INTERNATIONAL CONFERENCE ON WORKING MEMORY

Cambridge, 9-11th July 2014

SPEAKER ABSTRACTS

Wednesday 9th July, 2.00pm

Introduction by Susan Gathercole (Cognition and Brain Sciences Unit, Cambridge)

Wednesday 9th July, 2.05pm

Working memory at 40

Alan Baddeley, University of York

With the multicomponent model reaching its fortieth birthday and the field of working memory as a whole over fifty, it seems timely to reflect on where we are and how we got there. I will begin by briefly discussing my own approach to the development of theory before going on to consider each of the four components of our current working memory model. In each case I will briefly discuss precursors followed by the evidence that led to the initial formulation. This will be followed by a very brief account of subsequent developments and possible future directions. I will conclude with a brief account of how I see the current model relating to some of the other approaches that feature prominently in the talks that follow.

Wednesday 9th July, 2.50pm

Loss of information from working memory

Pierre Barrouillet, Université de Genève

Working memory is characterized by severe limitations in both the amount of information that can be hold in an active state and in the time during which this information remains available for treatment when maintenance activities are prevented. However, the nature of the sources of forgetting from working memory remains a matter of controversy. Whereas some authors assume that working memory traces suffer from both representation-based interference and temporal decay, others assume that time does not play any role per se in this forgetting process, which would entirely result from interference phenomena. After a brief presentation of the main arguments against the temporal decay hypothesis, I review a series of past and more recent empirical findings for which temporal decay provides the simplest account.

Wednesday 9th July, 3.10pm

The mechanisms of reconstruction in working memory

Valérie Camos, Université de Fribourg

Working memory is the structure devoted to the maintenance of information at short term during concurrent processing activities. In this respect, the question regarding the nature of the mechanisms and systems fulfilling maintenance function is of particular importance and has received various responses in a recent past. In this talk, I will address the question of the mechanisms by which information is maintained in working memory, counteracting the deleterious effect of temporal decay and interference. In the extended version of the time-based resource sharing model, I suggest that only two mechanisms sustain the maintenance of information at short term. A subvocal rehearsal, similar to the one described by Baddeley in the phonological loop model, uses language processes to reactivate phonological memory traces. Besides this mechanism, an attentional refreshing process reconstructs memory traces through attentional refocalisation. After reviewing evidence, which favours the segregation between these two mechanisms, I will develop the consequences of the existence of two distinct mechanisms on working memory functioning.

Wednesday 9th July, 3.30pm

Process Overlap Theory: A new interpretation of working memory capacity

Andrew Conway, Princeton University

Process Overlap Theory is a recently developed account of variation in intelligence (Conway & Kovacs, 2013; Kovacs & Conway, 2013). The theory provides a novel explanation of the positive manifold, which refers to the pattern of positive correlations observed across diverse mental tests included in a battery of intelligence tests. The positive manifold is also observed in individual differences studies of working memory capacity (WMC). In such studies, WMC is often assumed to be a latent ability and the positive manifold is due to the causal effect of the latent variable, WMC, on manifest variables, or individual WM tasks. In contrast, according to process overlap theory the positive manifold is an emergent property, the result of the specific patterns in which item response processes overlap. A central assumption is that any item requires a number of domain-specific as well as domain-general cognitive processes. Domain-general processes involved in executive attention are central to performance. That is, they are activated by a large number of items. In turn, they overlap with domain-specific processes more than domain-specific processes overlap with one another. A crucial aspect of the theory is it emphasizes the processes responsible for errors in performance. The processes that are responsible for various aspects of executive attention (goal-monitoring, updating, inhibition, etc.) reflect limits

in domain-general processes that affect performance on a wide range of items. The theory accounts for the hierarchical structure of cognitive ability, the strong relationship between WMC and fluid intelligence, the worst performance rule, and ability different.

