABI (Oatman-Stanford, Adlam, & Limond, *in preparation*).

When selecting an intervention at this level, it is important to consider developmental and maturation factors. For example, if impairments are detected in both processing speed and working memory, it is predicted that interventions will be more effective if processing speed is targeted before engaging in working memory training, or indeed that improved processing speed might facilitate the development of working memory (Fry & Hale, 1996).

It is of note that many of the interventions described above are reported as a distinct programme that canbe given to the child in a specified format. For example, Cogmed computerised working memory training is a manualised intervention lasting five to nine weeks. Whilst the research evidence is encouraging, the programmes are not specifically designed for CABI. Applying them within the ABI context does raise specific issues that may need to be addressed, again supporting the child, carers, and education professionals to accept and understand the programme and adhere to treatment guidelines is a crucial issue.

Many young people with ABI who have difficulties with insight and engagement, may struggle to maintain motivation, regulate frustration, monitor progress or form their own goals.They will rapidly disengage from challenging programmes that do not have an obvious outcome in line with their own priorities. It, therefore, requires a great deal of preparation with the individual and their 'supporters' to ensure that they are ready to engage with a chosen programme. Then they need systems in place to maintain this interest and remember how these immediate goals are a step towards a more significant longer-term goal. For example, many young people with an ABI have a primary goal of having friends and a social life, similar to their peers. It can involve a great deal of work and support to help someone recognize that to achieve this they need to put effort into improving their working memory skills and processing speed to engage in meaningful conversation with their peers. In these situations it can be important to include generalisation approaches which are more accessible to the child, such as role-play conversations that feed back how processing speed and working memory can affect their long-term goal of social change. These types of activities can also serve the purpose of demonstrating progress during and after the intervention programme.

Evaluative and Fundamental Executive Function Skills (Level C of the PNI Model)

In typical development, middle childhood to early teenage years see a significant increase in the fundamental executive skills (Diamond, 2013) that are the first steps towards independence. Cognitive flexibility, metacognition, supervisory processes, self-regulation and reasoning skills become consolidated and more robust. The PNI model argues that metacognitive skills are required if the aim is for children to independently apply the right strategies at the right time, and that developing these skills is an important pre-requisite to teaching complex strategies. Level C of the PNI model, therefore, addresses skills that are required for independent use of the cognitive strategies that can be taught at level D.

Of particular note at this level of intervention are the importance of metacognitive skills and the individual's awareness of their own strengths and weaknesses. If an individual does not perceive themselves as having difficulties and cannot evaluate their own performance, then they are unlikely to be able to effectively choose and implement strategies. Prior to teaching metacognitive strategies it may be important to work with the individual on their awareness of their difficulties (e.g., "I know I have a memory problem because everyone tells me so and I trust them to be right") and also on their understanding of its impact on their experiences ("I struggle with remembering what I've done at school because of my memory problem"). Approaches such as role play and video feedback of real-life situations can be particularly helpful for individuals who struggle to recognise the impact of their cognitive weaknesses.

Following an understanding of personal cognitive weaknesses, individuals need to be able to evaluate situations accurately to identify when they might have difficulties, what these difficulties might entail, and what they might be able to do in order to manage those difficulties. It is increasingly recognised that cognitive flexibility and metacognitive skills (Butler et al., 2008; Ylvisaker & Feeney, 2002) are a critical component in the successful use of more specific strategies following CABI. Cognitive flexibility includes the ability to take a variety of perspectives, both interpersonally and when addressing a novel task or problem. Metacognitive skills include insight/self-awareness, self-monitoring, and supervisory processes. All of these would be considered as contributing to executive function development and continue to mature throughout childhood into early adulthood (Diamond, 2013).

