Fish, J. (2017) Rehabilitation of attention disorders: a) adults. In: Wilson, B. A., Winegardner, J., van Heugten, C. M. and Ownsworth, T. (eds.) Neuropsychological Rehabilitation: the International Handbook. Routledge: London ; New York, pp. 172-178. ISBN 9781138643093.

Author's final accepted version. Please cite as: Fish, J.E. (2017). The neuropsychology and rehabilitation of attention in adults. Pp. 172-178 in B.A. Wilson, J. Winegardner, T. Ownsworth, & C. van Heugten (Eds.). *Neuropsychological rehabilitation: An international handbook*. Hove: Psychology Press. For the full book please see https://www.taylorfrancis.com/books/neuropsychological-rehabilitation-barbara-wilson-jill-winegardner-caroline-van-heugten-tamara-ownsworth/e/10.4324/9781315629537.

The Rehabilitation of Attention in Adults

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Overview

The first section of this chapter summarises the most influential models of attention in adults, based upon current cognitive neuroscience. It then considers clinical assessment of attention, including the integration of attention in clinical neuropsychological formulations. Approaches to the rehabilitation of attention are then summarised. The second section of this chapter considers the impairment and rehabilitation of attention in children. Note that there is conceptual overlap between the concepts of attention and speed of information processing, and there is a separate chapter devoted to this topic. In addition, note that disorders of spatial attention are covered in chapter XX, on visuoperceptual disorders.

Introduction

William James famously wrote that "every one knows what attention is", and yet it can be difficult to define, operationalize, and hence assess and intervene with. Klein & Lawrence (2010) define attention simply as the processes whereby information-processing resources are differentially allocated. Their conceptual classification system specifies that differential allocation occurs in two modes (endogenous, exogenous), and across four domains (time, space, sense, task). The term *endogenous* refers to internally-generated, non-reflexive, and stimulus-independent processes. These are often referred to as 'top-down'. The term e*xogenous* refers to externally-cued, reflexive, stimulus-driven, or 'bottom-up' processes. This classification is useful when measuring attention, since this can only be achieved indirectly. At the behavioural level, this may be by measuring the speed and accuracy of responses during a task, along with their variation with the manipulation of experimental factors. At the neural level, this may be by measuring the variation in relevant parameters (e.g. regional cerebral blood flow in functional MRI) over different epochs of task completion, or in response to given events. It is also helpful for categorizing and critically evaluating findings from research studies (e.g. which level(s) are being measured, is there comparable evidence relevant to other modes or domains?), and even for guiding clinical assessment. Based on this conceptualization one might develop clinical questions to address, such as: does this client have a difficulty with endogenous attention across domains, or is there domain specificity? It could also help us to evaluate the current evidence base and the range of clinical tests available, and hence develop our practice, by considering such matters as whether we have measures that adequately differentiate between exogenous and endoengous modes, or that adequately sample across domains.

Models of attention

Posner and Petersen (1990) described a highly influential framework for understanding human attention, which has been recently updated (Petersen & Posner, 2012). The framework sets out that attention is anatomically separate to other cognitive systems (e.g. those concerned with perception or decision-making processes), and that what we know as 'attention' comprises three different functions across a network of brain areas. These processes are referred to as alerting, orienting, and executive attention.

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The alerting system, alternatively described as *arousal, sustained attention*, and *vigilance,* maintains a state of readiness to respond. The alertness system could be seen as synonymous with wakefulness, though of course, as a state this too varies throughout the day, in response to stimulation, etc. Virtually all tasks involve alertness, but the alertness demands increase when e.g. the task duration is extended (with errors being more likely over time), the complexity of the task increases, or when targets are rare or unpredictable. An example situation placing demands on alerting would be waiting in a doctors office ahead of an appointment, or for your stop on the bus or train. In each example, it is necessary to remain 'ready to respond'. The alerting network includes the brain stem, reticular formation, and thalamus, and is largely right hemisphere-lateralised (Petersen & Posner, 2012; Sturm & Willmes, 2001).