3.50-4.20pm Refreshments

Wednesday 9th July, 4.20pm

Memory for alternating lists: evidence for, rather than against, chaining models of serial order

Clive Frankish, University of Bristol

Theories in which the serial order of verbal items in short term memory is coded as a chain of item-to-item associations have been criticised firstly, because they cannot explain data for immediate recall of alternating sequences of phonologically confusable and nonconfusable items (Baddeley, 1968; Henson, Norris, Page & Baddeley, 1996), and secondly, because they predict that recall should be subject to catastrophic breakdown, which is assumed not to occur. Both issues are addressed by an experiment which demonstrates that the relative recall accuracy of confusable and nonconfusable items in mixed lists is strategy-dependent. The characteristic sawtooth serial position curve for alternating lists is obtained when list structure is predictable, but is attenuated when the same lists are interleaved with mixed lists in which the two classes of item are randomly arranged. In both conditions, recall attempts typically begin with a sequence of reponses that are either correct, or are phonological approximations to the corresponding list item. Recall accuracy is very much lower for all items that follow the first phonologically mismatched response, regardless of serial position and phonological confusability. This pattern suggests a two-stage recall process in which the first stage is based on a chained representation that can fail catastrophically, with subsequent responses generated by backup routines that draw upon a variety of information sources. A quantitative model of this two-stage process provides a good fit to experimental data, and also accounts for the locality constraint; the observation that misplaced items tend to be recalled close to their input positions. Most errors are attributable to processes occuring after the primary retrieval mechanism has catastrophically failed. This limits the extent to which analysis of error characteristics can be interpreted as evidence for theories in which serial order is represented by positional cues.

Wednesday 9th July, 4.40pm

Working memory for serial order and the development of verbal and numerical abilities

Steve Majerus, Université de Liège, Belgium

One of the fundamental functions of verbal working memory is to maintain arbitrary serial order information about a sequence of verbal events. The assessment of working memory for serial order is often neglected or confounded with other working memory variables in studies examining the relationship between working memory and cognitive development. We will present several studies showing that working memory for serial order is a critical variable for understanding the impact of working memory capacity on the acquisition of oral verbal, written verbal but also numerical abilities. We will examine the processes underlying these associations and discuss a theoretical framework linking working memory for serial order and knowledge bases in verbal and numerical domains.

Wednesday 9th July, 5.00pm

Removal of distractors in complex working memory span tasks

Klaus Oberauer, University of Zurich (with Stephan Lewandowsky, University of Bristol)

Complex span tasks interleave encoding of memory items with processing of distractors. The SOB-CS model provides a fine-grained account of many behavioral phenomena with the complex-span paradigm (Oberauer, Lewandowsky, Farrell, Jarrold, & Greaves, 2012). SOB-CS makes two key assumptions. First, representations used for the processing task are encoded into working memory, thereby interfering with memory items. Second, when time allows, these distractor representations are removed from working memory. We present experiments providing direct evidence for distractor interference and distractor removal. Instead of interleaving distractor processing with list encoding, all distractors were processed before the uninterrupted encoding of the memory list. Distractors tended to intrude in list recall, demonstrating proactive interference. In Experiment 1 we varied the unfilled time between distractors. Memory was better, and distractor intrusion reduced, with longer inter-distractor time. This is as predicted by SOB-CS, because that time could be used to remove distractors from memory. In Experiment 2 we included a further condition with long inter-distractor times filled by an attention-demanding task. Memory was worse, and intrusion rate increased, compared to long unfilled intervals separating distractors, as predicted if the filler task prevented distractor removal.
Oberauer, K., Lewandowsky, S., Farrell, S., Jarrold, C., & Greaves, M. (2012). Modeling working memory: An interference model of complex span. Psychonomic Bulletin & Review, 19, 779-819.