Table 3: some examples of Level C interventions

PNI strategy	Brief description and key references
Metacognitive strategies	Metacognitive strategies can include activities that encourage preparedness, different approaches for tackling a task, self-talk and

	strategies to support staying on-task and post-task generalisation strategies such as reviewing work and predicting when it might be useful in the future (see Butler et al., 2008). This also includes supporting the child to engage in self-reflection and self-awareness (e.g., asking "How did you approach that task/ situation? What worked well? What did not work so well? What would you do if you had a similar task/situation again?").
Goal Management Training	Goal Management Training (Levine et al., 2000) involves teaching the child about goals, attention slips and how to manage these, how to review and prioritise goals (e.g., Stop, Think, Organise, Plan), and how to keep goals in mind (e.g., using analogies such as, the mental blackboard). This training can be delivered in one-to-one or group settings using handouts and real-world examples (and homework tasks). Session length and number varies depending on the level of content to be taught. This has been found to be effective in ABI when content-free cues are given to alert the individual to engage in a goal review. For a review see Krasny-Pacini, Chevignard, & Evans (2014).

Ylvisaker and Feeney (2002) highlight the importance of metacognitive skills in behavior and social function and recommend following a scaffolded[1] approach to ensure their emergence in CABI. There isalso evidence for self-regulation interventions (self-monitoring, self-monitoring plus reinforcement, self-management, and self-reinforcement) in dysexecutive conditions such as attention deficit hyperactivity disorder (e.g., Reid, Trout, & Schartz, 2005).The contribution of these types of skills to broader intervention programs is further demonstrated by Butler and Copeland (2002) and Butler et al. (2008) who developed a metacognitive program to be used alongside more traditional attention process training programmes for children following treatment for cancer. Their results indicated positive outcomes in academic attainments and parental reports of everyday behavior, following the intervention (Butler et al., 2008).

Related metacognitive training programmes are Goal Management Training (Levine et al., 2007; 2000; see Table 3) and content-free cuing to prompt prospective memory (Fish, Wilson, & Manly, 2010). These have strong traditions in adult neuropsychological rehabilitation and are now being explored in CABI (Krasny-Pacini et al., *in press*; Rous, Adams, Gracey, Fish, Manly, & Adlam, *in preparation*).

As with previous levels of intervention it is important to consider the wider system when introducing the interventions, especially when it comes to generalising and maintaining skills. The majority of these interventions require clinical input from the neuropsychologist, not just to develop

[1] "Scaffolding occurs when experts are sensitive to the abilities of a novice and respond contingently to the novice's responses in a learning situation so that the novice gradually increases his or her understanding of a problem" Bjorklund, 2012; p84

materials and interventions but to train and support the carers who deliver and monitor the interventions (e.g., Krasny-Pacini et al., *in press*).

Teaching and Facilitating Independent Strategy Use for Specific and Enduring Cognitive Impairments (Level D of the PNI Model)

This level of intervention could be considered the 'pinnacle' of cognitive rehabilitation, where an individual with cognitive impairments can learn strategies that improve performance in a variety of old and new settings and situations , and applying these strategies independently without prompting or cueing from others. It is a level of functioning that is not expected in early childhood and gradually emerges through middle childhood, adolescence and early adulthood.

Identifying appropriate intervention strategies relies on a thorough assessment and understanding of a young person's strengths and weaknesses and ideally a dynamic assessment (see box 1) of the individual's responses to various interventions. It is important to note that these responses may change over time (e.g., Bjorklund, Miller, Coyle, & Slawinski, 1997). Many of the strategies described at Level A (Establishing a Semantic Knowledge Base, Supporting Core Skills and Supporting Adaptive Functioning) may still be appropriate but are taught and supported in the initial stages, with metacognitive skills utilised to gradually remove this 'scaffolding' to encourage independent use of the strategies. This scaffolding approach is described in more detail by Mark Ylvisaker (e.g., Ylvisaker, Hanks, & Johnson-Green, 2003) and is time intensive. It requires a high level of commitment and motivation from the child or adolescent with an ABI as well as support from those around them as described at previous levels of intervention.

