Action for Brain Injury Week 2019

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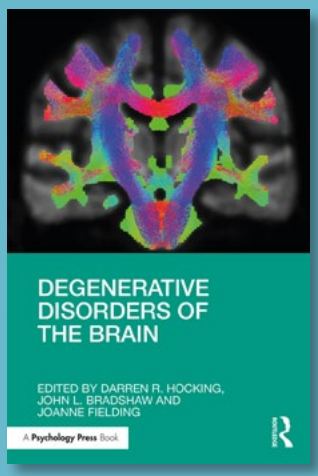

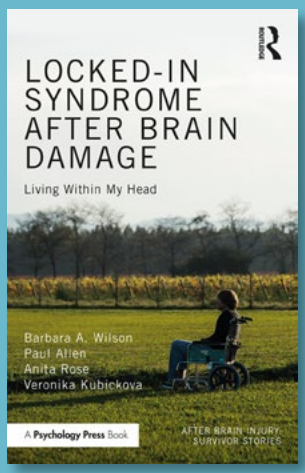

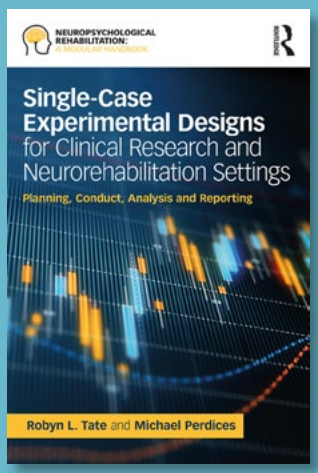

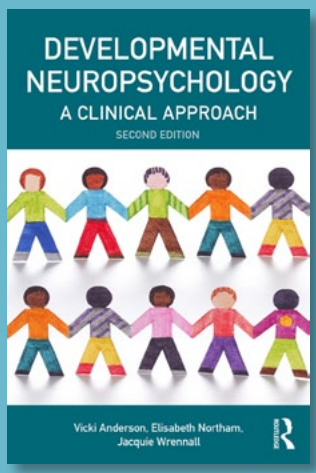

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10

PRACTICAL APPLICATION OF SINGLE-CASE METHODS IN THE NEUROREHABILITATION SETTING

Hints for the researcher and clinician

This chapter integrates information from previous chapters to show how single-case methods can be implemented. We present a practical, ten-step procedure for implementing a SCED in the neurorehabilitation setting, which is particularly applicable to clinical practice, but also useful in research. The chapter concludes with a model of clinical practice that incorporates a range of practice options, including single-case methodology.

Ten steps for implementing a single-case experiment

In this section of the chapter, we present a structured procedure to implement a single-case experiment. Throughout the section, we illustrate how the ten steps can be implemented by using the example of Ben, one of two participants described in the SCED study reported by Feeney and Ylvisaker (2008). The target behaviour of the case example involves challenging behaviours, but the ten-step framework can be applied to any target behaviour, including cognitive, communicative, emotional, functional, or motor-sensory domains.

Implementing an intervention can be divided into two main stages: the planning stage and the conduct stage, both of which are conducted in collaboration with the participant. If the planning stage can proceed carefully, systematically and thoroughly, then this provides optimal conditions for the conduct stage.

Stage 1: The planning stage

The order of the first two steps (the participant and the literature) will depend on circumstance. If the SCED is implemented in response to a referral in the clinical setting, the logical place to start is with the participant. If the SCED is implemented as a consequence of research interest in a particular topic, the literature may be the better starting point. Having refined the topic, the researcher then seeks to identify participants meeting selection criteria.

Step 1: The participant

Many different types of information need to be gathered about the participant. This will include medical information, a psychosocial history, evaluation of current level of functioning, and an articulation of the presenting problem. All of this knowledge, together with more detailed information about the target behaviour (see Step 3), will be used in the case formulation described in Step 4.

Pertinent *medical information* is essential to obtain in neurorehabilitation, especially in terms of the participant's presenting neurological condition (type, onset, severity, course, impairments), as well as any pre-existing conditions and comorbidities. A targeted *psychosocial history* provides critical contextual information about the participant and his/her social environment, along with his/her plans, hopes, aspirations, personal preferences, and values. Supplementary interview with an informant, such as a family or staff member, is vital if the participant has cognitive impairments (particularly in memory, executive function, self-awareness) that may compromise accuracy of information. In some circumstances, it may be necessary to obtain detailed information about the functioning of members of the family or the family unit because this may be relevant to and impinge upon the target behaviour.

Current *level of function* needs to be documented in a standardised way. One approach is to administer a rating scale that captures the overall level of functioning (e.g. World Health Organization – Disability Assessment Schedule 2.0 (Garin et al., 2010)). Other situations may indicate specific neuropsychological, language or functional assessment. This is then supplemented by detailed and comprehensive evaluation of the particular domain of function to be treated using direct observation and/or performance-based measures wherever possible.

The *presenting clinical or research problem* needs to be articulated and evaluated. Some standardised instruments are helpful, but often they are not sufficiently specific to the target behaviour. The practitioner may need to develop a tailor-made measure that captures the presenting issue or problem in order to delineate its dimensions. This is described in more detail in Step 3.

ILLUSTRATION: STEP 1: THE PARTICIPANT

In Ben's case, from the Feeney and Ylvisaker (2008) study, he was aged 5 years when he sustained traumatic brain (and other organ) injuries when his bicycle was hit by a car one year previously.

- *Medically*, Ben's past history was unremarkable, and he did not have any developmental or other problems. He sustained an extremely severe brain injury with bilateral focal frontal injury, as well as damage to the mesolimbic regions. Ben was hospitalised for two weeks in acute care, and thereafter for four months in an inpatient rehabilitation facility. He was discharged home to his family, but had continuing impairments that impacted on his functioning.
- *Psychosocially*, before the accident, Ben lived with his parents and three older siblings. Educationally, there were no academic problems and he had established many friendships. After the injury, Ben's parents divorced, and he lived with his mother and siblings, and had little contact with his father. He returned to his preinjury school and repeated the kindergarten first grade.
- *Current level of function*. According to his teacher, Ben did not experience motor deficits. Academically, his skills were similar to preinjury levels, but he exhibited challenging behaviours, including physical aggression and episodes of screaming in class. Ben was socially immature, bullied other students who were frightened by him, and he became socially isolated.

The *presenting problem* was Ben's challenging behaviour and its adverse impact on his schoolwork, which was further analysed (see Steps 3 and 4).

Step 2: The literature

Prior to developing an intervention, recommended practice is that the literature is searched to identify interventions with the best evidence of effectiveness (Sackett, Straus, Richardson, Rosenberg, &

Haynes, 2000). This makes sense, because an appropriate intervention to treat a particular target behaviour may already have been trialled and would be recommended for clinical practice if (i) the study was methodologically sound and (ii) the intervention had proved successful and was appropriate for the target behaviour.

Many hundreds of systematic reviews are available that synthesise the evidence for interventions in multiple problem areas in various neurological conditions. A search of PsycBITE, for example, an evidence-based database of nonpharmacological interventions to treat the psychological consequences of acquired neurological conditions (accessed 20 September 2017) identified 789 systematic reviews. This represents a huge amount of evidence that synthesises results from thousands of clinical trials.

Of course, literature review may not yield fruitful results. In this situation, the investigator may find it helpful to repeat the search using another but broadly similar clinical population. If the search results are still unproductive, then the investigator may need to adapt an already existing intervention or even develop an intervention de novo (see Step 5).

ILLUSTRATION: STEP 2: THE LITERATURE

- Regarding suitable interventions for Ben, one of the authors had previously conducted a systematic review of the literature on challenging behaviours after traumatic brain injury (Ylvisaker et al., 2007). The review highlighted the increasing use of positive behaviour intervention supports in comparison with the traditional contingency management approach to treating challenging behaviours.
- In Ben's case, the authors were interested in building on their previous work and replicating the multi-component intervention (using *inter alia* positive behaviour supports) which they had developed and used in previous single-case experiments.

Step 3: Identify, define, and measure the target behaviour

The target behaviour/s need to be (i) identified, (ii) operationally defined in precise, specific and quantifiable terms, and (iii) details about the method of measurement determined. Chapter 3 covers these and other issues pertinent to the target behaviour.

Identifying the target behaviour

How does one go about identifying the target behaviour? Although referring agents, staff, families, and the participant may have a general idea about the domain of behaviour in question, this is not sufficient for the purpose of implementing an intervention in a single-case study. Moreover, on occasion the behaviour that drives the referral, may not, when further examined, be the behaviour of relevance. In other cases, participants may present with multiple problems, and initially it may not be clear which behaviour should be targeted for intervention.

Careful observation, documentation, and discussion with relevant persons (one of whom will be the participant, even if he/she experiences significant cognitive impairment) is necessary. Depending on the domain, the procedure will involve assessment (usually) with standardised instruments or direct observation of overt behaviour.

In many cases, behavioural observations can take place in the settings in which the to-be-targeted behaviour occurs. Observations can be made in a number of ways, and the ABC (antecedents, behaviour, consequences) approach is frequently used, particularly in the context of challenging behaviours. Other domains addressed by SCEDs in neurorehabilitation (e.g. cognitive, communicative, emotional, functional, motor-sensory) may not be suitable for a structured behavioural observation, and Chapter 3 describes alternatives. The principle to emphasise here is the importance of undertaking a systematic evaluation of the target behaviour and the context in which it occurs, because this will inform the intervention.

If an ABC assessment is made, documentation should include at least the following:

- the behaviour (what occurred)
- the time (when it occurred)
- frequency (how often it occurred)
- duration (how long it lasted)
- intensity/severity/magnitude
- consistency of the behaviour over time

In addition to a record of the observed behaviour, it is necessary to record other information:

- contextual factors (e.g. the setting, presence of other people)
- antecedents (what was happening just before the behaviour occurred)
- consequences (what happened after the behaviour occurred)

- factors that might have exacerbated/attenuated the behaviour while it was occurring

The data produced from the above areas are particularly important, because they may provide insights into factors that serve to maintain the target behaviour (see Step 4), which will inform case formulation and guide selection of the intervention. In cases where direct observation is not practical or possible (e.g. 'private events' such as mood or pain), interview with the participant and using his/her self-ratings is indicated. The practitioner may wish to supplement subjective self-report with proxy measures that are related to the construct of interest and are observable (e.g. for depression, to document the number of activities completed). The practitioner may not be able to directly observe behaviours occurring in some settings and in this case she/he will need to rely upon other people (including the participant) to record the behaviour or report details of its occurrence.

Defining the target behaviour

Having identified the target behaviour, it then needs to be operationally defined. What do we mean by this? Take, for example, 'losing balance'. Although the general domain is clear (i.e. it is *not* memory, or challenging behaviour, or communication), more information is required to define 'losing balance'. Is a self-adjusted stagger classified as losing balance, or a trip, or is it necessary for the person to fall to the ground? The objectivity, clarity and completeness of the operational definition of the target behaviour has important implications for reliable measurement (see Step 8).

Measuring the target behaviour

After identifying and defining the target behaviour, the next step is to determine how to measure it. The single-case study measures the target behaviour continuously during every phase, both prior to commencing the intervention (A phase), and while ever the intervention is in place (B-phase). The requirement in single-case methodology for measures to be taken repeatedly and frequently can be a challenge because it will preclude the use of lengthy test batteries, as well as instruments that are subject to practice effects.

In addition to their length and possible practice effects, standardised instruments are often too general to capture the target behaviour. This

can make them an inefficient and imprecise way to track the target behaviour. Measures need to be direct and proximal to the behaviour that is to be targeted by the intervention. Nonetheless, sometimes standardised instruments *do* make suitable measures of the target behaviour if they are amenable to repeated administration and contain items directly relevant to the target behaviour. Of course, standardised instruments and assessment batteries can be administered before and after implementing the intervention (just as in a between-groups design) or intermittently throughout the study and may provide valuable information about the response generalisation effects of the intervention to other behaviours, both those closely related to the target behaviour, as well as more distal aspects of function (e.g. quality of life).

But it is usually the case that measures of the target behaviour are developed for the study at hand. The more objective the measure, the better. In some situations, self-report measures are crucial for tracking the target behaviour (e.g. mood, pain, insomnia) but because of their subjective and unverifiable nature they should be supplemented with other measures wherever possible. Measures of the target behaviour often comprise frequency counts of the target behaviour, its duration, intensity, and so forth (see the SCED studies summarised in the Appendix, which document a wide variety of target behaviours used in neurorehabilitation and their measurement). The downside of tailor-made measures is the lack of external evaluation of, in particular, their reliability. Thus, any measure requiring human judgement needs to have a reliability evaluation, and this is covered in Step 8.

In the course of determining the measure that will be used for the target behaviour, the practitioner will need to consider the following:

- What mode will be used to measure the target behaviour: self-report, informant report, direct observation, performance-based response, machine recording?
- Where, when, and how often will the measures/observations take place?
- Who will measure the target behaviours and is training required?
- Will coding of responses be required, can another person independent of the observer do it, and is training required?
- Are there ways that the measures can be recorded so that they can be rated at a later time with the rater being blind to phase, as well as to be used for determining inter-observer agreement?

For example, by using manual recording sheets, audio or videotape recordings.

- Can equipment be used to measure the target behaviour to enhance objectivity? For example, computers, weighing scales, pedometers, audio/video records.
- In addition to the target behaviours, are there any other aspects that need to be measured? For example, generalisation measures sampled throughout all phases, social validity measures made at the conclusion of the intervention.

ILLUSTRATION: STEP 3: IDENTIFY, DEFINE, AND MEASURE THE TARGET BEHAVIOUR

Ben's two target behaviours were specified as follows:

Domain	*Target behaviour definition*	*Measure*
Aggression	"attempted or completed physical aggression (e.g. hitting, pushing) or verbal aggression (e.g. threats). The aggressive behaviors of the participants were operationally defined by the consultant who then trained classroom staff in data collection" (p. 118)	– Frequency counts of observed incidents of aggressive acts (as defined) – 20 disruptiveness items from the Aberrant Behavior Checklist rated on four-point intensity scale. Completed by staff after each aggressive act
Schoolwork	"the number of activities, problems, questions, or assignments completed", based on hard copies of Ben's work that the staff provided	– Percentage of work completed

- Staff were trained to mastery in accurately recording the (i) frequency and (ii) intensity of the aggression target behaviour. Their ratings were compared against those of the consultant, and the study did not commence until two consecutive ratings exceeded the a priori specified threshold (90% agreement).
- In addition to the target behaviours, two measures of social validity were made: staff judgements about the effectiveness of the intervention for (i) the student, and (ii) the staff, using the Intervention Effectiveness Evaluation Scale.

Step 4: Case formulation/functional behavioural analysis

Case formulation can occur in a descriptive way to integrate the information collected in the assessments conducted in Step 1 (contextual information) and Step 3 (e.g. ABC approach). This will provide hypotheses about factors that serve to maintain the behaviour, which will inform selection of the intervention (see Step 4 below). At its most sophisticated level (and particularly applicable to the domain of challenging behaviours), case formulation will be based on a functional or structural experimental analysis of behaviour in which environmental conditions serving to maintain the target behaviour will be verified via an experiment (see Chapter 3).

ILLUSTRATION: STEP 4: CASE FORMULATION

In Ben's case, the following steps were taken to arrive at a case formulation:

- In an initial step, the consultant met with classroom staff to obtain a descriptive functional behavioural assessment to identify situations and consequences associated with the target behaviours.
- The staff then completed the 16-item Motivational Assessment Scale (MAS) to identify factors that served to maintain Ben's challenging behaviours: attention, tangible reinforcement, escape/avoidance, sensory stimulation.
- Finally, the consultant scored the MAS and corroborated the results with direct observation of Ben, using the ABC approach, over several school days.
- The results "indicated that aggression and other disruptive behaviours typically served the primary function of avoiding assigned work, especially in situations that required organization or that were cognitively challenging" (Feeney & Ylvisaker, 2008, p. 119).
- These data informed the intervention (see Step 5) which had "the goal of making challenging behaviours unnecessary and inefficient" (p. 119)

Step 5: The intervention

The intervention (see also Chapter 4) will be informed from two principal sources: the literature review, as conducted in Step 2, and the case formulation, as completed in Step 4.