5.20pm Close

Thursday 10th July, 9.15am

Exploring the episodic buffer

Graham J. Hitch and Alan D. Baddeley, University of York

The episodic buffer (Baddeley, 2000) was proposed as an addition to the three-component model of working memory (Baddeley & Hitch, 1974) to address some issues of executive control in a modular system. It consists of a limited capacity temporary store linked to the central executive, holds information in a multimodal code and is associated with conscious awareness. An assumed function was to bind information from different subsystems and long-term memory into integrated episodic representations. We began our exploration by testing the assumption that executive control processes are crucial for binding, finding consistently negative results in dual-task experiments, regardless of the type of binding (e.g. within or across domains). However we did find that memory for bindings was fragile and susceptible to interference from external inputs. A series of experiments followed this up and supported the idea that the episodic buffer holds bound representations that are determined by a combination of external and internal attention. Thus we conclude that the episodic buffer has a somewhat different binding function from that originally assumed. We regard the buffer as providing storage back-up to the central executive and as corresponding broadly to the focus of attention in alternative models.

Thursday 10th July, 10.00am

Exploring the dynamic interplay between attention and working memory

Richard Allen, University of Leeds (With Graham Hitch, Alan Baddeley, Yanmei Hu)

Experimental work is reported that examines whether distinct forms of attention can be demonstrated to influence working memory in separable ways. Various manipulations were applied to a task measuring memory for short sequences of shape-colour conjunctions. Addition of concurrent executive load (through backward counting) during sequence encoding disrupted memory for earlier items in the sequence without impinging on the final item. In contrast, introduction of external interference through a to-be-ignored 'suffix' stimulus presented following a target sequence only reliably impacted on later sequence positions. Encouraging participants to prioritize first or final sequence items influenced the size of primacy and recency effects, and also mediated the size of suffix effects. Specifically, strategically prioritizing the first item increased susceptibility to suffix interference, whereas the suffix disrupted the final item regardless of strategic focus. These findings suggest distinctions between forms of attentional orientation and control, with differential contributions to the retention of visual sequences in working memory.

Thursday 10th July, 10.20am

Perceptual-motor affordance and short-term memory

Dylan M Jones, Cardiff University (with John C. Taylor and William J. Macken)

Two new lines of evidence show the importance of considering perceptual-motor determinants of serial short-term memory. The first relates to the advantage of words over non-words in recall – the lexicality effect – that is relatively absent in serial recognition. Commonly this has been attributed to the reduced support from long term or item memory. We show that reduced lexicality in serial recognition is not due to retrieval conditions, rather it is the result of the previous use of auditory presentation from which acoustic pattern matching is a viable strategy; visual presentation of the same task does show a clear lexicality effect. The second relates to the pattern of errors that emerges in lists of alternating similar and dissimilar items, classically interpreted as showing independence of item-level representation. We show that the particular pattern of errors is determined by the way sequences themselves, not the items per se, induce particular prosodic rehearsal patterns: error probabilities at successive input/output distances were modulated by sub-vocal rehearsal patterns across items, despite all item related parameters being held constant.

Thursday 10th July, 10.40am

Tracking the content and quality of working memory with near real-time temporal precision

Edward Awh, University of Oregon (with David Anderson, John Serences and Edward Vogel)

An emerging hypothesis is that the cellular assemblies that represent items in working memory (WM) may be coordinated via the precise synchronization of neural activity in the alpha frequency band (8-12 Hz). In line with this hypothesis, past work has found that variations in alpha power track individual differences in the number of items observers can store. Here, we show that oscillatory activity in the alpha frequency band is also linked with the content and quality of representations in visual WM. We recorded EEG while observers stored items in visual WM, and measured the spatial distribution of oscillatory power across a range of frequency bands. Using a forward encoding model of orientation selectivity, we were able to reconstruct orientation-specific response profiles, or channel tuning functions (CTFs) that tracked the feature value stored in visual WM with near-real-time temporal resolution. Critically, the tuning properties of these EEG-based CTFs predicted both between- and within-subject variations in memory quality. These findings suggest that synchronization in the alpha frequency band plays a central role in the storage of information in visual WM, and offer a powerful method for tracking the precision of online memories with high temporal resolution.