The strategies suggested here may be the same as those introduced at level A, or may be more complex (see Table 1). Potential strategies include: Organisational strategies, errorless learning of new information, repetition to an identified optimal level, expanded rehearsal, explicit linking of information to knowledge, elaborative encoding, developing step-by step templates for multiple tasks, using revision study techniques (e.g., PQRST), multi-modal processing, ensuring the environment is optimal for learning (e.g., lowering or increasing external stimulation and distractors), highlighting and repeating key foci. With all of these strategies it may be possible to use dynamic assessment methods, using newspaper articles or books of interest to the young person and compare their performance with and without the intervention. Those strategies that are shown to be helpful can then be evaluated more fully using single-case experimental designs monitoring learning and behaviour on academic materials and tasks that the individual needs to learn to progress academically or adaptively. The use of feedback through dynamic assessment and ideally single-case experimental designs can also be a substantial motivating factor for individuals,

increasing their motivation and likelihood of maintaining the use of these sometimes effortful strategies.

Further principles underlying the PNI model

Working on multiple impairments at the same time

The approach to cognitive interventions described here does not preclude the use of multi-level or multi-impairment interventions, rather it suggests that a multi-level intervention will be most effective if it targets lower level process (e.g. working memory) and higher level strategy (e.g., metacognition) sequentially. Indeed, two examples of published multi-level interventions with evidence of efficacy with CABI such as the web-based Teen Online Problem-Solving intervention (Wade et al., 2005; 2006); and the Amsterdam Memory and Attention Training – for Children (van't Hooft et al., 2005; 2007; Sjo et al., 2010), use a module-based approach with the lower process-based training occurring earlier in the programme than the higher metacognitive strategy elements.

Future Directions

The immediate priorities for developing cognitive interventions are i) to increase the evidence-base for different interventions, and include key information such as specifying participants' psychosocial environments, injury variables, cognitive strengths and weaknesses, and developmental stage at time of intervention, and ii) to ensure that ecologically valid approaches which can be implemented in a community setting are considered e.g. utilising computers and mobile devices. Given the difficulties of conducting intervention research on heterogeneous groups, the use of single-case experimental designs is becoming increasingly recommended, and following recent guidelines to ensure that data collected is as robust as possible (e.g., Tate et al., 2013).

Box 1: **DYNAMIC ASSESSMENT**

Selecting the most appropriate intervention: Dynamic Assessment (DA)

We know that there are many recommendations made about potential interventions, the majority of which are not well evidenced in childhood ABI. It is not appropriate to exclude any method that may be beneficial without evidence of it in relation to the specific client you are working with. Many neuropsychology reports often provide logical and theoretically-based recommendations. However, individual responses to these recommendations are not easy to consider given the complexity of age and stage of development, environment, and personality, among other factors. Therefore a quick and effective way of testing the strategies and approaches that may be relevant would be

particularly helpful. We would recommend that clinicians use dynamic assessment (DA) for this purpose, as it is a data-driven but patient-centred approach. There is some evidence supporting the use of DA for adults with traumatic brain injury (e.g. Haywood & Miller, 2003) and for interventions that support children's language development (e.g. Larsen and Nippold, 2007). DA is most applicable at levels A, C and D of the PNI model.

Haywood and Tzuriel (2002) define dynamic assessment as "a subset of interactive assessment that includes deliberate and planned meditational teaching and the assessment of the effects of that teaching on subsequent performance" (p40). There are several different approaches to conducting dynamic assessment but all could be considered to involve mediation of learning (thereby assessing learning potential), havinginstruction and feedback built into the testing process, "and are differentiated on the basis of an individual's performance. Thus the amount of assistance provided is directly contingent upon the testee's performance and modifiability" (p17; Elliott, 2003). These DA concepts can, in our view, be used to develop intervention plans using children's current academic material, texts or more generic problem-solving tasks (e.g. matrices, logic puzzles) that are developmentally appropriate.