In any given situation, the practitioner is likely to encounter one of three scenarios from the literature review:

1. an intervention is available and can be implemented without adaptation
2. an intervention is available, but for any of a number of reasons, it needs to be adapted for the purpose at hand
3. no suitable intervention is available, and so the practitioner has to develop one de novo

All of the above scenarios are compatible with an evidence-based approach when using single-case experimental methods. Indeed, single-case methodology will provide evidence for the effectiveness of the intervention (cf. practice-based evidence), albeit only for that particular individual unless the study is replicated.

In the happy event of scenario 1 (a suitable intervention is identified), the next steps are to read the report to (i) evaluate its scientific quality and (ii) consider the evidence for its effectiveness. This is important because if a study has significant methodological flaws, it will be at risk of bias and the results of the study and conclusions drawn may be misleading (see Chapter 2 for discussion of issues surrounding risk of bias and threats to validity). It also stands to reason that if (in a well-designed study) an intervention is shown *not* to be effective, the practitioner or researcher needs to have a very good reason for implementing it without adaptation.

The more challenging event of scenario 2 (an intervention is available but needs to be adapted), may occur for many reasons. In particular, an intervention developed for the general or other clinical populations may need to be adapted to accommodate the configuration of the participant's cognitive and non-cognitive impairments, functional and emotional status, and other personal and environmental factors.

In the disappointing event of scenario 3 (no suitable intervention is available), the practitioner will need to develop one de novo. It goes without saying that an intervention that has not been evaluated previously should be implemented in the context of a single-case experiment (or evaluated in an RCT).

In all scenarios, a procedural manual should be compiled, treatment protocols developed, practitioners trained in the procedures, and ongoing monitoring/supervision provided. Having treatment protocols assists in ensuring that a treatment is implemented as intended (see Step 9). At this point, many decisions need to be made:

- What number, duration and regularity of intervention sessions is required?

- Who will implement the intervention?
- Do practitioners need training?
- What form will supervision/mentoring take?
- How will the intervention be delivered?
- What are the factors that will maximise participant adherence and how will they be built into the intervention plan?

ILLUSTRATION: STEP 5: THE INTERVENTION

The intervention used with Ben was a combination treatment, "derived from the functional behavioural assessment and elements based on theory and experience with children with TBI [traumatic brain injury]" (Feeney & Ylvisaker, 2008, p. 119). It drew upon contextually relevant cognitive (executive function) and behavioural strategies, along with positive-behaviour supports.

- The components of the intervention were as follows:
  - Daily routine: negotiations about the minimum amount of work to be completed
  - Behavioural momentum: tasks sequenced in such a way that easy tasks with high success rates were used before difficult work was introduced
  - Reduction of errors: staff provided modelling and assistance
  - Escape communication: Ben was taught positive communication alternatives (e.g., "I need a break")
  - Adult communication style: staff were trained in specific techniques
  - Graphic advance organisers: Ben was provided with photographic cues because of his executive impairments in organisation
  - Goal–plan–do–review routine: brief questions posed by staff for sequencing of activities
  - Consequence procedures: procedures for staff to follow in the event of target behaviour occurrence
- Staff were trained with a 30-min orientation and training in each component, followed by training to mastery for components in the use of photographic prompts and escape communication strategies

Step 6: The design

The design of the study will be dictated by multiple factors, including the type of target behaviour/s, number of participants/settings involved, the nature of the intervention, as well as the level of functioning of the participant. Chapters 5 to 8 described four prototypical designs and

their variants used in single-case interventions. There are other, and more complex, designs (e.g. nested designs – see Chapter 1), but these require expertise to design and implement with scientific rigour.

Compared with the relatively small number of designs used in between-groups research, the newcomer to the field of single-case methodology can be overwhelmed with the variety of designs available, and knowing which type of design to choose can be a daunting task. To this end, we have developed a decision tree (Figure 10.1) and the answers to questions will guide selection of the appropriate design to evaluate the intervention.

- An initial question that the investigator needs to answer is whether the intervention can be meaningfully withdrawn. By this we mean, that it is possible to, literally, take away the intervention, such that its effect on the target behaviour will only be manifest when the intervention is being delivered. Withdrawable interventions usually (but not always – see example of Feeney & Ylvisaker, 2008, below) involve aids, equipment, or substances. It is clear that such interventions can be taken away so that there are no long-lasting 'carry-over' effects of the intervention to the subsequent A phases. Non-withdrawable interventions include those that teach a skill (e.g. communication competence, improved gait mobility, behavioural self-regulation). Once learned, such skills generally cannot be unlearned. Accordingly, if the answer to the question (can the intervention can be meaningfully withdrawn?) is yes, then consider a WRD (e.g. A-B-A-B; see Chapter 5). An ATD (see Chapter 7) could also be considered, if the aim is to compare two interventions (one of which could be a no-treatment control condition). MBD (Chapter 6) and CCD (Chapter 8) are also suitable, and are particularly relevant for non-withdrawable treatments.
- Deciding between a WRD or ATD will depend on a number of factors. Of most relevance in the WRD is the issue of the ethics of withdrawing an intervention which is proving successful. If this is a problem, then consider using an MBD, which can be applied to both withdrawable and non-withdrawable interventions.
- The ATD can appear to be an attractive option because of its efficiency in comparing multiple interventions simultaneously (as opposed to sequentially in the A-B-A-B WRD), but there are challenges in its application. It will require fairly rapid (e.g. daily) alternation of multiple conditions (e.g. intervention 1 and intervention 2), and this may be a limiting factor in its practical

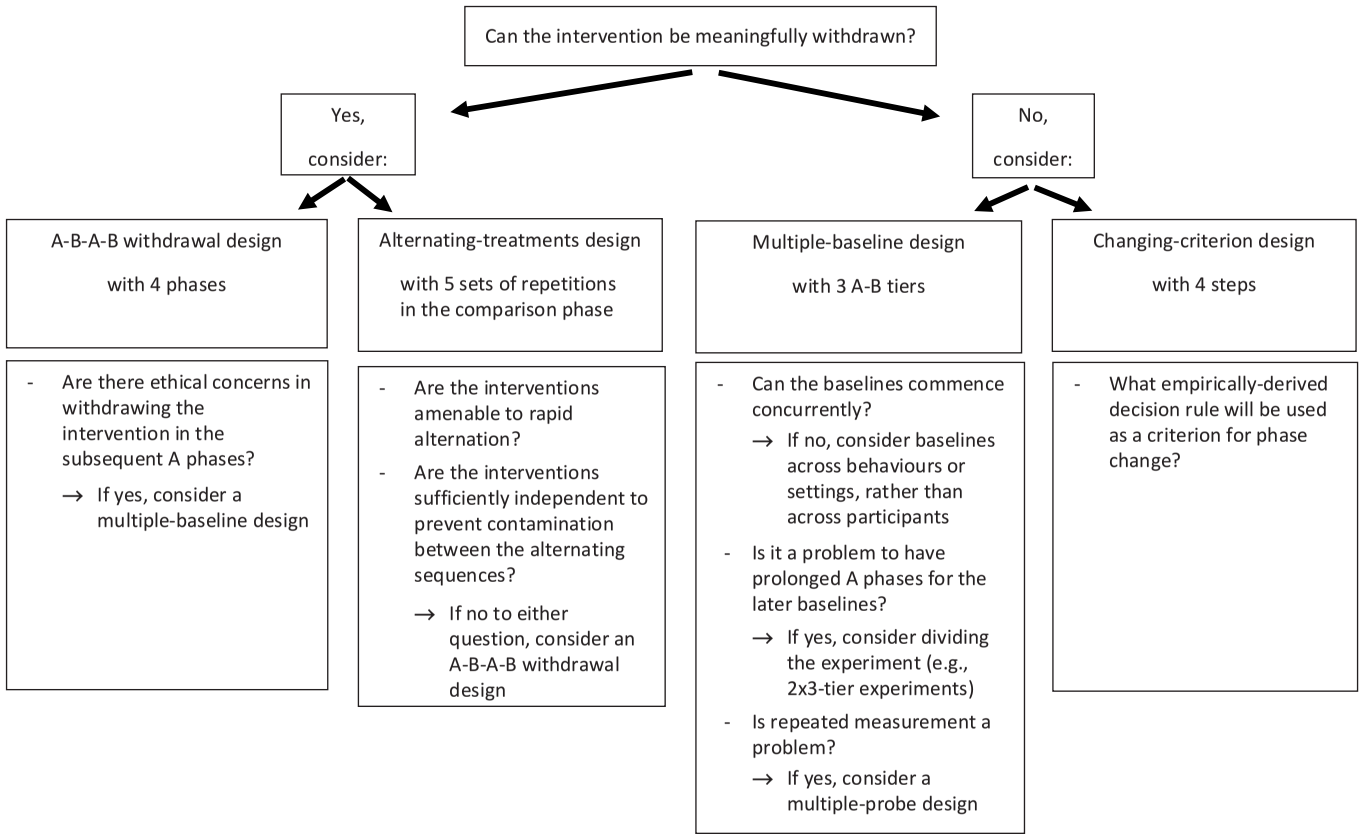

FIGURE 10.1 A decision tree for selecting the design in single-case methodology

application. Additionally, the conditions of the intervention need to be sufficiently independent that carry-over effects are minimised, and the target behaviour needs to be responsive.

- If the intervention *cannot* be meaningfully withdrawn, consider an MBD or CCD. If using an MBD, a series of decisions need to be made (see Chapter 6 for a discussion of options in the MBD):
  a Will the different baselines (tiers) be across behaviours, settings or participants?
  b If the different baselines are across participants, will the baselines be concurrent (i.e. data collection for all participants commences at the same point in time)? There are important consequences of using a concurrent versus non-concurrent design.
  c If the different baselines are across behaviours or settings, interdependence of behaviours/setting needs to be minimised to reduce the risk of behavioural covariation.
  d Because the MBD is sequential in nature, it (like the A-B-A-B WRD and CCD) can result in a lengthy study. This has particular ramifications for the later baselines (tiers), and the practitioner could consider using a multiple-probe study.
- If the desired level of the target behaviour is difficult or slow to achieve, a CCD may be useful, so that behaviours can be shaped. The main decisions to be made in a CCD is the criterion that will be used to change phase.

All the foregoing designs will require decisions to be made about the length of phases and when to change phases (see Chapter 1). Recommended practice is that phase change occurs after stabilisation of responses. But a rule of thumb is that each phase should have at least three data points (but a minimum of five is better) to ensure sufficient sampling of behaviours. Sometimes, this is necessarily curtailed in the initial baseline phase if the intervention needs to commence immediately because of concerns for the safety of the participant or other people.

The recommended number of phases required to demonstrate the experimental effect should be used (see Chapter 1 for more detail), because the greater the number of intra-subject replications, the more convincing the evidence of a functional relationship between the dependent and independent variables. Current standards recommend a four-phase WRD (which allows for three

opportunities to demonstrate the experimental effect); a six-phase, three-tier MBD; five sets of alternating sequences in the comparison phase of an ATD; and a four-step CCD (Horner et al., 2005; Kratochwill et al., 2010; 2013; Tate et al., 2013a; 2015).

ILLUSTRATION: STEP 6: THE DESIGN

Feeney and Ylvisaker (2008) argued that a withdrawal A-B-A-B design would be the most appropriate way to evaluate the effect of the intervention for Ben. They hypothesised that when the supports underpinning the intervention were withdrawn, the target behaviours would return to baseline levels.

- The authors reported that the criterion for phase change (B–A), was that the target behaviours occurred no more than two times per day for five consecutive days.
- Following a five-day baseline, the intervention was implemented across nine days in the first B phase, followed by a three-day second A phase, with the intervention reinstated for a further four days in the second B phase.

Step 7: Other considerations

Three other issues should be considered in the planning stage: randomisation, blinding, and consent to conduct the study. The randomised, double-blind, placebo-controlled trial is considered the gold standard of between-groups intervention research because it incorporates strategies to minimise risk of bias, thus making study results more credible. Undoubtedly two of the strongest strategies to minimise risk of bias are randomisation and blinding. To date, these strategies have not been widely incorporated into the single-case paradigm.

Randomisation

This can be used in the prototypical designs. In single-case research randomisation procedures differ to those used in between-groups designs in which participants are randomly allocated to different conditions. It is obvious that in single-case studies, where the sample comprises a single individual, this is not possible. The main way that randomisation works in single-case studies is by randomising (i) phase order (or in alternating-treatments designs, alternation sequence) and/or (ii) the onset of the phases (Edgington, 1980; 1987).

Other features of the design can also be randomised (see Ferron & Levin, 2014; Kratochwill & Levin, 2010; 2014), but in terms of minimising threats to internal validity randomising order and/or onset of the interventions are the most important.

Blinding (or masking) in a SCED

This refers to the person (whether participant, practitioner or assessor) being blind to phase. Although blinding of the participant and practitioner are difficult to achieve with most behavioural interventions commonly used in the neurorehabilitation setting, use of technologically driven interventions may provide the opportunity for blinding the practitioner (see Chapter 2). Blinding of the assessor is easier to achieve if a permanent product record of the target behaviour can be made. In this case, an independent person re-orders the sessions so that they are not chronological, and the assessor then evaluates the data not knowing whether they come from the baseline or intervention phase. If blinding the assessor is not possible (e.g. observations of the target behaviour are made in real time), then it is advised that the assessor is independent of the practitioner, which addresses possible bias due to investigator reactivity.

Consent

This can be considered from two perspectives: participant consent to treatment and approval from a formally constituted ethics committee to conduct the study. Recommended practice is that the participant should provide informed and written consent to participate in any single-case intervention (Mechling et al., 2014; Tate et al., 2016b). In the case where a person is unable to provide informed consent (e.g. due to cognitive impairment), they should assent to the intervention, and written consent be provided by their appointed guardian. Ethics approval from a formally constituted ethics committee is almost a universal requirement for research.

Stage 2: Conduct after the study starts

Once the study starts the investigator needs to pay ongoing attention to two features in particular: (i) measurement of the target behaviour and (ii) implementation of the intervention. It is necessary to monitor data quality and procedural fidelity, and take remedial action, when and if necessary.

Step 8: Data fidelity

As discussed in Chapter 2, instrumentation, testing and participant and investigator reactivity can pose threats to internal validity compromising the reliability of data being collected. Close monitoring of the data collection process is necessary to maintain high standards of accuracy. These include ensuring that observations are being made how, when, where, and as frequently as planned. 'Observer drift' needs to be avoided, so that the behaviour as recorded continues to meet operational definitions as initially established. If equipment is used, it is important to ensure that it continues to function as intended and is regularly recalibrated so that data can be accurately recorded throughout the duration of the study.

It is necessary but not sufficient to have procedures in place to maximise data fidelity; evidence for data fidelity also needs to be established empirically. This is done by conducting an inter-rater/observer agreement study. It is particularly important in situations where human observers are used, but not so critical if the target behaviour is measured with equipment free from human influence (Tate et al., 2015). In situations where the target behaviour is measured via self-report it is not possible to establish inter-rater reliability and for this reason it is advantageous to have other measures in addition to self-report.

The following steps are recommended for an inter-rater agreement study:

1. A permanent product record of the target behaviour (e.g. video, audio, written response) allows for two raters to independently evaluate the data records after the event, and also the opportunity to verify decisions.
2. The rules of thumb for establishing inter-rater/observer agreement are described in Chapter 3 and are repeated here:
    - at least 20% of data points are selected from each condition (e.g. baseline condition, intervention condition). It strengthens the methodology if the data are randomly selected which can be done if a permanent product record is available
    - two raters independently evaluate the data (for occurrence, frequency, intensity, or other quality of the target behaviour as being measured) separately for each condition (baseline; intervention)

- inter-rater agreement is calculated by the following simple formula:

$$\frac{number\ of\ agreements}{(number\ of\ agreements) + (number\ of\ disagreements)} \times\ 100$$

- a high level of agreement, at least 80%, is required

ILLUSTRATION: STEP 8: DATA FIDELITY

Feeney and Ylvisaker (2008) put procedures in place to maximise data fidelity and also evaluated inter-rater agreement.