11.00am-11.40am Refreshments

Thursday 10th July, 11.40am

Local and global effects of distraction in complex span

Simon Farrell, University of Bristol (with Klaus Oberauer, Martin Greaves, Kazimir Pasiecznik, Stephan Lewandowsky and Chris Jarrold)

Evidence from the complex span task indicates that any free time after processing operations can be used to offset the detrimental effects of the distracting activity. We tested two competing hypotheses about the beneficial effects of free time: that free time allows for the refreshing of memory traces that decayed during the distracting activity; and that free time is used to remove distractors that have been encoded by virtue of having been processed. In several experiments the density of processing was varied within lists, such that one burst of processing following an item on the list was particularly dense or particularly undemanding. The density of the distractor burst had both proactive and retroactive effects, and was mostly confined to items surrounding that particular burst. Simulations of TBRS*---a computational version of the time-based resource sharing model---showed that the model can do a surprisingly good job of capturing these effects, but at the cost of predicting unrealistic serial position functions. SOB-CS---an interference model of complex span---missed some more subtle patterns, but on balance was found to provide a better account of the key aspects of the data.

Thursday 10th July, 12.00pm

Revisiting assumptions about the physiological mechanisms underlying the short-term retention of information

Brad Postle, University of Wisconsin-Madison

The first of Hebb's (1949) dual traces was reverberatory activity within the circuit representing the to-be-remembered information. Empirical evidence that elevated activity may serve as the physiological basis for the retention of information in working memory began to accrue in the 1970s with monkey electrophysiological studies, and in the 1980s/90s with human neuroimaging and EEG/ERP studies. Indeed, it has underlain virtually every study that has sought to relate neural activity to cognitive models of working memory. Many current theoretical models posit multiple states in which items can be held in working memory. Tasks like Garavan's (1998) two-running-sums and Oberauer's (and others') prioritization-via-retrocuing, demand, at a minimum, a focus of attention (FoA) for attended memory items (AMIs), and a distinct state for items that are in working memory but outside the FoA (unattended memory items; UMIs). The difference between these two states is often framed in terms of different "levels of activation". Recent applications of multivariate pattern analysis (MVPA) to fMRI and EEG data sets, however, raise questions about the presumed link between physiological activation and working memory. First, "head-to-head" comparisons of the results of mass-univariate vs. MVPA analyses indicate that regions displaying

elevated delay-period activity in frontal and parietal cortex may not carry stimulus-related information, whereas regions that do not display such activity do carry stimulus-related information. Second, experimental dissociation of AMIs from UMIs suggest that only the former may be held in a physiologically active state, suggesting that activation may relate more to attention than working memory per se.

Thursday 10th July, 12.20pm

Working Memory Capacity and Fluid Intelligence: Maintenance and Disengagement

Zachary Shipstead (Arizona State University)

Working memory-related maintenance is typically treated as an explanation of individual differences in fluid intelligence. We reframe this relationship by proposing that working memory capacity and fluid intelligence are dissociable processes that are commonly reliant on top-down attention. They respectively facilitate complex cognition by providing controlled maintenance of relevant information and controlled disengagement from outdated information. In support, we review recent demonstrations of a strong relationship between fluid intelligence and disengagement in standard memory tasks.

Thursday 10th July, 12.40pm

Working memory and perception: dissociating maintenance and cognitive control functions through load

Nilli Lavie, Institute of Cognitive Neuroscience, UCL

Working memory (WM) plays an important role in visual perception serving both to exert cognitive control and to maintain sensory visual representations in line with the current task goals. Here I present work that allows us to dissociate WM maintenance and cognitive control functions through the effects of different types of WM load on perception. Specifically, we contrasted the effects of loading visual maintenance and loading cognitive control on measures of visual detection and irrelevant distraction during the memory task delay. Considering the findings that visual maintenance recruits the same sensory visual cortex regions as those involved in perception (e.g. Pasternak & Greenlee, 2005; Serences et al., 2009) within the load theory (e.g., Lavie, 2005) led us to predict that: i) visual maintenance load would tax sensory visual-representation capacity, thus resulting in reduced perception and detection of task-unrelated distractors (similarly to perceptual load). ii) WM cognitive control load would reduce priority-based control, thus resulting in enhanced perception and detection of irrelevant distractors. The results from a series of experiments using neuroimaging, behavioural distraction measures, and visual detection psychophysics

confirmed these predictions. These findings allow us to resolve apparent discrepancies in previous work and establish a new functional dissociation between the roles of WM maintenance and cognitive control in visual perception.