The *orienting* system serves to prioritize information across sensory modality (e.g. hearing, vision, touch) and space. It is also referred to as *selective* attention. An example might be when waiting in a shopping queue, keeping your attention vaguely oriented to the location of the 'next available counter' sign, and noticing when the information updates changes. The orienting network includes areas in the frontal lobe, particularly those involved in making eye movements, along with the parietal lobe, and at the temporoparietal junction. The orienting system has two components. The first is for deploying rapid control over attention (e.g. keeping attention on the area around the display board), and is associated with a dorsal network (n.b. a predominantly endogenous, top-down process). The second is involved with responding to sensory events and switching attention (e.g. noticing when counters become available). This involves a more ventral and largely right-lateralised network, including ventral frontal regions and the temporoparietal junction. Corbetta & Shulman (2002) liken this ventral network to a 'circuit breaker' serving to interrupt ongoing activity.

Posner and Peterson (2012) describe that the alerting and orienting systems are independent, but almost always working in tandem. It is clear that most everyday scenarios would tax both components – remaining ready to respond, and responding in turn.

As attention is of limited capacity, we need mechanism(s) that control where it is directed, or prioritise what gets selected. Ideally, this 'direction' should be the one most likely to lead towards our goals. Posner and Peterson refer to this mechanism as executive attention[1], and specify that two networks are involved. One is for 'setting up' a task according to its main goal (e.g. notice the next available counter when I get to the front of the queue) and the second for maintaining focus on that task (e.g. remain aware of this goal, even if we are also talking on the phone). When we really attend, this has a knock-on effect on other aspects of the attention system. For example, when the display eventually updates to show the intended counter number, our attention will be captured and the resources available for other purposes (e.g. participating in the phone conversation) are temporarily reduced. This idea of limited capacity has lead to the use of terms such as *attentional switching* and *divided attention*, to refer to situations in which we need to keep more than one thing in mind – be it shifting attention from one thing to another or completing two concurrent tasks with interfering demands. There is a system of frontal and parietal brain areas involved in executive attention, with the medial frontal lobe, anterior cingulate cortex (ACC) and insula being particularly important. This is consistent with Corbetta & Shulman's (2002) dorsal attention network. Please also refer to the chapter on executive functions for related material.

Linking Theory with Practice

Attentional Concepts in Clinical Groups

Spikman et al., (2001) examined the construct validity of attention by reviewing factor analytic studies of people with brain injury and controls, and found only two useful and consistent factors, those of processing speed, and 'control' or 'working memory'. The striking thing here is the lack of consistency with the theoretical models previously outlined. Terms such as 'speed' and 'control' refer more to the

[1] Note that in Posner and Peterson's (1990) framework, 'executive attention' was referred to as 'target detection', and can also be called 'focal' or 'focussed' attention.

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behaviourally observable characteristics of attention, rather than mechanistic processes through which the brain creates attention, the latter being the focus of theoretical models. These differences in terminology and level of focus have likely contributed to a lack of integration between the theoretical and applied work on attention. Though many studies have employed theoretically-driven tests in clinical groups (e.g. using the Posner cueing paradigm), and clinical observations and data have been integral in the development of some models (e.g. the Corbetta & Shulman and their observations of patients with stroke), there remains a clear disconnection.

Another related issue is the remarkable overlap between what we refer to as 'attention', and other concepts, including speed of information processing, working memory, and executive functioning. The boundaries are neither immediately obvious, nor absolute (as sketched in Figure 1, below). I think it is helpful here to return to the term 'differential allocation of resources', the essential characteristic of attention, and the one to consider in clinical research and practice.