- First, as noted in Step 3, staff were trained to mastery in recording the frequency and intensity of the aggression target behaviours. Staff recordings were compared with those of the consultant and the study did not commence until there were two consecutive occasions where agreement was at least 90%
- An inter-rater agreement study was conducted. Two observers were present and made ratings at the beginning of the study and after every fifth session (corresponding to 20%). More than 80% and 85% agreement occurred throughout all conditions for ratings of frequency and intensity respectively.

Step 9: Procedural fidelity

Procedural fidelity, which is discussed in Chapter 4, is closely related to the intervention (see Step 5). It stands to reason that if one wants to know whether an intervention is effective, then it is necessary to know exactly what occurred. Was the intervention implemented as intended and described in the manual or was the intervention somehow inadvertently modified during the study (e.g. some procedures were omitted/not followed, or extra components were added)? Having a study with high treatment adherence enhances both internal and external validity.

Moreover, authorities in the fields of clinical psychology and special education have emphasised that it is not only the active intervention that needs to be evaluated for adherence to protocol, but also the baseline conditions. This addresses threats to internal validity posed by diffusion of treatment effect (see Chapter 2). Ensuring adherence to

protocol in both the baseline and intervention conditions is referred to as procedural fidelity. The advantage of establishing procedural fidelity is that it not only allows the researcher to comment on treatment adherence, but also on treatment differentiation (i.e. that procedures/techniques specific to a condition/intervention are confined to that condition/intervention and do not occur in other conditions/interventions; see Chapter 4).

Periodic checks should be made to ensure that the practitioner continues to adhere to the requirements for implementing the conditions of the study. For empirical demonstration of procedural fidelity, the rules of thumb are described in Chapter 4 and are repeated here:

- Compile a protocol of required components in both the baseline and intervention conditions
- Select at least 20% of sessions in each of the baseline and intervention conditions
- A person who is independent of the practitioner (and not in a personal relationship with the participant) evaluates each of the selected sessions to determine whether each component of the protocol did or did not occur
- Treatment adherence is calculated by the following simple formula:

$$\frac{number\ of\ times\ an\ agreement\ is\ recorded\ between\ the\ rater's\ observation\ and\ the\ protocol}{(number\ of\ agreements) + (number\ of\ disagreements)} \times 100$$

- High fidelity is suggested by at least 80% agreement between the rater and protocol in each of the baseline and intervention conditions

ILLUSTRATION: STEP 9: PROCEDURAL FIDELITY

Feeney and Ylvisaker (2008) put procedures in place to maximise procedural fidelity, although they did not formally evaluate adherence:

- Prior to commencing the experiment, the staff were oriented and trained in each component of the intervention in a 30-min session. They then practiced and were required to reach mastery for two of the components (photographic cues and escape communication strategies)
- Specification of procedures to be followed in the baseline conditions minimised the risk of diffusion of treatment effect and enhanced treatment differentiation. At the beginning of each day of the baseline (A) phases (and "intermittently throughout the day"), Ben was given reminders about his work schedule and assignments. Reminders were often consequent upon off-task, inappropriate or oppositional behaviours. None of the supports trialled in the B phases were used during baseline phases.
- During the intervention (B) phases, "periodic checks of procedural mastery" were conducted, and the consultant met with staff from time to time to evaluate progress of the intervention.

Step 10: Data evaluation

A wide variety of analytic techniques is available to evaluate data from single-case studies, using both visual analysis and statistical procedures (see Chapter 9). Traditionally, single-case data are presented graphically, and visual inspection is used to determine whether there are differences between phases. The reasoning is along the lines that if differences are not visually apparent, then they are probably not clinically meaningful and socially important. Statistical analysis has gained prominence over recent years and it is generally recommended to use both visual and statistical analysis as complementary methods of data evaluation (e.g. Parker & Brossart, 2003; Kratochwill et al., 2014).

ILLUSTRATION: STEP 10: DATA EVALUATION

Feeney and Ylvisaker (2008) made descriptive comments about the results of the intervention, supplemented with graphical representation of the daily recordings throughout the 22 days of the experiment. They did not, however, conduct formal analysis of the results using statistical procedures. Visual inspection of the data suggest that Ben showed a dramatic response.

- The frequency of the aggressive target behaviour decreased from between 8 and 13 occurrences per day during the first A phase, to less than two per day when the B phase was implemented (apart from the first day of the B phase). The target behaviours increased to pre-intervention levels when the second A phase was introduced, and immediately decreased with the reinstatement of the B phase.
- A similar pattern occurred for the intensity of the aggressive target behaviour which decreased from a mean of 2.5/4 in the first baseline to 1.7/4 in the first B phase
- Similarly, completion of schoolwork improved, increasing from approximately 30% in the first baseline to more than 90% during the intervention.

In summary, the above ten-step procedure facilitates the implementation of a single-case study, both in clinical practice, as well as the research setting. Of course, we could have added an eleventh step. Having carefully conducted a SCED, the investigator needs to consider whether the work should be published. A reporting guideline, specifically developed for SCEDs in the behavioural sciences (Tate et al., 2016a; 2016b; see Chapter 2) is available to assist authors to write reports with clarity and completeness. As we noted in Chapter 2, the neurorehabilitation field needs more good quality SCEDs and we encourage investigators to publish their work.

The study by Feeney and Ylvisaker (2008), used as an example throughout, was implemented in the everyday context of a school setting. Even so, the study was rigorously designed and implemented, giving the reader confidence that the risk of bias was minimised. Although elements such as randomisation and blinding of assessors to phase of the study would have strengthened internal validity, nonetheless the study scored reasonably well on the Internal Validity (5/14) and External Validity and Interpretation (11/16) subscales of the RoBiNT Scale (Tate et al., 2013a; 2015). Parenthetically, it must be kept in mind that RoBiNT Scale, which uses stringent criteria in keeping with standards of evidence proposed by Kratochwill et al.

(2010; 2013), was published subsequent to the Feeney and Ylvisaker report and so the authors are at disadvantage in being evaluated on a scale that was not available at the time of their study. Their study was carefully planned and conducted in accordance with accepted criteria at the time.

A model for neurorehabilitation practice in the clinical setting

One might reasonably ask whether it is feasible to use single-case methods in the general neurorehabilitation setting, where patients/clients often have multiple areas of impairments all of which are treated concurrently by therapists from different disciplines. In addition, there are often many pressures to implement an intervention immediately upon referral. Sometimes pressures are external, for example, payors may set limits on the number of therapy sessions available, or institutions may dictate the length of admission. Other times pressures are clinically driven, when, for instance, a patient poses a threat to the safety of him/herself or others. Examples commonly encountered in neurorehabilitation include swallowing problems, risk of falls, physical violence. Of course, one could always implement a B-A-B-A-B design (if the intervention was withdrawable) in the above situations, and hence commence the intervention immediately, but when safety issues are involved the withdrawal design raises ethical concerns.

Because it is not always possible to implement single-case experiments in the clinical environment, Tate and colleagues developed a framework, the Model for Assessing Treatment Effect (MATE; Tate, Aird, & Taylor, 2012; Tate et al., 2013b), that incorporates all scenarios encountered in clinical practice. We describe the MATE here because it provides the clinician and researcher with a range of options to implement an intervention that might be considered in situations where it is not feasible to conduct a textbook-quality, single-case experiment. The structure of the MATE also serves the purpose of a conduit to allow clinical practice, within the practical constraints described above, to be elevated to a more scientifically rigorous level.

The seven levels of the MATE are shown in Table 10.1. The most scientifically rigorous way to implement an intervention is at Level 6 of the MATE: a single-case experiment with controlled implementation of the intervention and sufficient sampling of the target behaviour in each phase, operationally defined for the MATE as at least three measurement occasions per phase. But circumstances may dictate implementation at a lower MATE level. In our opinion, Level 5

TABLE 10.1 Levels of the Model for Assessing Treatment Effect (MATE)

MATE Level and definition	*Distinctive features*
Level 0: No intervention is implemented	Typical scenarios include patients who are admitted for assessment only, or those with very low levels of functioning who are not ready to engage in an active therapy programme.
Level 1: An intervention is implemented, but without a formal pre-intervention evaluation.	A common reason that formal pre-intervention assessment is not conducted is due to urgency of dealing with behaviours that present a risk to the safety of the patient or other people, with previously noted examples including swallowing problems, risk of falls, presence of challenging behaviours.
Level 2: An intervention is implemented following a formal pre-intervention evaluation.	By a formal pre-intervention assessment we refer to the administration of standardised instruments (tests, rating scales, questionnaires, interviews), structured observations with a quantitative record, or measures of a specific target behaviour. Some case descriptions that contain pre-intervention data are eligible for classification at Level 2.
Level 3: An intervention is implemented following a formal pre-intervention evaluation, including specific measure/s of the behaviour targeted for intervention.	Occasions of measurement of the target behaviour need to be made repeatedly and frequently during the intervention phase. Some B-phase training studies are characteristic of a Level 3 intervention.
Level 4: A formal evaluation is conducted before and after an intervention is implemented, including at least three measures of a specific target behaviour taken at some point.	The so-called "pre-post" designs, in which assessment occurs both before and after an intervention enables the clinician to document whether there has been a change in particular behaviours. This approach may be classified at Level 4, if the specific behaviour that is targeted for intervention is also measured on a minimum of three occasions.
Level 5: Single-case methods are used	There are at least two phases (baseline and intervention) during which measures of the target behaviour are taken repeatedly, even though the intervention may not be implemented in a scientifically controlled manner (e.g. some A–B designs) or other features of the design are less than optimal (e.g. fewer than 3 data points in any phase).
Level 6: A single-case experiment	There are three or more phases, during which measures of the target behaviour are taken on at least three occasions per phase. (See Chapters 6–9 for descriptions of prototypical single-case experiments.)

(an A-B design) or Level 4 (a pre-post design, which includes measurement of target behaviour/s) represent a minimum standard of clinical practice, in that the practitioner needs to at least evaluate the effect of the intervention at its conclusion. Levels 4 or 5 should be feasible to conduct in virtually all cases.

The MATE provides clear direction about what is required to progress from one level to the next. To further assist this process Tate et al. (2012) developed a decision tree consisting of a series of questions with yes/no responses (see Figure 10.2). Each question that is answered in the affirmative allows progression to the next step in the model; if it is answered in the negative then that is the level of the model which applies. The questions can be answered retrospectively to evaluate what was done, or prospectively to plan how an intervention will be delivered. Thus, a practitioner or researcher can use the MATE decision tree to reflect upon how an intervention was implemented with a particular patient/client and to determine where improvements could occur for subsequent patients/clients.

Concluding remarks

Single-case methods are certainly not new in the scientific literature, however their application in neurorehabilitation practice is, with some exceptions, neither routine nor common. This chapter has described a ten-step procedure to facilitate the planning and implementation of a single-case study. We also presented the MATE as a framework that incorporates all scenarios encountered in a clinical neurorehabilitation setting and identifies levels of scientific rigour of implementing interventions.

The traditional approach to clinical practice is usually characterised by the following sequential steps: initial assessment and case formulation, setting of goals, implementing an (ideally, evidence-based) intervention, and, following completion of the intervention, determining whether goals have been achieved. Single-case methodology also does this, but additionally includes two unique features: (i) repeated and frequent measurement of the behaviour targeted by the intervention throughout the rehabilitation programme, both before the intervention is implemented and while it is in progress, and (ii) implementing the intervention in a scientifically controlled way.

The advantage of the first feature (repeated and frequent measurement) is that systematic and continuous monitoring and

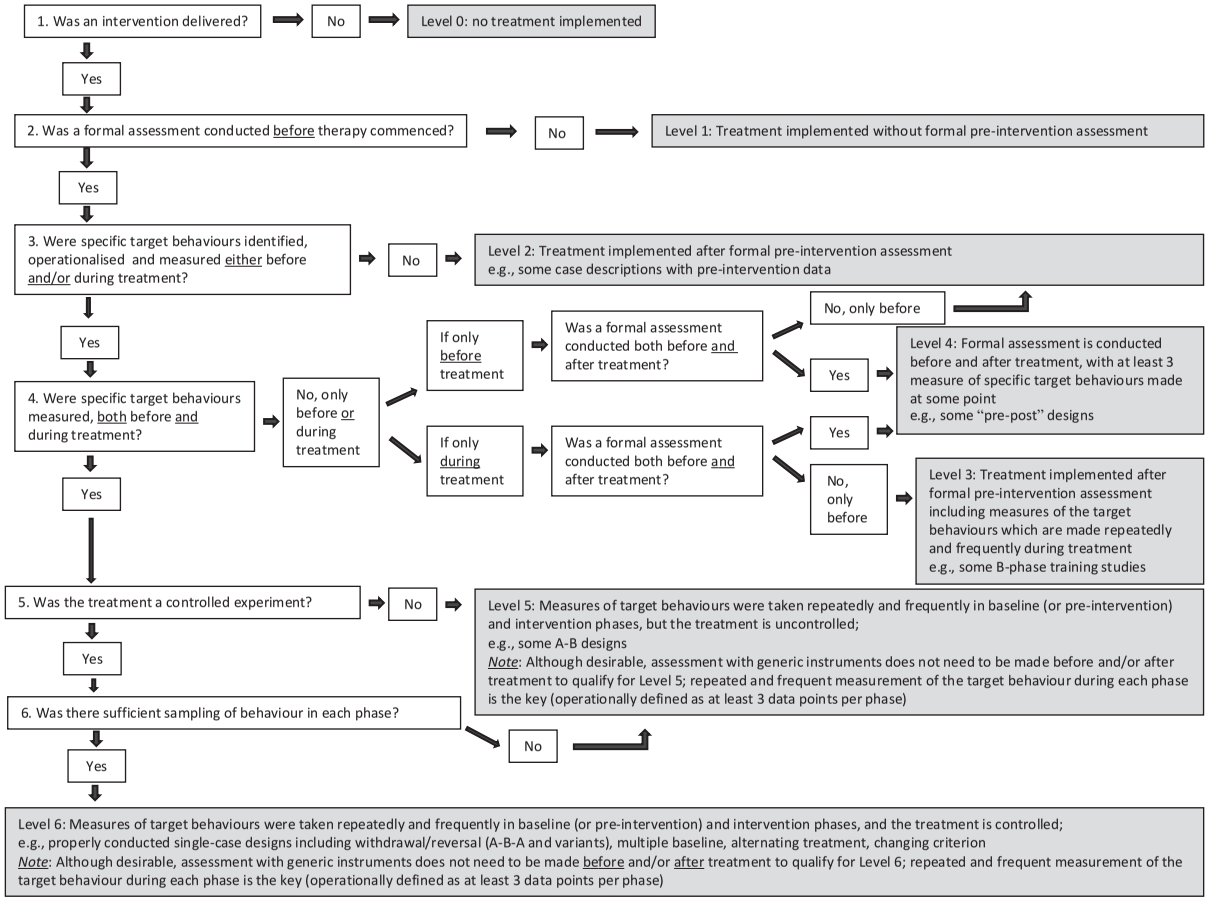

FIGURE 10.2 Decision tree for the MATE
Source: Tate, Aird, and Taylor (2012); reprinted with permission

measurement of the behaviour targeted for intervention means that an intervention that is not working, or not working optimally, can be recognised and adapted. And this can occur without necessarily compromising the scientific rigour of the intervention implementation. Stewart and Alderman (2010), for example, treated a 39-year-old man for severe challenging behaviours after traumatic brain injury. The severity of his aggression interfered significantly with his rehabilitation programme, and in particular, developing a personal hygiene routine. An intervention, using differential reinforcement of incompatible behaviour was instigated for 26 sessions, but results of time-series analyses showed that there was no significant decrement in the aggressive behaviour from the baseline phase. The intervention was changed to differential reinforcement of low rates of responding, over 29 sessions, but that too proved ineffective. A third intervention was trialled, using situational time out with sustained prompting, and there was an immediate and dramatic response, which was sustained over 44 sessions.