Haywood and Lidz (2007) provide detailed information and some materials that can be used in the process of conducting a dynamic assessment and these authors highlight the importance of using standardised neuropsychological, cognitive and educational assessments alongside dynamic assessment. Haywood and Lidz's approach seems particularly helpful for developing interventions for children with acquired brain injury, and recommends that "DA is used principally to identify areas of strength, and potential strength, to discover what performance might be possible given optimal learning conditions and appropriate intervention, and to specify what those optimal conditions might be" (p4).

HOLISTIC APPROACHES AND CULTURAL CONTEXT

Involvement of the wider system – Holistic approaches and Cultural context

Recent guidelines from the Scottish Intercollegiate Guidelines Network (SIGN 130, 2013) for adults, determined by the evidence-base, are only able to make the following limited recommendations:

- "Patients with memory impairment after TBI should be trained in the use of compensatory memory strategies with a clear focus on improving everyday functioning rather than

underlying memory impairment.

    - For patients with mild-moderate memory impairment both external aids and internal strategies (e.g., use of visual imagery) may be used.
    - For those with severe memory impairment external compensations with a clear focus on functional activities is recommended.

- In the post-acute setting interventions for cognitive deficits should be applied in the context of a comprehensive/holistic neuropsychological rehabilitation programme. This would involve an interdisciplinary team using a goal-focused programme which has the capacity to address cognitive, emotional and behavioural difficulties with the aim of improving functioning in meaningful everyday activities".

For children, there are, and have been, services in Europe and potentially across the world, that provide this holistic approach, but these have tended to be for children with very severe injury and disability. As a result a literature base does not appear to have emerged in relation to post-acute interventions for cognitive deficits acquired in childhood. One hypothesis for this lack of support for holistic services is the desire of children and their families for children to return home as soon as medically possible. However, it is often at this point that the extent of the child's cognitive difficulties are recognised and then difficulties are encountered when seeking appropriate support from local services. Ideally, it would be possible to provide a holistic approach within the child's home and school environment and to work systematically to provide this.

Lucia Braga's (2005) work in Brazil shows a good evidence-base for the successful implementation of rehabilitation programmes for CABI with family, carers and education specialists as key personnel in the delivery of care. However, in other cultural contexts this can be difficult to achieve (e.g. Krasny-Pacini et al, *in press*). Issues of cultural context at all levels (from a family and friendships level, through to religion and national culture) will affect the implementation of all cognitive interventions. Applying Cognitive interventions requires a high level of understanding and commitment from those around the child to support maintenance of interventions and generalisation to new environments and new activities and could perhaps be considered as a significant component of the holistic approach that may be required in childhood.

Case Study: Katie

This case study is presented to illustrate the importance of providing interventions in the most appropriate sequence, where each intervention is a hypothesis-testing process. It is implicit in this

approach that if initial intervention is unsuccessful then this may be an indication of a more fundamental impairment that would benefit from intervention (e.g., psychosocial or lower-level neurocognitive foundations). Continual re-evaluation is warranted because a patient's failure to benefit is not seen as evidence that they cannot benefit from rehabilitation. Rather, failure to respond to one treatment is a learning opportunity, contributing to a gradually improved formulation with each new trial. Secondly, for developmental reasons consideration should always be given to the possibility that strategies that were less effective at an earlier stage might become useful later on. This is a continual process and may mean providing different types of intervention at different times across a child or young person's development. Verbal consent was obtained to share details of the interventions provided and information regarding this individual's history. However, several elements of this case study have been changed in order to ensure anonymity.

Katie was referred at 8 years of age with a history of birth trauma with hypoxic-ischaemic injury, temporal lobe epilepsy and diagnoses of dyslexia and dyspraxia. Katie was diagnosed with episodic memory impairment at the age of 9 years, reflected in reports of everyday memory failures and poor performance. Katie had been kept back a year at school, repeating her second primary school year, but was still struggling to keep up. Katie was experiencing some bullying at school as a result of being seen as 'slow' by her peer group.