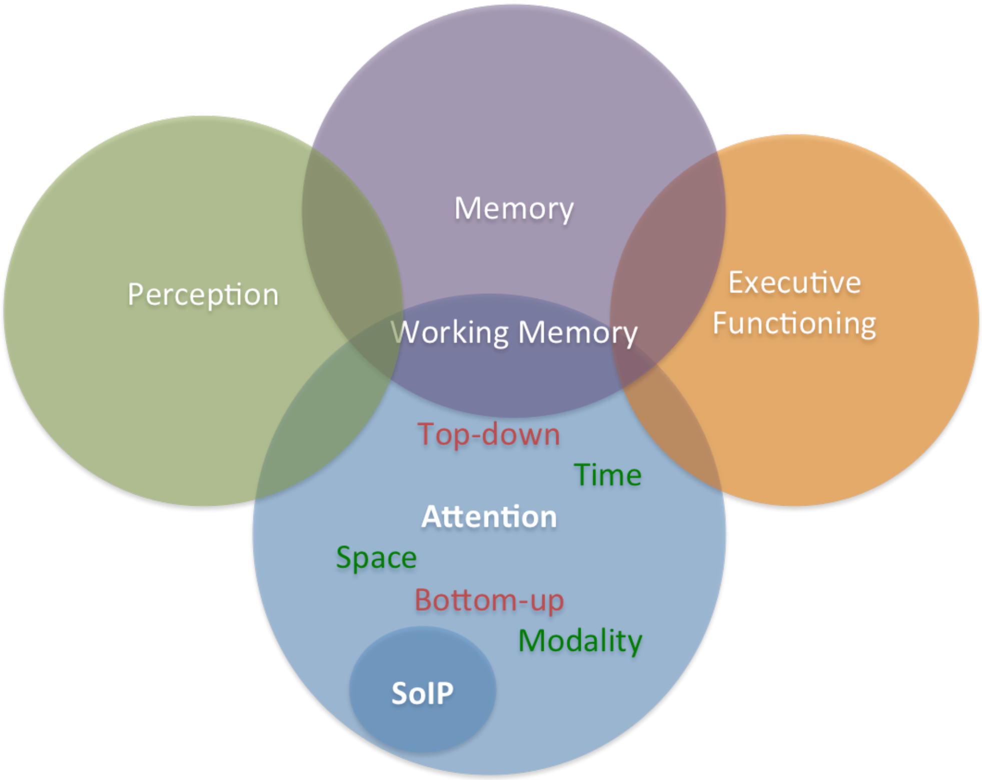

Figure 1. The central components of attention and their conceptual overlap with other domains of cognition. Note SoIP refers to Speed of Information Processing.

Assessing an individual client for clinical purposes

As with any clinical neuropsychological assessment, when assessing attention one needs to think holistically. This includes making use of interview data from the client and an informant, considering behavioural observations and performance on functional tasks, and selecting tests that enable hypotheses to be tested. The primary domains to be assessed are summarised in Table 1.

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Testing domain	Relevant theoretical constructs	Behavioural description	Example tests
Attention 'span'	Assessing essential attentional capacity, exogenous mode, orienting and selection. Also referred to as primary memory or working memory (without manipulation)	Measuring how much information can be held in mind	Digit span, Corsi blocks, e.g. as included in Wechsler batteries.
Information processing speed	Speed of Information Processing, usually exogenous mode and involving orientating and selection over time.	Assessing how quickly a person can take in, use, and respond to information	Examples include the symbol search and coding subtests from the Wechsler intelligence batteries and the 'silly sentences' test from the Speed and Capacity of Language Processing Tests.
Attentional search	Exogenous mode, Orienting, selection, and potentially executive if the difficulty level is high.	Examining the speed and efficiency with which arrays can be investigated to identify targets	Tests in the visual domain are most common, such as part A of the Trail Making Test and the Map Search subtest of the Test of Everyday Attention. Note however, that the Test of Everyday Attention for Children - Second edition includes auditory search.
Vigilance/sustained attention	Testing the alerting system over time, so largely an assessment of endogenous attention albeit with exogenous components (e.g. in target detection).	Determining how well a person is able to continue responding over time	The Continuous Performance Test, the Sustained Attention to Response Test, Paced Auditory Serial Addition Test.
Attentional switching and/or divided attention	Complex/executive attention, likely combination of endogenous and exogenous modes.	Exploring what happens to performance when additional constraints are imposed upon attention.	Trail making test part B Stroop test, e.g. in Delis-Kaplan Executive Function System; Brown-Peterson procedure for interference/divided attention.