The advantage of the second feature (implementing the intervention in a scientifically controlled way) is that single-case methods have the capacity to provide definitive evidence regarding the success (or otherwise) of Intervention X to treat Behaviour Y, allowing cause-effect functional relations to be established. Because the traditional clinical approach does not implement the intervention in a scientifically controlled manner, the capacity to draw valid inferences or conclusions about the effectiveness of the intervention per se is weakened. We encourage all practitioners to incorporate the steps outlined in this chapter as representing good clinical practice. In one sense, every patient/client in the neurorehabilitation setting is a single case, and single-case methods are the very embodiment of the scientist-practitioner model.

10

NEW CLINICAL NEUROSCIENCE TECHNOLOGIES FOR TREATING NEURODEGENERATIVE DISORDERS

Wei-Peng Teo, Alicia M. Goodwill and Peter G. Enticott

Introduction

The use of electricity and electromagnetism to probe neural activity and function has been described in fair detail even in ancient literature almost 2000 years ago (AD 43–48) (Ceccarelli, 1962). The earliest record for the use of electricity to treat ailments of the brain was by Scribonius Largus, Roman physician to the Emperor Claudius, who reported that placing a torpedo fish (a species of electric ray) over the heads of patients with headaches induced a transient period of stupor and analgesic effect. In a similar fashion, Muslim physician Ibn Sidah (AD 1007–1066) further suggested that placing a live electric catfish on the frontal bone of the skull may help to treat epilepsy (Kellaway, 1946). However, it was the work of Italian physician Luigi Galvani (de Micheli, 1991), who inadvertently discovered the phenomenon of 'animal electricity', and physicist Alessandro Volta (Pancaldi, 2003) that founded the field of electro-neurophysiology. Galvani's nephew, Giovanni Aldini in 1804, was one of the first to report the successful treatment of patients suffering from melancholia by applying direct electrical current over the head. Aldini further assessed the effects of direct electric currents applied to himself and reported an unpleasant sensation followed by insomnia for several days.

In the last two decades, advances in our understanding of electro-neurophysiology have led to the development and refinement of both invasive and non-invasive forms of brain stimulation to treat psychiatric and neurodegenerative diseases. In the field of non-invasive brain stimulation, transcranial magnetic stimulation, or TMS, has become a standard tool to probe cognitive functioning. Based on Faraday's law of electromagnetism, TMS is capable of stimulating cortical neurons so as to activate or inhibit specific regions of the brain (Ziemann, 2010). When applied repetitively with the appropriate pulse frequency, duration and intensity, repetitive TMS (rTMS) can exert a neuro-modulatory effect by which neural

function and behaviour may be altered during (online) and after (offline) the stimulation period (Hallett, 2007; Thickbroom, 2007). Similar to TMS, another form of non-invasive brain stimulation, known as transcranial direct-current stimulation (tDCS), has in recent years received great attention (Nitsche et al., 2008; Tanaka & Watanabe, 2009). tDCS works by placing two electrodes (a positive anode and negative cathode in saline-soaked sponges) over the scalp of targeted brain regions. This method allows weak direct current (typically 0.5–2mA) to pass through the scalp from the cathode to anode non-invasively and safely to stimulate cortical regions of the brain. This effect of tDCS results in polarity-specific changes to brain activity (anodal/positive tDCS increases brain excitability; cathodal/negative tDCS, inhibits brain excitability) (Nitsche & Paulus, 2000; Priori, Berardelli, Rona, Accornero & Manfredi, 1998) that may have a follow-on effect on motor and/or cognitive performance.

While non-invasive brain stimulation techniques are capable of modulating cortical brain regions, their effects on subcortical structures are limited. In this sense, invasive techniques such as deep brain stimulation (DBS) may be used to target known neurological pathologies that stem from subcortical deficits, such as Parkinson's disease (PD). This procedure, while highly invasive in nature, produces almost immediate relief from PD-related motor symptoms such as resting tremors, muscle rigidity and gait disturbances. More recently, improvements in DBS therapy with the development of multi-directional electrical implant probes have a greater ability to deliver targeted, individualised DBS therapy to optimise treatment outcomes for people with PD.

While recent advances in non-invasive and invasive brain stimulation techniques have once again sparked renewed interest for its use to treat neurological and psychiatric disorders, its clinical efficacy and application are still unclear. In this chapter, we will highlight the current evidence for the efficacy of rTMS, tDCS and DBS as a treatment for neurodegenerative diseases. Further we will discuss some of the limitations with each method that may be used for future research and clinical considerations.

Transcranial magnetic stimulation in clinical neuroscience

Transcranial magnetic stimulation has emerged as a popular technique for treating physical, cognitive and behavioural symptomology in neurodegenerative disease. TMS is currently approved for treatment-resistant major depressive disorder (MDD) in many geographical locations including Australia, New Zealand, Japan, India, United States, Canada and Europe. Due to the non-invasive nature of this technique, scientists are continuing to uncover its therapeutic potential for relieving a range of symptoms in various neurodegenerative conditions, such as PD and Alzheimer's disease (AD).

The principles of TMS are derived from Faraday's law of induction, whereby a magnetic pulse is penetrated through the scalp perpendicular to a coil, eliciting a series of electrical currents. Traditional coils are circular or figure-of-eight in

design, enabling widespread and more focal stimulation of brain regions respectively (Rossini et al., 2015). Newer H1 coils have also been developed, which can penetrate deeper neuronal regions (Tendler, Barnea Ygael, Roth & Zangen, 2016). TMS can be delivered through single-pulse, paired-pulse or repetitive rhythmic stimuli. Single- and paired-pulse methods provide transient stimulation and are generally utilised for assessment of the corticospinal pathway. In contrast, rTMS modulates underlying neuronal activity that outlasts the stimulation period (Rossini et al., 2015), providing an environment for the induction of brain plasticity.

The desired outcomes from rTMS can be manipulated primarily through the stimulation frequency. Higher rTMS frequencies (≥ 5Hz) and intermittent theta-burst stimulation (iTBS) facilitate cortical excitability, whereas lower rTMS frequencies (≤ 1Hz) and continuous theta-burst stimulation (cTBS) suppress cortical excitability (Rossini et al., 2015). Animal models have also suggested a neuroprotective role of rTMS (Lu et al., 2017). Collectively, the ability to manipulate these parameters holds promise for individualising treatment and specifically targeting symptoms that result from altered cortical neurotransmission and neurodegeneration.

Repetitive TMS is safe, non-invasive and may come with less adverse effects than many available pharmacological treatments. The most commonly reported side-effects include mild headaches following stimulation and a tingling sensation on the scalp. There is also a small (0.1%) risk of experiencing a seizure, however, this risk is low in people without history of epilepsy and can be mitigated through appropriate screening and adherence to the current safety guidelines for frequency and intensity of stimulation (Rossini et al., 2015).

The first insights into the benefits of rTMS in people with PD began over 20-years ago (Pascual-Leone et al., 1994). Since then numerous reports have highlighted its potential as a non-invasive adjunct to conventional physical and pharmacological therapy. The cardinal motor signs of PD can be examined via the United Parkinson's Disease Rating Scale subscale III (UPDRS III) and have been the most studied outcomes following rTMS. Pooled data from over 636 patients has showed improved UPDRS III scores (Goodwill et al., 2017; Xie et al., 2015) and gait (Goodwill et al., 2017) following both high- and low-frequency rTMS over the primary motor, supplementary motor and premotor cortical brain regions. The most recent large-scale clinical trial demonstrated the efficacy of high-frequency rTMS over bilateral motor cortices to improve bradykinesia and rigidity, but gait and tremor remained unchanged (Brys et al., 2016). This finding is perhaps expected considering the differing pathophysiology underpinning hypo- and hyperkinetic symptoms observed in PD. In this context, facilitated cortical excitability through the application of high-frequency rTMS may compensate for reduced output from the basal ganglia to motor cortical areas that plan and initiate voluntary movement.

Low-frequency rTMS has the potential to target hyperkinetic symptoms of PD and reduce neurodegeneration (Dong et al., 2015). Several studies have shown low-frequency rTMS to be effective in relieving levodopa-induced dyskinesias

(Filipovic, Rothwell, van de Warrenburg & Bhatia, 2009; Sayin et al., 2014; Wagle-Shukla et al., 2007) and improving hand dexterity (e.g. buttoning up clothes) (Ikeguchi et al., 2003), however changes on the UPDRS scale have been variable (Filipovic, Rothwell & Bhatia, 2010; Shimamoto et al., 2001).

Despite majority of the research regarding rTMS and PD focusing on motor symptoms, cognitive and mood disturbances, which are observed in up to 50% of people with PD (Cosgrove, Alty & Jamieson, 2015; Reijnders, Ehrt, Weber, Aarsland & Leentjens, 2008), may also benefit from this type of brain stimulation. Pooled data from 312 patients showed high-frequency rTMS improved depression on two clinical scales, to a similar magnitude as that observed from antidepressant selective serotonin re-uptake inhibitors (Xie et al., 2015). Following that report, two large randomised controlled trials have also demonstrated high-frequency rTMS over the motor cortex and dorsolateral prefrontal cortex effectively reduced depressive symptoms in people with PD (Makkos et al., 2016; Shin, Youn, Chung & Sohn, 2016). There is currently insufficient evidence in support of rTMS on cognition in PD (Goodwill et al., 2017). Of the few published studies, most have reported no marginal improvements in neuropsychological performance (Benninger et al., 2012; Sedlackova, Rektorova, Srovnalova & Rektor, 2009) or mild cognitive impairment (Buard et al., 2018) following high-frequency rTMS over the motor and/or dorsolateral prefrontal cortex.

In addition to cognitive dysfunction associated with PD, rTMS has been identified as an efficacious therapy for people with mild cognitive impairment and AD. While its intended use is not to provide a cure, rTMS can modulate cortical networks in specific areas of cognitive processing and has been beneficial in improving cognitive functioning in patients with mild-moderate AD (Cheng et al., 2018). rTMS may also exert neuroprotective properties which aim to slow the progression of cognitive decline in people with AD, through upregulating brain-derived neurotrophic factor (BDNF) within the hippocampus (Yulug et al., 2017).

In a number of randomised controlled trials in AD, high-frequency rTMS applied over the dorsolateral prefrontal cortex improved naming ability (Cotelli, Manenti, Cappa, Zanetti & Miniussi, 2008), global cognition (Alcalá-Lozano et al., 2018; Zhao et al., 2017), episodic memory and verbal learning (Zhao et al., 2017) and activities of daily living (Ahmed, Darwish, Khedr, El Serogy & Ali, 2012). Preliminary evidence has also shown that these improvements in cognitive functioning can be retained up to a month post-treatment (Alcalá-Lozano et al., 2018). Longitudinal research is required to determine whether rTMS can be used to prevent cognitive decline and conversion from mild cognitive impairment to AD.

Repetitive TMS can also be applied as an adjunct to other therapeutic techniques, such as cognitive training (Bentwich et al., 2011; Nguyen et al., 2017; Rabey & Dobronevsky, 2016). Improvements on the Alzheimer's Disease Assessment Scale following high-frequency rTMS and cognitive training were also comparable to the magnitude of improvement seen from cholinesterase inhibitors (Bentwich et al., 2011). In some patients, improvements in cognition following high-frequency rTMS have lasted from up to nine to 12 months following

stimulation (Nguyen et al., 2017; Rabey & Dobronevsky, 2016), however retention may be unique to strong rTMS responders (Nguyen et al., 2017). Of note is the absence of control groups in these previous studies, which makes it difficult to distinguish whether the benefits are due to rTMS, cognitive training, the concurrent application of these techniques, or placebo effects. This promising evidence should be confirmed in larger randomised controlled trials.

Repetitive TMS has also been shown to improve other neuropsychological symptoms in AD. rTMS applied concurrent with antipsychotic medications resulted in improved cognition, behavioural and psychological symptoms (Wu et al., 2015). Moreover, in patients with mild cognitive impairment, high-frequency rTMS improved apathy symptoms, which is a predictor of conversion to AD (Padala et al., 2018). This preliminary evidence highlights the potential for rTMS to be utilised as a preventative technique in the early stages of mild cognitive impairment, which could delay or prevent the conversion to full-blown AD.

There is preliminary evidence regarding the benefits of rTMS to improve symptoms in multiple sclerosis (MS). MS is characterised by demyelination of nerve fibres and impaired neurotransmission; accordingly, most of the research has utilised high-frequency rTMS to target motor symptoms. In early small-scale studies, high-frequency rTMS over the motor cortex reduced spasticity (Centonze, Koch et al., 2007) and urinary dysfunction (Centonze, Petta et al., 2007), while improving hand dexterity (Koch et al., 2008) and working memory (Hulst et al., 2017). There are also reports of deep rTMS and iTBS reducing fatigue (Gaede et al., 2018) and spasticity, respectively (Mori et al., 2010). rTMS has also been prescribed as an adjunct to exercise therapy in this population, with reports of concurrent iTBS and exercise therapy yielding greater improvements in spasticity symptoms, physical function and quality of life than either modality alone (Mori et al., 2011).

There is insufficient available data to draw conclusions about the efficacy of rTMS in other neurodegenerative conditions such as motor neuron disease (MND) and Huntington's disease. Two case-reports have documented improvements in Huntington's disease-related chorea symptoms (Berardelli & Suppa, 2013) and anxiety, memory and physical pain (Davis, Phillips, Tendler & Oberdeck, 2016). Two small studies in people with ALS have reported modest-to-insignificant slowing of decline on the Amyotrophic Lateral Sclerosis Deterioration Scale following cTBS (Di Lazzaro et al., 2006, 2009), while high-frequency rTMS improved maximal strength and quality of life. Considering the lack of treatment or cure for these conditions, ongoing investigation into the benefits of rTMS to manage symptoms in these populations is warranted.

rTMS is a promising therapeutic tool that can be utilised alongside traditional physical and pharmological therapies to manage physical, behavioural and cognitive symptoms in neurodegenerative conditions such as PD and AD. Given the inherently large variability in outcomes following rTMS, individually prescribed protocols are needed to maximise the efficacy and clinically utility of this technique.

Transcranial electrical stimulation: old application, new uses

The main mechanism of tDCS acts by inducing a subthreshold shift in resting membrane potential towards depolarisation or hyperpolarisation of neurons. As a result, this shift in resting membrane threshold increases or decreases the likelihood of an incoming action potential to result in post-synaptic firing. For instance, when delivered to the primary motor cortex (M1) of healthy participants, anodal tDCS increases the excitability of the underlying cortical neurons of the M1, as measured by an increase in TMS-induced motor-evoked potential (MEP) amplitude, whereas cathodal tDCS elicits an opposite effect (Nitsche & Paulus, 2000). Moreover, the application of tDCS over several minutes may induce changes in excitability that can outlast the period of stimulation (Nitsche & Paulus, 2001). While in most of these seminal studies the M1 was the target, similar effects were found when tDCS was applied over the visual (Antal, Kincses, Nitsche, Bartfai & Paulus, 2004; Chaieb, Antal & Paulus, 2008) and somatosensory (Dieckhofer et al., 2006; Matsunaga, Nitsche, Tsuji & Rothwell, 2004) cortices.

Due to its highly portable nature and ability to induce sustained changes in cortical excitability, tDCS offers the potential to be used as an adjuvant therapy in a clinical setting. In clinical populations, most tDCS studies to date have focused predominantly on the use of anodal or cathodal tDCS to improve motor or cognitive outcomes in chronic conditions such as stroke (Marquez, van Vliet, McElduff, Lagopoulos & Parsons, 2015), PD (Elsner, Kugler, Pohl & Mehrholz, 2016; Goodwill et al., 2017) and AD (Hsu, Ku, Zanto & Gazzaley, 2015). Other clinical conditions, such as chronic pain (Vaseghi, Zoghi & Jaberzadeh, 2014), dystonia (Franca et al., 2018) and epilepsy (Regner et al., 2018), have also been investigated. Based on collective evidence from meta-analyses of tDCS literature, the application of tDCS in neurodegenerative disorders such as PD and AD showed a modest but significant improvement in motor and cognitive outcomes. However, these improvements were highly dependent on several factors that are not limited to stimulation type (anodal vs cathodal), stimulation intensity (0.5–2 mA), site of stimulation, disease severity and duration, functional status at baseline and the nature of motor or cognitive test that was used. It should be noted that the two biggest limitations in tDCS research to date are the lack of consistency and standardisation of stimulation parameters (i.e. electrode size and placement and stimulation intensity) and the relatively small sample sizes (between 20–40 participants) used in randomised controlled trials, which often limit the interpretation and generalisability of the results.