When Katie presented for rehabilitation support, her parents were keen for her to receive neurocognitive interventions that might promote independence and school achievement. Further assessment at this time indicated that she had mild working memory problems and that the most significant stressors were organisational problems (e.g. schoolbag, desk), transitions between classes, not understanding her homework and 'never being able to find anything'. She had a supportive family and a stable and well organised home environment so the environmental and psychosocial foundations were good, and the family required no more than psychoeducational support to provide appropriate support and encouragement for any intervention strategies introduced.

In the absence of other clinical priorities or risks, the decision was made to support Katie's organisational difficulties by providing herewith lists and visual cues (what to take to school; what to keep in your desk; what to take home) that she could use independently (i.e. level D of the PNI model). Following a dynamic assessment framework, she was provided with sessions to investigate any differences in her ability to use these lists and cues in different situations, when self-generated

(or generated by others) and to ensure that she was motivated to use these approaches to support her difficulties. Within individual sessions, Katie was able to demonstrate her use of these lists and showed a preference (and better ability) for self-generated instructions and lists. Academic strategies were also explored using dynamic assessment approaches, including the use of essay planning templates, identifying key information in academic texts, and using revision strategies such as PQRST. These strategies were identified as useful for Katie and required liaison and coordination with school staff and family to support their use. However, when taken into her school and home environments, despite high levels of encouragement and facilitation from staff and family, outcomes for this initial intervention were not good (assessed using goal attainment measures). Katie was unable to use even simple photo-based lists, and further assessment highlighted strategy-use deficiencies of a dysexecutive nature. She was easily distracted or forgot tasks even when they were self-generated and prompted by others. Whilst it was not possible to fully demonstrate, it was agreed across the family and school that the level of prompting and support required was very high, and that while it could be achieved in individual sessions, itcould not be provided within a typical mainstream setting, or family life.

Our next step was then to reconsider whether the presenting problems were actually due to more fundamental difficulties. The rehabilitation plan was reformulated to target skills that would be required for Katie to be able to follow lists and stay on-task, namely working memory, attention, and sequencing. She worked through the Cogmed computerised working memory program (e.g., Holmes et al., 2009) targetting level B of the PNI model, and practiced on the target tasks (e.g., bag, desk, and home-time). Whilst measures had not been put in place to assess sequencing it was noted within 3 weeks of starting Cogmed that Katie appeared to be better at following routine sequences. For example, before undertaking Cogmed she would need her clothes put out in the right order to ensure that she put them on in the right sequence (e.g. vest before shirt before cardigan), whereas after starting Cogmed, she began to achieve this independently .

After completing Cogmed, re-evaluation showed that she was more able to implement the strategies originally introduced, but was not always able to accurately decide which one to use and still needed prompting, particularly in relation to strategies supporting academic tasks. Support staff were then trained to deliver an individualised strategy-matching program. This involved working on a) Task preparation: would this task be easy or difficult, would it require a strategy, if it did require a strategy which one might work; b) Task monitoring and evaluation: whilst working on academic tasks, using 'stop and think' to evaluate where she had got to on the task, how it was going and what

strategies might help complete it successfully; c) Task review: after completing the task considering what had been helpful and what had not been helpful, and considering what she would use for future similar tasks. Katie also did some direct work with activities such as practicing following instructions, maze-learning and essay planning to provide intensive practice of forward planning (level C of the model) and using "Stop and Think" strategies. Once this work had been completed over a period of several months, Katie was able to recognise independently when to use most of the strategies. In addition, questionnaire and interview outcome measures completed by parents and school staff indicated improvements in behavior, organisation and everyday memory.

This case study highlights the difficulties that clinicians can have in interpreting a patient's response to intervention, as well as knowing where to start when delivering neurocognitive interventions. It was not inappropriate to start with an attempt at teaching lists, as Katie may not have needed a comprehensive and exhaustive intervention. However, having found them ineffective, it was then necessary to update the case formulation, identify obstacles and go on to test a second line hypothesis. This led us to address core skills followed by metacognition, after which the list-based strategies were found to be more effective, and were applied increasingly independently.

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