Table 1. The clinical assessment of attention, example tests, and their relation to attentional theory

Measurement in clinical research

In clinical research applications, it is necessary to employ a fixed battery. Considerations will of course depend upon the research questions, client group, the psychometric properties of the tasks, along with time and other resource constraints. It is beyond the scope of this chapter to give specific recommendations in this domain. However, there are a number of guiding principles that lead from the literature: (i) use repeated observations, (ii) include measurement of top-down and bottom-up attentional processes, (iii) consider speed, accuracy, and response variability, (iv) consider modality and especially spatial vs non-spatial attention (v) consider the time span and include measurement

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over longer time periods if possible (to consider variations in alertness and the impact this will have on behaviour), (vi) consider complexity and include tasks of varying complexity if possible.

Incorporating attention into neuropsychological formulations

Duncan (2013) considers attention a building block of cognition and by extension all human behaviour. These building blocks are described as "a series of focussed, momentarily assembled temporal fragments… with many fragments assembled to achieve short- and long-term goals". This 'assembly' is shaped by arbitrary requirements of current activity. As such, attention interacts with virtually all other cognitive skills. It is important to consider potential interactions in the process of clinical formulation, as once the links are made, strategies attempting to either strengthen or weaken them as appropriate can be devised. See table 2 for some considerations.

Domain	**Potential considerations**
Interactions between attention and memory	- Reduced span and/or poor sustained attention reduce the amount of information that can be encoded in learning trials, which then impacts on retrieval. - Impaired orienting/selection/executive attention serve to truncate the memory search process in free recall, again showing apparently reduced memory performance.
Interactions between attention and executive function	- Reduced span/impaired selection/reduced sustained attention can impair performance on more complex tasks (i.e. those that verge into 'executive' territory). Knowledge of basic attentional functioning is essential to reliably interpret performance on executive tasks.
Emotion	- Emotionally-salient information tends to grab our attention. It can then difficult to disengage attention. This can impede progress towards other goals, especially those that are more emotionally neutral. - Difficulties with worry or rumination consume attentional capacity and can hence mimic or exacerbate difficulties with attention and/or memory (Bessell, Watkins, & Williams, 2008).
Physical and environmental factors	Various physical factors can influence attentional performance. - Fatigue and poor sleep are associated with reduced vigilance and information processing speed (Ponsford et al., 2012) - There is evidence of circadian variation in attentional performance (Manly, Lewis, Robertson, Watson, & Datta, 2002), so consider this in repeat or multi-session assessments and in linking test results to everyday behaviour. - Other factors such as noise, temperature, clutter, may all impact.

Table 2. Example interactions between attention and other domains that can be used to inform clinical formulations

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Neuropsychological Rehabilitation of Attention

In 2014, an international group of experts published findings from a process of reviewing clinical guidelines and the published literature, to generate an authoritative set of clinical recommendations (Ponsford et al., 2014). Their primary recommendations can be found in Table 3.

Empirically supported interventions identified by the INCOG group (Ponsford et al., 2014)
Metacognitive strategy training applied to personally and functionally relevant tasks
Dual tasking training also on individually relevant tasks
CBT to address interactions between emotion and attention
Treatment of sleep disorders that exacerbate attentional problems
Environmental adaptations
Methylphenidate effective as a short-term intervention
No consistent evidence of functional gains from computerised training

Table 3. Recommendations on the rehabilitation of attention from the INCOG review group

Computerised or otherwise repetitive training (see also chapter 15)

Two of the most frequently-studied training packages are Attention Process Training (Sohlberg & Mateer, 2011), and AIXTENT (Sturm, Orgass, & Hartje, 2001). Both involve repetitive practice on attentional tasks, with APT including those of sustained and selective attention, response suppression, switching, and working memory, compared with AIXTENT's focus on alertness, vigilance, selective attention and divided attention. Though training effects are large in methodologically weak studies (Barker-Collo et al., 2009; Sturm, Willmes, Orgass, & Hartje, 1997), studies using more stringent designs tend to find less encouraging results, most pressingly, a lack of generalisation beyond improvement on the trained tasks or close analogues thereof (Park & Ingles, 2001). Two small RCTs have also identified benefits from relatively brief periods of training in dual-tasking (e.g. walking whilst performing increasingly challenging auditory cognitive tasks), but again, evidence of generalisation is lacking (Couillet et al., 2010; Evans, Greenfield, Wilson, & Bateman, 2009).