A major advantage of tDCS over any other non-invasive brain stimulation techniques is its portability and capacity to be delivered in conjunction with other forms of therapy. This represents an attractive option to clinicians and patients as it is both cost- and time-effective. The rationale of combining tDCS with conventional therapy (most often physical or cognitive therapy) is two-fold: (1) using

tDCS as a primer by increasing the brain's propensity to activate and (2) reinforcing accurate patterns of movement or cognitive activation through practice. Indeed, there is evidence to support the combined use of tDCS and cognitive/motor training as being superior to either tDCS or cognitive/motor training alone in a range of populations that include healthy subjects (Elmasry, Loo & Martin, 2015), people with PD (Lawrence, Gasson, Bucks, Troeung & Loftus, 2017) and AD (Hsu et al., 2015). Furthermore, studies in people with stroke suggest that combined tDCS with motor skills training may facilitate long-term retention of arm function than skills training alone (Goodwill, Teo, Morgan, Daly & Kidgell, 2016; Lefebvre et al., 2012).

While the vast majority of non-invasive transcranial electrical stimulation literature has so far focused primarily on tDCS, other variants of neuromodulatory electrical brain stimulation techniques such as transcranial alternating-current stimulation (tACS) and transcranial random-noise stimulation (tRNS) warrant discussion. Compared to tDCS, paradigms such as tACS and tRNS are considered to be true neuromodulation techniques as they are capable of eliciting functional changes in neuron activation. In particular, these hybrid forms of non-invasive transcranial electrical stimulation techniques have been designed to incorporate a 'temporal' application, much like rTMS, to induce a frequency-specific neuromodulatory effect that may be used to enhance or suppress neural oscillatory waves.

As the name implies, tACS produces a flow of electrical particles that alternates equally between the positive and negative charge (Paulus, 2011). This means that the net direct current component is zero and therefore, unlike tDCS, the aftereffects of tACS are not likely to be a result of polarity-specific neuromodulation. Instead the primary neuromodulatory effect of tACS appears to act by inducing frequency-specific neural entrainment of cortical oscillatory activity (see Teo, Hendy, Goodwill & Loftus, 2017 for brief review). In preliminary clinical studies, tACS has been used to attenuate resting tremors by up to 50% in people with PD by disrupting the timing of cortical oscillations responsible for resting tremors (i.e. cortical tremor frequency) (Brittain, Probert-Smith, Aziz & Brown, 2013). This was done by identifying and delivering tACS that would drift in and out of phase alignment with the cortical tremor frequency. A variation of tACS, known as tRNS, adopts the same alternating current principle (Terney, Chaieb, Moliadze, Antal & Paulus, 2008). However, instead of using a constant stimulation frequency and intensity throughout the duration of stimulation, tRNS uses a random stimulation frequency (between 0.1–640 Hz) and intensity (–500 to +500 mA) approach throughout the period of stimulation. This form of stimulation is thought to cause repetitive opening of sodium channels (Paulus, 2011) or cause an increase in sensitivity of neuronal networks to neuromodulation (Francis, Gluckman & Schiff, 2003). As with tACS, tRNS has only recently been applied to clinical populations to provide relief from pain in patients with multiple sclerosis (Palm et al., 2016), schizophrenia (Haesebaert, Mondino, Saoud, Poulet & Brunelin, 2014) and tinnitus (Joos, De Ridder & Vanneste, 2015).

Advances in deep brain stimulation in clinical neuroscience

The major neurotechnological advance in the treatment of PD over recent decades has been DBS. A highly invasive neurosurgical procedure requiring significant preparation, DBS for PD involves neurosurgical implantation of electrodes in one of two brain sites: the subthalamic nucleus (STN) or the globus pallidus interna (GPi) (Ramirez-Zamora & Ostrem, 2018). These electrodes are connected to a battery powered titanium device, the neurostimulator, that is implanted subcutaneously (typically below the clavicle) and connected via implanted leads. Although there are dopaminergic effects, the mechanisms of action for DBS are many and diffuse (Herrington, Cheng & Eskandar, 2016).

DBS is now a very well-established treatment, with tens of thousands of patients around the world having successfully undergone the surgery. DBS is intended to target cardinal motor symptoms of PD, and there have been several large-scale clinical trials reporting improvements in tremor, rigidity, bradykinesia, and quality of life equivalently for both target regions (Follett, 2010). While both sites appear to have similar effects on motor function, there are a number of differences in the broader effects exerted (Ramirez-Zamora & Ostrem, 2018). For instance, STN stimulation can produce a more rapid clinical effect, a reduced need for medication, and improvements in non-motor areas (e.g. depression, which affects up to 50% of people with PD; Gökbayrak, Piryatinsky, Gavett & Ahmed, 2014), while GPi may be better for bradykinesia and gait (Ramirez-Zamora & Ostrem, 2018). The decision as to where to implant the electrodes is often not entirely clear, and particular groups may favour stimulation of one site over another (ibid.).

While DBS is performed with respect to motor symptoms of PD, there have been reports of other beneficial effects, including non-motor domains. For instance, depression, which affects around 50% of those diagnosed with PD, has been reported as reduced in PD following DBS, although results are inconsistent. STN stimulation has also been linked to improved sleep quality (Eugster, Bargiotas, Bassetti & Michael Schuepbach, 2016).

Perhaps unsurprisingly given the invasive nature of this approach, there have been a number of adverse events associated with DBS. Intraoperatively, there is a small risk of a number of complications, including stroke, infection, or seizure. STN stimulation has been linked to increased gait freezing (Cossu & Pau, 2017; although see Schlenstedt et al., 2017), disruption of speech (e.g. articulation) (Aldridge, Theodoros, Angwin & Vogel, 2016), and impulsiveness (Callesen, Scheel-Krüger, Kringelbach & Møller, 2013). There have also been reports of increased suicide attempts after DBS, particularly for STN DBS (Voon et al., 2008). Cognitive decline has been inconsistently reported, more so for STN (Combs et al., 2015), although a recent meta-analysis suggests no difference between stimulation sites on most neuropsychological measures (Elgebaly, Elfil, Attia, Magdy & Negida, 2018). It is important to note that while DBS for PD has been associated with consistent benefits in the motor domain, there is much that we do not know about the full range of side-effects, and how to best predict these at an individual level.

The success of DBS for PD has led to the exploration of DBS for particularly intractable cases of some neuropsychiatric disorders. For instance, DBS has been performed for major depressive disorder (MDD), with electrodes implanted within one of several cortico-limbic pathway regions including nucleus accumbens, the ventral capsule/ventral striatum, the subcallosal cingulate, and the medial forebrain bundle (Fitzgerald & Segrave, 2015). A very recent meta-analysis found general support for the efficacy of sham-controlled DBS trials in MDD, but serious adverse events were common (Kisely, Li, Warren & Siskind, 2018).

DBS has also been performed for obsessive-compulsive disorder, Tourette's syndrome, and anorexia nervosa, with all showing some degree of promise (Graat, Figee & Denys, 2017). Needless to say, a highly invasive treatment such as DBS will only be considered where (a) there is a serious decrement in quality of life and/or risk of suicide and (b) conventional treatments, including psychotherapy, pharmacology, repetitive transcranial magnetic stimulation (rTMS), and electro-convulsive therapy (ECT), have proven ineffective or intolerable.

Concluding remarks

Advancements in brain stimulation technologies provide an exciting opportunity to reinstate motor and cognitive functions in people with neurodegenerative disease. Invasive techniques like DBS are typically reserved for cases that have been resistant to traditional physical and pharmacological treatment, while non-invasive methods (rTMS and TMS) can be prescribed as an adjunct therapy in the early to moderate stages of disease. Challenges still remain for the clinical utility of non-invasive brain stimulation, including homogenisation of research protocols and establishment of optimal stimulation parameters for targeting various symptoms. Importance should also be placed on longitudinal follow-ups to establish whether changes observed from experimental protocols generate lasting clinical improvements in people with neurodegenerative disease.

Abbreviations and glossary

AD	Alzheimer's disease.
ALS	Amyotrophic lateral sclerosis.
BDNF	Brain-derived neurotrophic factor. Protein implicated in learning, memory, and associated neuroplastic processes.
cTBS	Continuous theta burst stimulation. Form of high frequency, low intensity electromagnetic brain stimulation that typically produces an inhibitory neuroplastic response.
DBS	Deep brain stimulation. Invasive therapeutic brain stimulation technique that involves neurosurgical implanting of stimulating microelectrodes.
EMG	Electroencephalogram. Provides an index of corticospinal excitability.
GPi	Globus pallidus interna. Part of the striatum/basal ganglia that may be a target of DBS for Parkinson's disease.

iTBS Intermittent theta burst stimulation. Form of high frequency, low intensity electromagnetic brain stimulation that typically produces an excitatory neuroplastic response.

MDD Major depressive disorder.

MEP Motor-evoked potential. Response to single TMS pulse to motor cortex as measured via electroencephalogram.

PD Parkinson's disease.

rTMS Repetitive transcranial magnetic stimulation. Repeated delivery of non-invasive brain stimulation technique that involves the delivery of strong magnetic pulses to the scalp, which induces current in the cortex, and can produce lasting modulation of brain activity.

STN Subthalamic nucleus. Part of the basal ganglia (ventral to thalamus) that may be a target of DBS for Parkinson's disease.

tACS Transcranial alternating current stimulation. Non-invasive brain stimulation technique that modulates cortical activity by using oscillatory electrical stimulation in different frequency bands via scalp electrodes.

tDCS Transcranial direct current stimulation. Non-invasive brain stimulation technique that modulates cortical activity by delivering weak electrical current to the brain via scalp electrodes.

TMS Transcranial magnetic stimulation. Non-invasive brain stimulation technique that involves the delivery of strong magnetic pulses to the scalp, which induces current in the cortex and activates neurons and interneurons.

tRNS Transcranial random noise stimulation. Non-invasive brain stimulation technique that modulates cortical activity by delivering variable intensity and polarity electrical current to the brain via scalp electrodes.

UPDRS United Parkinson's Disease Rating Scale.

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12 Interventions for children with brain disorders

The goal of rehabilitation and intervention practices is to obtain the best outcome for the child/adolescent across cognitive, social, behavioural and functional domains. The primary aims of paediatric rehabilitation and intervention are to: (i) reduce the everyday consequences of impaired cognitive functioning (disabilities); and (ii) reduce the level of handicap (the extent these impairments impede successful re-entry into society), with the ultimate goal of community integration (Chevignard, Brooks, & Truelle, 2010; Wilson, 2000). In order to do this, the focus in the paediatric context involves working with both the child and the family to understand and treat impairments and to identify the link between impairments and functional or everyday difficulties (Catroppa, Anderson, Yeates, & Beauchamp, 2016; Ylvisaker, Szekeres, & Feeney, 1998).

The following discussion takes a generic approach to cognitive and psychosocial rehabilitation and intervention for children, with more diagnosis-specific information provided in earlier chapters. We will further structure content around models of intervention relevant to the child's primary contexts: (i) school, where we consider the neuropsychologist's role in the child's development and education; and (ii) home, where consideration is given to optimising parenting and parent mental health in the context of family burden associated with early brain insult.

In general, neuropsychology-orientated interventions within the child context are reported relatively infrequently, and the evidence base for such interventions is extremely small. Perusal of the increasing number of child neuropsychology texts identifies a lack of focus on this area, possibly due to the difficulties in initiating, maintaining and evaluating such activities. Further, there are relatively few rehabilitation facilities specifically designed for the treatment of children with early brain insults, in contrast to the large industry directed towards rehabilitation in adults. Rather, the focus in the paediatric domain is to reintegrate the child back to home and school as soon as possible. As a consequence, children and their families often struggle to identify appropriate intervention resources or they must access and 'case manage' piecemeal services, thus increasing family stress and burden. For children with developmental disorders (e.g., cerebral palsy, severe developmental

delay), early intervention services may be available that provide multidisciplinary treatment for physical and language impairments specifically. For children with serious acute brain insults (e.g., traumatic brain injury, stroke, tumour), once the child is medically stable and the parents are sufficiently informed regarding care requirements for the child, the goal is rapid transition back to the home environment. While intensive intervention and rehabilitation may continue to occur on an outpatient basis, this is most common in school-aged children, and such services tend to diminish as the child is well enough to return to school. Further, such services are more difficult to access for less severe early brain insults, and the more subtle or specific functional impairments associated with such insults (e.g., social impairments, executive dysfunction) will often go untreated.

School entry, reintegration and maintenance

In the context of early brain insult, entry or reintegration into the school environment is seen as an important step in recovery, and is initially aimed at enhancing socialisation and adjustment, even before the child is ready to benefit from the educational curriculum. Thus, the school becomes a de facto 'rehabilitation' provider, often despite any previous expertise in working with children with neurological impairments. The nature and degree of support provided within the school environment can be highly variable and will depend on the resources of the school and its staff, their attitude to accommodating children with special needs and the quality of liaison with rehabilitation staff. In optimal situations, the school, family and rehabilitation team work together, via regular school meetings and less formal contact, to provide an appropriate context and educational programme for the child. At this phase of the child's journey, the neuropsychologist will play an important role, being able to document the child's strengths and difficulties in a holistic way and with reference to normative data.

For very young children, the most accessible supports are usually provided through community-based early intervention services. These tend to have a focus on maximising development in speech and language and motor domains, with behaviour management support where necessary. Few such services will incorporate neuropsychology expertise.

The neuropsychologist may take on a number of roles in the context of the child's school experience. At the point of school entry, the neuropsychologist is often involved in contributing objective assessment data, in accordance with local educational policies, to support applications for educational assistance and/or special conditions. Possibly the most critical task, however, is the communication of medical and assessment data in a manner appropriate and useful for the school context. Rourke, Fisk and Strang (1986) describe a model for such a process, suggesting that relevant factors for consideration include: (i) the types of skills impaired; (ii) the number of skills impaired; (iii) the degree of impairment; (iv) the child's capacity for adaptation; and

(v) the quality of intact abilities. These factors then need to be integrated with the demands of the child's environment, both academic and social. The treatment goals formulated need to take each of these elements into account in order to design a realistic and feasible programme. In particular, in order to maintain a positive approach, the child, family and teacher/therapist all need to be able to observe improvements in line with documented goals. While this model is primarily presented from a cognitive perspective, it may also be extended to incorporate social and behavioural features of the child's presentation, enhancing its utility.

The neuropsychologist's role is to inform teachers of the child's neurobehavioural strengths and weaknesses and the way these might be displayed in the classroom or playground. As previously discussed, common issues for the child with an early brain insult may include attention and learning difficulties, slowed speed of processing, emotional dysregulation and social and executive deficits. From a behavioural perspective, symptoms such as fatigue, irritability, mood lability, poor impulse control and adjustment problems may also be present. Each of these problems will impede the child's efficient functioning within the school environment. Impairments in such functions may cause the child to exhibit vagueness and distractibility, impulsivity, difficulties listening to and acting on instructions, inability to commence or complete work without assistance and supervision, poor organisation and reasoning, inability to complete work within given time frames, low frustration tolerance and inappropriate social interactions or social isolation. Without detailed knowledge of the child, teachers may interpret such behaviours in terms of laziness or poor motivation, rather than as consequences of brain insult. However, with appropriate guidance, the classroom environment and teacher expectations may be modified to accommodate the child's needs, leading to a more sympathetic and supportive situation.

The neuropsychologist may also contribute to the development and evaluation of specialist educational and behavioural programmes, using the knowledge gained from assessment and combining this with the skills of educational specialists to design realistic methods and goals. At a generic level, the neuropsychologist can assist in developing a programme in the context of the child's cognitive strengths and weaknesses that emphasises: (i) the importance of understanding the demands of the child's environment; (ii) setting realistic and achievable therapy goals; and (iii) providing the child and those working with him/her with regular feedback on progress. Such a model argues for the importance of ongoing review and follow-up to monitor recovery, measure the benefits of intervention and review and adapt goals. A secondary advantage of this type of involvement is the availability of long-term support for the child, family and school. Thus, child neuropsychologists often play a less 'hands-on' role in acute rehabilitation, but are more involved in liaison and consultation within a multidisciplinary team and in later school and family consultation.

In contrast, in some cases, particularly where return to school has been traumatic the neuropsychologist may institute specific therapies. Optimally, such programmes would have a defined evidence base or be evidence informed and would usually focus on specific areas such as memory, attention and social skills, with other therapists involved in language and physical rehabilitation. Group therapy techniques may be particularly beneficial for children, enabling them to interact with other children with similar difficulties, an opportunity frequently unavailable in the school situation.

For children with severe developmental disorders, such as cerebral palsy or language disability, interventions may be in place from early childhood. Formal early intervention programmes are commonly available within the community, providing resources such as physiotherapy, occupational therapy and speech therapy. Neuropsychological assessment is often delayed until relatively late in this process, usually just prior to school entry, when the child is able to participate in a full range of test procedures. Other less severe developmental disorders, such as learning disabilities, may not be detected until middle childhood, with neuropsychological assessment providing important information to direct interventions and treatments (Robinson, Kaizar, Catroppa, Godfrey, & Yeates, 2014).

Social and behavioural problems may occur in the school environment. In fact, children with early brain insult and developmental disorders are at elevated risk of social isolation and behavioural difficulties for a variety of reasons: physical limitations, cognitive impairments, inappropriate social skills, impulsivity and poor self-regulation, challenging behaviour or adjustment problems. They may experience reduced confidence and self-esteem, finding it difficult to become involved in peer interactions. Resultant restriction in opportunities to learn and practise social skills is likely to further impede social development and social interactions. A range of interventions may be helpful within the classroom and playground, depending on the specific situation. In some instances, it may be beneficial to discuss the child's medical condition with the class (e.g., for the child with uncontrolled epilepsy) in order to demystify any unusual aspects of the child's presentation. The child may be linked to a supportive group of peers or playground activities may be structured to ensure inclusion of the child. Where the child's behaviours are unacceptable, there may be a need to institute behaviour modification techniques, encouraging the child to establish appropriate behaviours. In such instances, direct classroom observation may be a powerful approach for the neuropsychologist, where they are able to identify teacher-reported problem behaviours, explore more positive classroom behaviours and relationships and consider precipitating factors (e.g., classroom structure, peer interactions). These elements can then be integrated into well-informed behaviour management programmes and environmental modifications or lead to further specific referrals (Crowley & Miles, 1999; Feeney & Ylivasaker, 2003).

The family environment

The scope of rehabilitation and intervention following early childhood insult also needs to address family issues. Once again, the neuropsychologist can contribute, combining knowledge of the likely behavioural and social effects of brain insult with an understanding of normal development and adjustment responses and the role of the family in these domains.

Within the family context, family dynamics may be influenced by the persisting trauma around the child's diagnosis or injury (Muscara, Burke, McCarthy, Anderson et al., 2015; Muscara, McCarthy, Woolf, Hearps et al., 2015), loss of the child parents once had and concern about the future or the often substantial ongoing burden associated with caring for a child with early brain insult or serious developmental difficulties. The need to access and maintain appropriate rehabilitation/remedial resources, the additional attention required for care of the child, financial concerns, the stigma of the child's problems and the constant stress of containing problem behaviours may lead to significant pressures on the family unit (Brown, Whittingham, Boyd, & Sofrenoff, 2013). Neuropsychological support and advice may reduce some of these problems, but regular follow-up and family support are commonly required. Such follow-up is helpful in identifying difficulties before they reach crisis level and helping families through difficult developmental transitions. In our clinical experience, neuropsychological intervention, including family counselling or the implementation of behavioural management techniques, is often sufficient to treat and manage these issues. However, appropriate referrals for more specialised therapy may also be necessary.

Models of child-focused neuropsychological intervention

There is ongoing debate with respect to the most efficacious approach to child rehabilitation after early brain insult. Some advocate for an integrated, context-sensitive model, in which optimal quality of life of the child (and family) is the critical goal. The rehabilitation team, in collaboration with the patient, works dynamically, focusing on the most important intervention domain at any particular time in the context of the child and family's overall well-being. For example, acute rehabilitation is often focused primarily on mobility and communication, with chronic interventions targeting cognition, behaviour and social problems as they emerge.

Specific intervention approaches, such as goal-attainment frameworks, direct instruction or self-monitoring, may be implemented. To date, a review of the literature indicates little evaluation of such 'holistic' approaches, possibly because of difficulties parcelling out the relative contributions of the variety of strategies that might be incorporated. Despite these limitations, anecdotal evidence suggests that this approach has wide support from clinicians.

Neuropsychological approaches to rehabilitation and remediation for children with either acquired or developmental brain disorders usually fall into

two broad categories: *substitution* and *restoration* of function. Each perspective attempts to minimise the consequences of neurobehavioural impairments and maximise the opportunity to utilise the child's strengths. In general, specific programmes are not usually adopted, but rather interventions are customised to the child's needs, acknowledging the variability in neurobehavioural function present in children with brain dysfunction. In many instances, adaptation and compensatory approaches will be instituted in conjunction with other specific interventions, such as reading intervention or speech therapy. Thus, the child will be working on specific deficits, but within an environment where he/she can utilise cognitive strengths or develop strategies to circumvent problem areas.

Substitution of function

Perhaps the most popular approach to neuropsychological rehabilitation and intervention is to train and support individuals to perform various activities using alternative strategies or to modify the child's environment, enabling the person to compensate for their cognitive deficits and thus lessen the functional impact of the impairment (Catroppa, Anderson, Beauchamp, & Yeates, 2016). Successful implementation of adaptation and compensation techniques relies on a thorough understanding of the child's abilities and the way these interact with the environment and depends upon effective links among health professionals, home and school. Of note, such methods are most beneficial when less severe impairment is present. The more global and severe a child's deficits, the more difficult it is to identify an intact modality to use in the design and implementation of compensatory strategies. In addition to compensatory behavioural approaches, which emphasise changing cognitive strategies, the provision of external aids or cues such as lists, diaries or alarms may be helpful. For example, if the child has difficulty working unsupervised, then extra teaching support may be provided. If there is a problem with rate of output, the child's workload may be adjusted accordingly, with a reduction in the proportion of set tasks to be completed. In examinations, children may be given extra time or, if the problem is specific to motor skills, allowed access to a computer. From a behavioural perspective, if the child is easily fatigued, then classes may be shortened or the child may have the option of taking a break when required. Alternatively, the child might start or finish school early or have a day at home each week. Such procedures minimise the frustration for the child, ensuring that the learning and social environment is as accessible and rewarding as possible.

With respect to specific cognitive impairments, a child who has difficulty maintaining concentration in noisy environments may be seated close to the teacher. If a literacy disability is present, the child will not be asked to read aloud in class or copy work from the blackboard. Similarly, a child who exhibits a severe memory deficit may be trained to use a diary or other memory aids (e.g., Wilson, Emslie, Quirk, & Evans, 2001). In the school

situation, this may improve the likelihood that the child will 'remember' homework requirements and special events. Where executive deficits are observed, tutoring in research and study skills may be helpful to assist in developing effective study strategies and to provide a set of clear steps for the child to follow in complex or lengthy tasks (e.g., essay writing). If there is a problem with rate of output or with fine motor skills, the child may be tutored in word processing skills. Where arithmetic abilities are depressed, use of a calculator may be appropriate, or if a reading disability is present, the child might be encouraged to use audiotaped books or to dictate notes rather than write them down.

A number of studies have suggested that application of these techniques is related to improved skills (Catroppa, Anderson, Yeates, & Beauchamp et al., 2016; Mateer, 1999). Until recently, however, external cueing has not been found to be a particularly successful approach for younger children, but was thought to be of potential increasing benefit as children reach adolescence and develop the skills necessary to use these methods independently to enhance memory and retention. Wilson and colleagues (2001) have challenged this view in a randomised controlled trial that showed that children as young as eight years of age were able to benefit from a computerised reminder intervention programme ('Neuropage'), demonstrating increased ability to recall important events and information when accessing this system. Further support for the efficacy of this approach has been provided in a study by Selznick and Savage (2000). These authors recruited three adolescents with a history of brain injury and trained them with respect to on-task behaviour and self-regulation using an auditory cueing paradigm. Outcomes from the intervention suggested enhanced capacity on the target behaviours.

Restoration of function

Substitution approaches contrast with the more 'direct' approaches taken by other disciplines, such as physiotherapy, speech therapy and reading training, where interventions specifically address the deficient process. If the goal is to *restore* function, methods will focus on improving the individual's capacities (e.g., attention- retraining paradigms) by re-establishment of impaired functions. *Restorative interventions* are designed to treat the consequences of brain insult. Such approaches require an initial evaluation to identify impaired abilities. The child is then trained using specific exercises/activities focusing on deficient cognitive abilities in an attempt to improve these skills, as well as to impact more generally on cognitive functions. Here, the child's weaknesses are the focus of treatment, and the goal is to develop these skills to normal levels via training of the deficient skills. Similarly, there is a range of more 'indirect' methods available that avoid the impaired skill, providing training for peripheral skills. The underlying assumption is that the child's specific deficit is due to a problem in a related skill area. For example, in the learning disability field, sensorimotor integration programmes are commonly employed, with

the rationale being that an improvement in sensorimotor skills will lead to increased reading proficiency. Other commonly employed approaches include dietary interventions, such as reducing sugar intake and food additives, and the use of biofeedback. Some of these methods have been incorporated into treatment regimens for children with acquired disorders, although the outcome of such interventions has been poorly evaluated and efficacy remains unclear (Robinson, Kaizar et al., 2014).

Evaluation of interventions

Choosing an intervention

A range of intervention programmes have been developed to treat specific cognitive and behavioural impairments in the context of early brain insult. A review of the literature suggests that many evidence-based interventions have been developed for specific diagnostic groups, mostly developmental disorders such as attention deficit hyperactivity disorder (ADHD) or intellectual disability. Despite their proven efficacy, clinicians and researchers are often reluctant to implement such interventions outside the tested diagnostic group, with a tendency to assume that each group requires specifically tailored treatments. However, while this is likely the case for medical interventions, it is not clear that diagnostic-specific interventions are required for cognition and behavioural difficulties following early brain insult. As discussed in previous chapters, regardless of diagnostic label, there are many common cognitive and behavioural characteristics evident in children with early brain insult. Information processing problems – attention, processing speed, executive skills and learning deficits – are especially common and provide common targets for intervention. Similarly, the literature suggests that problems with social participation, inattention, overactivity and emotional regulation are also hallmark behavioural features. With this in mind, we would advocate that clinicians' choice of interventions should be based on several considerations.

Evidence-based treatment

Wherever possible, application of evidence-based interventions represents best practice. Interventions that have been tested through high-quality trials should be a clinician's first choice. Usually, such interventions have been manualised or their contents described in great detail, and they are supported by high-quality research methods, such as randomised control trials or multiple baseline case series, with rigorous methodologies. Thus, a clinician is able to replicate these methods with confidence or modify intervention content to the specific needs of their patients. For example, in our team, we have recently conducted a study in children with ADHD and anxiety (Mulraney et al., 2018) using a modified version of Cool Kids (Rapee, Lyneham, Schniering, Wuthrich et al., 2006), an evidence-based intervention developed to treat

typically developing children with anxiety disorder. Preliminary findings suggest significantly reduced anxiety in the ADHD groups. In a second study in our lab, Cool Kids has been modified for adolescents with traumatic brain injury, once again with successful outcomes (Soo, Tate, & Rapee, 2012). Unfortunately, in the field of early brain insult, there are few interventions that meet these standards (Robinson, Kaizar et al., 2014).

Choosing such evidence-based options, however, is often not a practical option. In some cases, there is no such treatment available and so clinicians will need to develop their own treatment methods, with reference to routine best practice or based on relevant literature, including published case studies. Further, while delivery of evidence-based treatment is optimal, there may be important limitations to the findings from these studies. Firstly, findings may be based on unrepresentative samples. This is particularly true where interventions require a substantive time commitment from children and families or where families need to attend a central location. In such cases, participating families may be those who are well functioning and with sufficient resources (financial, social) to attend. In such instances, outcomes may not be representative of the range of children needing treatment and may selectively exclude the most impaired children. Additionally, available evidence-based paradigms tend to be largely silent with respect to timing of interventions (e.g., acute versus chronic post-injury) and dose (number of session, duration of sessions) required to achieve benefits and frequently choose evaluation measures with limited ecological validity.

Clinicians may consider identifying evidence-based interventions that minimise inconvenience to families. For neuropsychologists, this may mean those targeting the school context and implementing environmental modifications or assisting in the design of other education-based programmes. Alternatively, with the advent of e-health options, the possibility of provision of treatment within the home context may provide a practical alternative. We have found this approach particularly useful when providing parenting or parent mental health support for parents of children with early brain insult. Offering clinician facilitated, psychological interventions via iPad or Skype and outside working hours may increase engagement in and completion of treatment, and also facilitate both mother and father involvement (Rayner, Dimovski, Muscara, Yamada et al., 2015; Rayner, Muscara, Dimovski, McCarthy et al., 2016). Where less serious problems are present, family/child-directed online treatments (e.g., Wade, Carey, & Wolfe, 2006; Wade, Wolfe, & Pestian, 2004) may also be useful.

Critical evaluation of evidence-based interventions should also consider the outcomes that have been measured. Traditionally, the outcome measures employed to assess the benefits of treatment have been limited to standard clinical tools. For example, an intervention targeting attention skills might employ a specific clinical attention measure as its index of success, but fail to evaluate whether treatment has provided any improvement in real-world function or generalised to other related skills. Optimally, evaluation of success should be

more broadly based. In particular, improvements in functional ability, such as an ability to concentrate better in class or to complete an activity without distraction, might be better indices of treatment success. While randomised controlled trials are considered the gold standard in the treatment domain, for child neuropsychology, reference to well-designed multiple baseline case series can also provide high-quality information. Such studies are designed to carefully detail children's function pre-intervention, during intervention, across treatment conditions and post-treatment. Such rich information can be particularly informative in the context of early insult, where children vary with respect to specific strengths and weaknesses, psychological status and home/school context.

Interventions also need to focus primarily on the needs and goals of the child and family. Goal-attainment approaches provide a good illustration of this approach, where the clinician does not simply impose an intervention model and related goals on the child and family, but rather works together with them as a team to determine what goals are most important.

Cognitive interventions

In the context of early brain insult, neuropsychological interventions targeting cognition most commonly target attention, memory and new learning and aspects of executive function. Such cognitive interventions tend to occur over a series of sessions and involve both instruction and practice in the targeted skill domain. Therapists generally work directly with the child, although technological advances have led to an increase in home-based, computer-delivered programmes. Commonly, therapy is supplemented by homework activities that may involve parent supervision or participation (Robinson, Kaizar et al., 2014). Benefits of treatment to date have mostly been measured via standard psychometric test performances, with less focus on assessing the more global impact of intervention in the child's day-to-day life.

Within the child neuropsychology domain, the majority of cognitive intervention studies to date have focused on improving attention. Although there is little evidence specific to children, studies evaluating the impact of attention training in survivors of childhood cancer have shown positive results, at least with respect to specific training measures (Butler, Copeland, Faircough, Mulhern et al., 2008). Similarly, Brett and Laatch (1998) found improved 'training test' performance and increases in neuropsychological scores after implementation of a cognitive intervention focused on the development of metacognition. Ogberg and Turktra (1998) used an elaborate encoding paradigm with two severely injured adolescents and demonstrated improvements on a trained task post-intervention, while in a single case study, Lawson and Rice (1989) reported improved list learning ability after direct training. Unfortunately, these studies have not included outcome measures that tap into improvements in everyday activities, and thus it is

unclear whether these findings can generalise to other cognitive domains or to daily functions.

In a rare randomised controlled trial conducted in Sweden, van't Hooft and colleagues (2005; 2007; 2010) provided the best evidence to date for the efficacy of cognitive interventions for children with acquired brain injury. In this study, researchers conducted weekly training intervention sessions (30-minute sessions over 17 weeks) to enhance children's attention skills. While little benefit of the intervention was seen on standardised neuropsychological test measures, improvement was evident from pre- to post-intervention on functional and self-report measures, highlighting the importance of employing appropriate outcome measures that are relevant to day-to-day functioning in intervention research (van't Hooft, Andersson, Bergman, Sejersen et al., 2005, 2007; van't Hooft & Norberg, 2010).