Meta-cognitive strategy training

Meta-cognitive strategy training is recommended by the INCOG group, on the basis of case studies, group studies, and an RCT. They form a primary component of all cognitively-focussed work of our programme at the OZC. This is partly because in our experience, clients disengage with computerised training programmes if not for the purposes of research, and partly because they are a necessary component of strategic adaptation to any cognitive and/or emotional difficulty. Our approach is to provide interactive, group-based psychoeducation about the nature of attention, to introduce strategies and to provide opportunities for clients to practice strategies within active tasks. Then, as part of individualised goal-based rehabilitation, these strategies are refined, and applied within a range of tasks from within-session activities to vocational and leisure activities. For a summary see Table 4, and more information see Fish, Brentnall, Hicks and Winson (2016).

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Attention-focussed rehabilitation on the OZC programme

- Formal assessment and formulation
- Psychoeducation about the nature of attention
- Exploring attention with exercises (e.g. listening to news stories and then answering questions about them; looking at complex images for particular targets, e.g. from the 'Where's Wally' books, walking whilst saying aloud types of musical instrument)
- Introducting different types of strategy:
    - Internal strategies: developing the metaphor of attention as a beam/flashlight, and generating associated mental images and/or keywords/mantras to enable easy access to this metaphor.
    - Reducing external distractions: noise, phones, emails, earplugs/white noise, decluttering, good lighting.
    - Reducing internal distractions: mindfulness exercises, or through strategies for mood and anxiety
    - Using external aids: for example, using automated cueing to encourage attentional focus, or referring to a memory and planning system
- Experimenting with strategies in a graded manner:
    - In the context of active exercises (e.g. looking for lost sunglasses, taking part in a 'treasure hunt', shopping for particular items, planning a trip to a gallery)
    - In the 'real life' context, setting functional goals and addressing those through the development of individualised strategies and behavioural experiments (e.g. where someone works in an administrative role, trying out the above strategies in 10-minute segments, then reflecting on the impact).

Based on Fish, Hicks and Brentnall (2017)

Comparisons and combined approaches

In a direct comparison in three cases of people with TBI, Dymowski, Willmott and Ponsford (2015) found that 9 hours of metacognitive strategy training was associated larger benefits on tests of attention than an equivalent duration of APT, but generalisation of these benefits to ecologically valid tests and rating scales was limited. It is also very likely, however, that computerised training would need to be at a much higher level of intensity to produce substantial changes (e.g. by analogy with exercise, or skill learning, it is in regular repetition that enables change and/or mastery, rather than initial instruction).

There remains the possibility that if carefully combined, metacognitive strategy training combined with computerised massed practice, may produce larger, more reliable, durable and/or generalised benefits. Indeed, the latest version of APT includes a focus on metacognitive strategy development, and an RCT of this is in process (Bartfai, Markovic, Sargenius Landahl, & Schult, 2014). There is also a problem of labelling within the literature – e.g. Bartfai APT versus 'standard' training RCT – APT is supplemented with metacognitive control too.

Other approaches to the rehabilitation of attention

Mindfulness or other meditation-related training programs have the development of metacognitive awareness, and the control of attention, as primary aims. Though a large placebo-controlled RCT of a brief mindfulness intervention in people with brain injury did not identify benefits to cognition, several studies in other populations do indicate that full mindfulness-based cognitive therapy programmes impact upon attention (Jha et al., 2015; Malinowski, 2013; Tang et al., 2007), as well as variables such as fatigue and mood (Bédard et al., 2014; Johansson, Bjuhr, & Rönnbäck, 2012). However, as these have not incorporated active placebo conditions, further research is required, as is further research in clinical neuropsychological populations.

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