Unfortunately, child-directed measures of functional ability are few. In our lab, we recently piloted an open-ended ecological task of executive functions in children, the 'Children's Cooking Task' (Chevignard, Catroppa, Galvin, & Anderson, 2010). Twenty-five children with mild or moderate-to-severe acquired brain injury and 21 matched controls (aged 8–20 years) participated in this open-ended cooking task, which required the preparation of two simple recipes using specific instructions. Outcome measures included number of errors made and an overall qualitative analysis of the task. The Children's Cooking Task was found to have good inter-rater and test–retest reliability, as well as good discriminant and concurrent validity. Due to the robust psychometric properties of the task, as well as its ecological approach and appeal and feasibility with children and adolescents, this approach offers an evidence-based method for assessing benefits of intervention within a more 'real-life' context.

Within the memory domain, the effectiveness of a programme for the remediation of memory difficulties has been investigated by Ho and colleagues (2011). They enrolled 15 children with a history of acquired brain insult in a programme that consisted of six sessions and included diary training, self-instruction and case examples. Post-treatment, children were better able to perform daily routines where they were required to recall information and events, and also used their diaries more frequently, providing preliminary evidence for the efficacy of the intervention (Ho, Epps, Parry, Poole, & Lah, 2011). In general, though, and despite memory difficulties being common following early brain injury, Lajiness-O'Neill, Erdodi and Bigler (2010) found that evidence-based intervention was lacking. These authors suggested that best practice should include systematic instructional methods in a context-sensitive approach with relevance to everyday life, which will assist with the maintenance of skills, and opportunities for generalisation of learned skills.

A recent systematic review (Robinson, Kaizar et al., 2014) of randomised controlled trials for cognitive interventions in children with developmental and acquired disabilities reports overall small but positive benefits. These authors found that most interventions targeted multiple cognitive skills (e.g.,

attention, working memory, new learning, inhibitory control) and used a variety of treatment doses, timings, delivery methods and outcome measures. They found medium to large effect sizes overall, representing post-treatment improvements, on child-directed attention tasks (0.86), working memory tasks (0.76), memory tasks (0.95) and inhibitory control measures (0.59), but no change on rating scales of attention and working memory, nor on academic measures. The authors note that positive results were mostly due to the good outcomes reported by van't Hooft and colleagues (2007), with improvements less evident in all other studies reviewed (Butler et al., 2008; Gibson, Gondoli, Johnson, Steeger et al., 2011; Gray, Chaban, Martinussen, Goldberg et al., 2012; Green, Long, Green, Iosif et al., 2012; Johnstone, Roodenrys, Blackman, Johnstone et al., 2012; Johnstone, Roodenrys, Phillips, Watt, & Mantz, 2010; Klinberg, Fernell, Olesen, Johnson et al., 2005).

In summary, some advances have been made in the management of child-focused intervention for cognitive sequelae in areas including executive functioning, attention and memory. While results are inconsistent, these programmes show promise in the prevention or reduction of cognitive impairments, but require a stronger evidence base to establish efficacy and to support implementation into clinical practice.

Social and behavioural interventions

Social and behavioural difficulties are often present in children with early brain insult and developmental disorders and can make participation in everyday life challenging. Intervention strategies in this area may be targeted at the child and include behavioural approaches such as reinforcement, shaping, modelling, cueing, use of contracts, self-monitoring, anxiety-managing strategies, relaxation techniques, didactic class activities and use of peer models. Parent or family-based interventions have also been shown to be clinically useful in reducing the child's problem behaviours, increasing child participation and decreasing parent mental health symptoms. However, despite the knowledge of possible intervention techniques, there is minimal research supporting their efficacy with children to date, and future research is needed to assist clinicians in identifying evidence-based treatment approaches.

Child-directed approaches

Feeney and Ylvisaker (2003) have contributed significantly to this area, investigating the efficacy of cognitive behavioural interventions for young children with brain insults who present with challenging behaviours, as well as organisation and planning problems in the classroom. Their model focuses on: (i) daily routine; (ii) positive momentum; (iii) reduction of errors; (iv) escape communication; (v) adult communication style; (vi) graphic advance organisers; and (vii) goal–plan–do–review routine, with staff trained in a number of these areas. Implementation of interventions based on these principles has consistently shown that challenging behaviours significantly

decrease in intensity and frequency, with maintenance of skills in the longer term. Similarly, Mottram and Berger-Gross (2004) used a behavioural intervention programme (e.g., programme rules, token economy) and documented clinically significant decreases in disruptive behaviours during the intervention and at follow-up.

In our lab, an intervention is in progress with the goal of adapting and trialling a cognitive behavioural therapy (CBT) programme, Cool Kids (Rapee et al., 2006), for managing social anxiety (Soo, Tate, & Rapee, 2012). A pilot study of the effectiveness of this adapted Cool Kids programme has also been completed and a larger randomised controlled trial has been commenced. A case study describing the outcomes for one of the adolescents who has participated in the pilot study is given in Table 12.1.

Parenting programmes

The 'Signposts for Building Better Behaviour' programme (Gavidia-Payne & Hudson, 2002) has proven successful with families of children with intellectual and developmental difficulties, and more recently in the context of acquired brain insults (Brown, Whittingham, & Sofronoff, 2015; Woods, Catroppa, & Anderson, 2012; Woods, Catroppa, Godfrey, Anderson et al., 2014). The programme, based on a cognitive behavioural (CBT) approach, aims to provide support and teach strategies to families of children with acquired brain injury in order to prevent and reduce challenging behaviours (e.g., disruptive behaviour, poor social skills). Details of the programme's content are provided in Table 12.2. In our study, we recruited 48 parents of children with acquired brain insults aged between 3 and 12 years with mild to severe injuries, who received the intervention in face-to-face (n = 23) or telephone-support (n = 25) format. All parents approved of the skills taught and a majority felt the materials were helpful for both managing behaviour and teaching new skills. The programme was reported to reduce the number of challenging behaviours in injured children and lower parental stress and family burden. Results indicated that Signposts was most effective for children with more severe brain insults, in whom improvement was evident for child behaviour immediately post-treatment and maintained to 18 months. Of note, there was also reduction in parent stress, as illustrated in Table 12.3 (Woods et al., 2014).

Another approach to involving the family actively in their child's care is to provide parents with training to improve the outcome of an implemented intervention. One of the earliest methodologically robust studies using this method was conducted by Braga, Da Paz and Ylvisaker (2005) to examine the effectiveness of family-based rehabilitation for children with early brain insult. These authors explored the effectiveness of a clinician-delivered versus a family support intervention for post-acute consequences of early brain insult. The intervention involved training parents to provide rehabilitation within the home setting and provided parents with a range of support resources. Both groups showed improvement, but only those with family

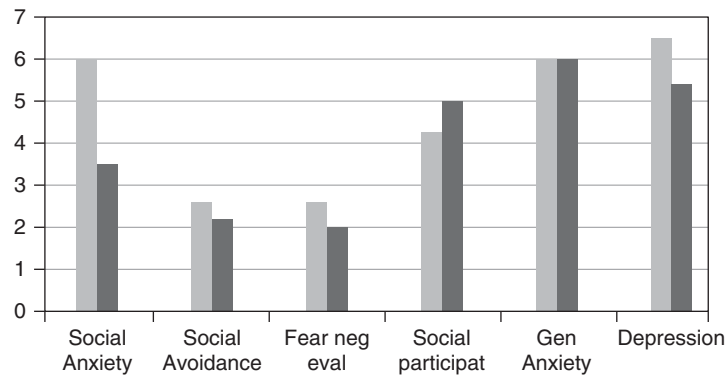
Table 12.1 Case study 5

Daniel: intervention for social anxiety

Injury history: Daniel is a 15-year-old boy with a history of acquired brain injury at age ten, which was associated with right frontal pathology. Daniel was referred for treatment of newly developed social anxiety. Of note, he reported no pre-insult anxiety or social difficulties. At the time of referral, Daniel noted that he was coping well academically and with daily living activities, but felt unable to participate in school sports and could not go to crowded places because of high levels of anxiety. He also reported persistent excessive fatigue.

Intervention goals: Daniel identified that his goal for intervention was to reduce his anxiety in social situations so that he could be more involved in sports and join his friends when they went to the local shopping centre.

Intervention outcomes: Daniel completed all 11 session of the Cool Kids Adolescent Anxiety programme via Skype, as he lived several hours from the outpatient clinic. Below are his results on standardised questionnaires for pre-treatment (dark bars) and post-treatment (light bars). Daniel's ratings suggest that he perceived improvements in his function in areas of social anxiety, social avoidance and fear of negative peer evaluation. There was also a small decrease in depressive symptoms. At interview, Daniel noted other benefits from Cool Kids that were not tapped by the study questionnaires including being proud that he had been able to meet the goals that he had set for himself and feeling more confident. In particular, he reported feeling subjectively less anxious and better able to participate in school sports and spend time with his friends in his local shopping centre.



support demonstrated significant improvements in both physical and cognitive domains. Similarly, Arco and Bishop (2009) reported on a number of case studies where parents were trained to use positive behaviour support in the home. As with Braga et al.'s work, parents, with the assistance of the health professional, participated in observations and assessment of their child's behaviour problems and in the planning and implementation of the intervention. Glang, McLaughlin and Schroeder (2007) trained parents of children with brain injury in educational advocacy skills using an interactive,

Table 12.2 Signposts pilot programme for an acquired brain injury population

Evaluation
☐ Content evaluation: Aims appropriate
☐ Input evaluation: Skills and information presented were useful
☐ Process evaluation: Parenting strategies and training methods appropriate
☐ Product evaluation: Signpost programme application evaluated

Feedback
☐ More focus on skills training for parents in the areas of:
  – Social skills for their children
  – Communication skills with their children regarding behaviours
  – The development of routines

Areas in which more information is needed
☐ Identifying links between cognition and behaviour
☐ Parent–child adjustment

Results
☐ Child: Improvement in all areas of function and decrease in inappropriate behaviours
☐ Parents: Improvement in parenting satisfaction and decrease in parenting hassles

Table 12.3 Child behaviour, parent function and family function for mild acquired brain injury group (n = 9)

Characteristic	*Pre-intervention*	*Post-intervention*	*6-month follow-up*	*18-month follow-up*
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
CBCL				
Internalising	48.78 (12.4)	45.78 (11.8)	43.89 (10.0)	48.89 (12.5)
Externalising	48.89 (12.5)	45.67 (12.1)	44.44 (11.7)	46.00 (12.5)
Total	49.44 (13.1)	45.33 (13.1)	44.00 (10.2)	46.00 (10.2)
PS				
Total	3.07 (0.80)	2.16 (0.56)	2.25 (0.70)	2.16 (0.37)
DASS				
Total*	15.78 (14.5)	6.44 (7.23)	13.11 (17.5)	12.44 (7.1)
FAD-GF	1.84 (0.44)	1.93 (0.23)	1.96 (0.47)	1.97 (0.32)

*$p < 0.05$, post-intervention vs. 18 months
CBCL: Child Behavior Check List; PS: Parenting Scale; DASS: Depression Anxiety Stress Scale; FAD-GF: Family Assessment Device – General Functioning

multimedia intervention. Those parents in the treatment group scored higher in the areas of application, knowledge and attitudes in comparison to the control group. Further, as mentioned above, CBT paradigms for parenting, such as Signposts, also show promise in reducing children's problem behaviours and improving family functioning (Woods et al., 2014). Taken together, these results suggested that this parent-implemented approach is effective.

Using web-based technology, Wade and colleagues examined the feasibility and efficacy of a web-based family intervention concerned with problem-solving skills for children and adolescents post-traumatic brain injury, with results suggesting it held promise for reducing child behaviour and adjustment problems post-injury (Wade, Carey, & Wolfe, 2006; Wade, Michaud, & Brown, 2006; Wade, Walz, Carey, & Williams, 2008; Wade, Wolfe, & Prestian, 2004). Improvements were found in parent-reported adolescent internalising behaviours, self-reported adolescent depressive symptoms, parental depression and parent–adolescent conflict, providing evidence for the efficacy of this approach with an older age group (Wade et al., 2008). With a focus of parental outcome, this web-based intervention was also found to reduce stress, anxiety and depressive symptoms and to facilitate parental adaptation in families of children with moderate-to-severe TBI (Wade, Wolfe, Brown, & Pestian, 2005).

In 2009, Cole and colleagues published a review of family intervention guidelines for paediatric acquired brain injuries. The findings identified psychological distress in carers and siblings of a child post-brain injury and showed that family functioning also impacted on the injured child's recovery. Guidelines were developed to guide those implementing interventions at a family level and included: the selection of developmentally appropriate interventions; matching between the intervention and the family; provision of advocacy and injury education; focusing on family readjustment; modifications to the child's environment; and provision of skills training to the child and the family. As family-based intervention studies are few, these guidelines were described as theoretically derived, rather than evidence based, requiring more empirical evidence to support their efficacy (Cole, Paulos, Cole, & Tankard, 2009).

Parent mental health interventions

To date, the focus of intervention in the early brain insult literature has been largely on approaches that will directly benefit the child, even where the family is the target of treatment (e.g., parenting interventions, psychoeducation). In our lab, we have recently implemented approaches that target parent mental health directly, based on literature demonstrating that: (i) a child's diagnosis or injury represents a traumatic event, which may lead to the development of acute stress disorder or more persistent post-traumatic stress symptoms in vulnerable families; and (ii) better parent mental health has been linked to better child outcomes. Our intervention approach, Take a Breath (Rayner et al., 2015; 2016), utilises an acceptance commitment therapy (ACT) framework, which supports parents to identify their core values and to keep these in mind while dealing with the various challenging aspects of their child's illness or recovery. Take a Breath is conducted after completion of acute treatment and hospitalisation, when the family has returned home and re-commenced their normal routines. The intervention is delivered by two trained facilitators over five 90-minute group-based sessions and via video-conferencing and

Table 12.4 Pilot data from Take a Breath parent mental health study

	Pre	*Post*	*6 months*	*P-value*
Traumatic stress	41.5 (8.0)	31.3 (10.0)	27.4 (9.7)	<0.001
Guilt and worry	2.5 (0.6)	1.9 (0.5)	1.8 (0.5)	0.003
Unresolved sorrow/anger	1.8 (0.4)	1.3 (0.4)	1.2 (0.4)	<0.001
Cognitive defusion	6.5 (1.2)	7.2 (0.9)	7.6 (0.6)	0.005
Experiential willingness	4.0 (0.7)	4.5 (0.7)	4.6 (0.6)	0.08
Acceptance	5.3 (0.7)	5.8 (0.7)	6.0 (0.7)	0.02

usually after work hours in order to encourage father involvement and to facilitate participation by parents distant from the city or who may not wish to return to the hospital environment. Early results from our pilot studies have demonstrated high levels of parent engagement and satisfaction, with qualitative parent reports noting significant changes in their capacity to cope with daily challenges and better support their child. In addition, benefits have been identified both for ACT-specific measures and for measures of stress, depression and anxiety (see Table 12.4). Randomised controlled trials are currently nearing completion in several groups of parents, including parents of children with cerebral palsy and other developmental disorders, acquired brain injury, childhood cancers and cardiac disease.

Future directions for evidence-based intervention

While descriptive research has made some progress in establishing acute and long-term outcomes following early brain insult, research into the efficacy of rehabilitation/intervention is still minimal and difficult to conduct. Therefore, a number of goals need to be addressed in order to manage the sequelae these children and families experience post-insult (Catroppa & Anderson, 2009):

- Extend research to develop and evaluate intervention programmes using a multidimensional approach inclusive of both interdisciplinary clinical collaboration and families and carers.
- Employ ecologically valid outcome measures (e.g., quality of life and child participation) to ensure generalisability of benefits to a real-life context.
- Modify and adapt established, evidence-based interventions designed for typically developing children or specific diagnostic groups for delivery with children with early brain insults and developmental difficulties.
- Utilise innovative research (e.g., case-based paradigms) methodologies when designing interventions in the paediatric area rather than focusing solely on traditional randomised controlled studies.

- Consider innovative delivery methods (e.g., Skype, video-conferencing) that minimise family burden, allow participation of families distant from services and reduce costs.
- Champion implementation of research findings into clinical practice, with the opportunity for feedback from clinical practice to guide future research initiatives.

While challenging, the development and evaluation of evidence-based, clinically feasible, low-burden interventions for children following early brain insult must be pursued. The long-term benefits, in terms of both quality of life for the individuals and families and the cost savings for the community, are worth the effort, as these individuals will be better able to function in society.

Conclusions

In summary, while often not involved in routine rehabilitation and therapy interventions, the neuropsychologist's knowledge of the impact of early brain insult on cognitive, educational, social and behavioural skills is central to the management of rehabilitation and intervention programmes. Communication of this knowledge, and other information achieved through careful evaluation and assessment, may direct appropriate management of the child, within both family and school contexts. Long-term involvement that takes into account the child's developmental stage and social context will provide much-needed support as the child moves through childhood and inform school and family regarding the child's recovery, effects of treatment and future needs.

10 Quality of life for people with LIS, and assessing capacity

The World Health Organisation (WHO) propose that quality of life (QoL) is

> an individual's perception of his or her position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and the relationship to salient features of their environment.
>
> (The WHOQoL Group 1995)

In considering this proposition of QoL in the context of a significant, chronic disability such as LIS, it could be argued that a positive adjustment to the disability would be indicative of a good QoL. However, it could equally be argued that it is not possible for an individual diagnosed with LIS to have a high QoL due to the significant levels of physical disability.

It is a challenge to define the term "quality of life" (QoL), as it can have a different meaning for each individual which can lead to corresponding personal definitions. Often in health and social care settings QoL is regarded in terms of health. The conception of QoL can be traced back to the 1940s when the WHO defined health as a "state of complete physical, mental and social well-being, and not merely the absence of disease and infirmity" (WHO 1947). However, the utilisation of the term "well-being" has led to confusion and disagreement about what is health and what is QoL. Such confusion can be seen throughout the medical literature where there appears to be a common understanding that good QoL suggests being in good health and experiencing subjective well-being and life satisfaction (Goode 1994). This gives rise to the question: can someone diagnosed with a significant disability such as LIS have good QoL given the impact of their diagnosis on health? Whilst arguably health is one of the most important domains of overall QoL, other domains exist and are key to an individual's QoL. These domains include

employment, education, housing, environment, cultural values, spirituality and so on. Having such a vast array of domains when considering overall QoL adds to the complexity of definition and measurement. What can be agreed on is that QoL is important to everyone. It is a multifaceted paradigm that relies on subjective appraisals of negative and positive characteristics of life.

Understanding QoL and the elements in QoL in LIS is important as it has implications for care management, ethical issues and intervention. However, it has been argued that communication limitations make QoL assessments in LIS patients difficult (Murrell 1999). It is claimed that this issue has affected the day-to-day assessment of QoL in people with LIS despite the advent and subsequent use of communication aids and devices. In the case of Paul, assessment is not hampered by him having LIS as he has a very clear and helpful communication system (as mentioned in Chapter Six), the only issue being the length of time it takes to utilise this system.

Over the last decade the issue of QoL in LIS has been explored, and interestingly reported QoL appears to be similar to that of healthy people and patients with non-terminal chronic disease (e.g. Bruno et al. 2011; Laureys et al. 2007; Lulé et al. 2009; Rousseau et al. 2015; Moons et al., 2006); and better than that of those with terminal cancer (McGee et al. 1991).

Lulé and colleagues (2009) report an unpublished study (Ghorbel et al., unpublished) in which patients with LIS were assessed, indicating that their subjective QoL was not related to physical impairment nor could it be predicted by this factor. These reports suggest that individuals with LIS maintain a positive QoL despite their significant physical limitations. This was indeed true of Tracey, described in Chapter Three (Wilson and Okines 2014). This could be due in part to factors of QoL previously noted in studies of severe disability which include disability status, family and social support, use of medical devices and levels of depression (Rousseau et al. 2011; 2013; 2015).

Doble and colleagues (2003) reported that such findings are seen as incongruous to many healthy individuals and medical professionals who might assume that the QoL of a LIS patient is so limited that life may not be worth living. Indeed, Kubler and colleagues (2005) reported that when significant others were asked to evaluate the QoL of a patient with severe motor impairment, arguably akin to LIS, they rated a significantly lower QoL than did the patients themselves. Ganzini and Block (2002) suggest such a dichotomy may be due to a psychological defence mechanism in that healthy people may find it difficult to imagine the experiences and emotions of severely impaired patients. This contradiction can be classed as the "disability paradox"; in other words, why is it that many people with serious and persistent disabilities, such as LIS, report that they experience a

good or excellent QoL when those around them perceive them as living an undesirable daily existence? (Albrecht and Devlieger 1999).

Those studies which have considered QoL in LIS have indicated that people diagnosed with LIS report positive QoL. However, none of these studies have considered changes in QoL over time. Arguably what is equally important to understand is whether QoL is only situation and time specific (i.e. at the point of assessment) or is it longitudinal (i.e. stable over time)? The only study to date that has considered this question was conducted by Rosseau and colleagues (2015). They surveyed people with LIS over a six-year period with the aim of determining the contribution of social demographic and clinical factors in predicting stability of QoL over time. The findings of this study concurred with other studies exploring QoL in LIS, showing that people with LIS report good and satisfactory QoL. The authors were able to show that QoL remains stable over time.

In order to understand how Paul perceives his QoL he was asked to complete the Short Form-36 (SF-36 – Ware et al. 1993) as well as to provide qualitative information about QoL. The SF-36 is a 36-item questionnaire which measures QoL across eight domains. The domains are both physically and emotionally based and are as follows: physical functioning; role limitations due to physical health; role limitations due to emotional problems; energy/fatigue; emotional well-being; social functioning; pain; general health. The SF-36 includes a single item that identifies perceived change in health. The inclusion of this item enables clinicians to use the SF-36 to assess change over time and treatment. Significant numbers of published studies have demonstrated its capabilities as a global QoL measure, leading to it having been widely validated for numerous patient groups including LIS.

On the SF-36 Paul unsurprisingly showed maximal limitations in physical activities (all scores were zero). He felt his general health was good, he believed he was functioning well and he gained benefit from social interaction. He did not rate himself as having any emotional problems and indicated overall that he had a positive QoL (see Table 10.1)

Although Paul's scores are in line with many of the studies investigating QoL in LIS with regard to physical well being, there are some differences in other areas as reported by, for example, Leplege and colleagues (1998), in which they compared results from SF-36 from LIS patients with age-matched controls. LIS patients, like Paul, predictably showed maximal limitations in physical activities and reported significant limitations in usual role activities because of health problems. However, unlike Paul, they reported restrictions in social functioning due to physical or emotional problems. Paul reports that his physical limitations may have impacted on him accessing social activities, as he has to rely on others

Table 10.1 Paul's scores from SF-36

Domain	*Score*
Physical functioning	0.0
Role functioning/physical	0.0
Role functioning/emotional	66.7
Energy/fatigue	70.0
Emotional well-being	76.0
Social functioning	75.0
Pain	100.0
General health	90.0
Health change	—

to facilitate access, but emotionally he believes LIS does not limit his social activities. The LIS patients assessed by Leplege and colleagues also showed significant limitations in usual role activities because of emotional problems and scored significantly less on the vitality items (dealing with energy and fatigue). Interestingly, Paul perceives his energy and fatigue as in line with those around him. He does not believe he has less energy than prior to his stroke and believes that it is simply used in different ways. In terms of mental health (i.e. emotional well-being) the patients with LIS, as with Paul, all scored consistently with the control group, suggesting that a diagnosis of LIS is not a precursor to mental health limitations. When considering Paul, he is a balanced person with no obvious depression, anxiety or other mood issues despite the severe limitations placed on him because of his diagnosis of LIS. This is not to say he does not get frustrated or low in mood at times, but this is mainly because he is still in hospital and the funders of his placement are not providing the financial and physical support he needs to return to his home with his wife. This does not however impact on his daily QoL.

Upon meeting Paul, it is apparent he is happy with his life. He is rarely seen without a smile (although this is a partial smile because of his paralysis) and he is eager to interact with those around him, often using humour to engage people. He is always patient with those who are unable to use his communication system and talks openly and frankly about his emotions and experiences. He reports that he sees his QoL as one that is positive and provides opportunities for learning and development.

To conclude the section on QoL, people with LIS appear to believe life is worth living despite their diagnosis, and despite what others around them perceive their QoL to be. In the case of Paul, he has reported he believes his life is worth living and those around him can see he evidently enjoys life and this has appeared to have been stable since his admission to the Raphael Hospital.

Assessing capacity for people who are locked-in

Neuropsychologists and other staff in the UK are sometimes asked to make judgements as to whether or not people have capacity. This is as a result of the Mental Capacity Act of 2005.

The Mental Capacity Act

The Mental Capacity Act (2005) provides a code of practice that healthcare professionals in the UK should adhere to when working with or caring for patients who lack capacity to make decisions for themselves.

Capacity should be assessed in the context of a specific decision, as patients may have capacity in some circumstances but not others; for example, they may have capacity to decide whether or not they will take antibiotics but not capacity to manage their own financial affairs. In cases where it is judged there is a temporary loss of capacity and that full capacity can reasonably be expected to return, only decisions which are time critical should be taken. The options considered around capacity should be the least restrictive to the patient's rights. It can only be determined that a patient lacks capacity after all reasonable efforts to enable the patient to make a decision have been exhausted. It should not be assumed that the patient lacks capacity when the decision that they take appears to be unwise.

The Mental Capacity Act sets out five core principles:

1 A person is assumed to have capacity. A lack of capacity has to be clearly demonstrated.
2 No one should be treated as unable to make a decision unless all practicable and reasonable steps to help him or her have been exhausted and shown not to work.
3 A person is entitled to make an unwise decision. This does not necessarily mean they lack capacity.
4 If it is decided a person lacks capacity then any decisions taken on their behalf must be in their best interests.
5 Any decision taken on behalf of a person who lacks capacity must take into account their rights and freedom of action. Any decision/action must show consideration of the least restrictive options or intervention possible to meet need.

In order to assess capacity, the Act details a two-stage test that must be followed:

1 **The diagnostic test:** Does the person have an impairment, or a disturbance in the functioning, of their mind or brain? This can include,

for example, conditions associated with mental illness, concussion, or symptoms of drug or alcohol abuse.

2 **The functional test:** Does the impairment or disturbance mean that the person is unable to make a specific decision when they need to? In this part of the test all appropriate and practical support must be offered to the patient before continuing on. This may include ensuring all documentation is in the first language of the patient, that documentation is both visual and verbal and, in the case of someone with LIS, appropriate communication aids and/or communication experts are part of the assessment.

This functional part of the test establishes that, to be able to make a decision, a person should be able to:

1 Understand information relevant to the decision.
2 Retain the information – they have to be able to retain the information given for long enough to make the decision. There is no set time limit prescribed for this.
3 Use or weigh that information as part of the process of making the decision.
4 Communicate their decision. A person is deemed as not having capacity if they are unable to communicate.

The Mental Capacity Act recognises LIS as a possible exception, acknowledging that people with LIS can in fact still understand, retain and use information and so would not be regarded as lacking capacity in these three areas. However, they note that some people with LIS can communicate by blinking an eye, whereas others cannot communicate at all. *Therefore, those that can communicate would not be regarded as lacking capacity, whereas those who cannot would be classed as lacking capacity.*

Assessing mental capacity in LIS

As previously acknowledged throughout this book, individuals with LIS are extremely physically impaired but have intact consciousness, hearing and normal or near to normal cognitive abilities (Smith and Delargy 2005). However, they require those around them to facilitate communication and without this they would be effectively "imprisoned". Being without a "voice" means people with LIS are disempowered and have no ability to make decisions around their care and future life. It is more common now that people are preparing advance directives and informing their loved ones as to what they would wish to happen in the case of severe illness or accident. However, arguably it would be difficult for many of us to predict what we would want to happen if we

were "locked-in". It has been highlighted that families often experience high levels of distress in dealing with treatment decisions when faced with a loved one having been diagnosed with LIS, despite that person being able to process information (Maiser et al. 2016).

There is empirical evidence suggesting that patients with LIS may have retained the capacity to make decisions about their care, their future needs and treatment (e.g. Carrington and Birns 2012). However, given the patient's limited responsiveness it can be assumed by healthcare professionals that the patient is cognitively impaired and therefore unable to participate in their own healthcare decisions. Such assumption is arguably dangerous and has many ethical implications, especially in use of life-prolonging treatments such as the use of gastrostomy and tracheostomy, or end-of-life care. Given the families' distress and the difficulty for the healthcare professional in the context of decision making it is imperative that that healthcare professionals prioritise communication rehabilitation right from the point of diagnosis. Making communication rehabilitation the priority will empower the person with LIS to participate fully in all decision making and, in turn, will support families and healthcare professionals at those points when assessing the patient's mental capacity is required.

The Mental Capacity Act states that all patients making decisions regarding their healthcare should be facilitated to understand all relevant information and to express their views. In the case of LIS there is a paucity of evidence to support healthcare professionals through the ethical quagmire of managing such complex cases. It is imperative that a thorough neurological, neuropsychological and communication assessment is conducted as soon as possible after diagnosis, and indeed throughout the person with LIS's life, in order to understand their preserved cognitive abilities and enable them to participate fully in their decisions.

As has been highlighted in this book, Paul has been "enabled" to communicate using a communication system that is individual to him. He expresses to those who work with him that this is his "voice" for this current time and he uses it well. His wish would be to be able to express himself verbally, i.e. using his own voice. There have been many times in working with Paul where establishing his mental capacity for decisions has been important, not only for decisions in his day-to-day care but also for major decisions around where he wishes to live, who should support him with his finances and his wishes around end-of-life care.

Assessment of Paul's capacity over decisions has followed a clear framework which has included neuropsychological assessment, current assessment of his physical well-being (i.e. no presence of infection which in turn may affect his cognition), choosing the best time of day (usually late morning), involving one of his keyworkers who is very familiar with

his communication aid, and ensuring enough time is allocated (given his communication is very slowed using his aid). If required, Paul is provided with visual aids placed in his eyeline. For more complex decisions the capacity will be assessed over a number of occasions at different times of day (e.g. the decision around his preferred place to live). This is important as he can tire easily, and this in turn affects his ability to communicate, and the 'listener' may not be sure they have understood his communication. Paul is always patient and accepting when the therapist turns up once again to go through the capacity assessment.

In many of situations when capacity needs to be established for Paul there has been no difficulty at all and the decision has not been a challenge. However, in the case of where he wants to live, he wants to be able to return to his own home. While establishing his capacity to make this decision was not difficult, ensuring his wishes are met has been, and still is, an ethical, political and clinical quagmire.

One more measure to illustrate that Paul feels his QoL is reasonable is his response to Seligman's (2011) PERMA model (**P**ositive emotion, **E**ngagement, **R**elationships, **M**eaning and **A**chievement). He communicated that he felt "positive" about life, he was "engaged" and gave as an example the fact that he had designed a house for himself in some detail. For "relationships" Paul said he had received more than 120 visitors since coming to the Raphael Hospital. He felt his life had "meaning" because he had sung in 60 shows. For "achievement" he reminded us that he was co-author of this book and was also writing another book about his life.

In conclusion, LIS is a rare and serious condition presenting with profound motor deficits and presumed intact cognition. As a result, it brings about communication challenges. Such challenges can affect the understanding of the decision-making process in individuals with LIS and these must be addressed by a clear framework as to how to assess capacity in such individuals. As has been reported in this book, research indicates that many individuals with LIS report that they have a good QoL and feel happy. Therefore, it is important that communication rehabilitation is prioritised from the point of diagnosis, rather than making assumptions about perceived QoL, in order to ensure the person with LIS can participate in decisions around their life choices. Continued assessment and discussions should take place with the person with LIS in order to ensure their wishes are considered. In taking such an approach, establishing capacity should not be difficult in those diagnosed with LIS.