1.00pm-2.30pm Lunch and Poster session II

Thursday 10th July, 2.30pm

Inter- and intra-individual differences in visual working memory capacity and attentional lapses

Edward K. Vogel, University of Oregon

The capacity of visual working memory (WM) is known to be severely restricted and varies considerably across individuals. These inter-individual differences in memory capacity are a stable trait of the observer and are positively correlated with many high-level aptitude measures such as fluid intelligence and reasoning. While they have historically been considered to be the consequence of variability in amounts of online storage space, extensive work from the past 10 years has suggested that much of this variability stems instead from the efficiency of the attentional control mechanisms that help restrict access to this limited representational space. In previous work using behavioural and electrophysiological (e.g., EEG & ERP) methods, we have found that low capacity individuals are poorer at keeping irrelevant items from being stored in WM and are slower to disengage from attentional capture than are their high capacity counterparts. In more recent work, we have sought to extend these findings by examining how intra-individual variability within a task session may be contributing to our estimates of the inter-individual differences in capacity. To do this, we developed a whole-report procedure that gives us graded information about how many items were accurately remembered on each trial, which allows us to measure the individual's moment by moment fluctuations in capacity throughout the session. This approach allows us to directly test a long standing question: do low capacity individuals have a consistently reduced capacity or is their poorer performance the result of a mixture of "normal" capacity trials and trials in which they were completely disengaged from the task? Using both behavioural and EEG (i.e., sustained alpha power) approaches we could successfully track trial by trial fluctuations in the number of items that were successfully maintained in WM. Importantly, while we found that low capacity individuals had roughly double the frequency of complete attentional lapses, this factor alone was insufficient to account for the entire extent of the differences between subjects. Instead, our results suggest that the apparent differences in capacity between individuals is determined by a combination of two intra-individual factors: attentional lapse rate and the consistency with which the individual achieved a maximal number of items stored.

Thursday 10th July, 2.50pm

Revisiting the role of persistent neural activity during working memory

Mark D'Esposito, University of California, Berkeley

What are the neural mechanisms underlying working memory (WM)? One influential theory posits that neurons in the lateral prefrontal cortex (lPFC) store WM information via persistent activity. In this talk, I will critically evaluate recent findings that together indicate that this model of WM needs revision. We argue that sensory cortex, not the lPFC, maintains high-fidelity representations of WM content. By contrast, the lPFC simultaneously maintains representations of multiple goal-related variables that serve to bias stimulus-specific activity in sensory regions. This work highlights multiple neural mechanisms supporting WM, including temporally dynamic population coding in addition to persistent activity. These new insights focus the question on understanding how the mechanisms that underlie WM are related, interact, and are coordinated in the lPFC and sensory cortex.

Thursday 10th July, 3.10pm

Visual short-term memory, visual working memory and the visuo-spatial sketch pad

Robert H Logie, University of Edinburgh

A range of terms has been used to refer to the cognitive functions associated with visual and spatial temporary memory and on-line processing. Indeed the original concept of a visuo-spatial sketch pad encompassed a broad range of cognitive functions including mental imagery and visual short-term memory. A parallel research endeavour has focused on visual short-term memory as a function of visual perception and attention, and the concept is treated as synonymous with visual working memory, although the relationship with the general concept of working memory is underspecified. A third approach considers visuo-spatial working memory as one function of a general purpose, capacity limited system that varies between individuals and is correlated with general mental ability. I will argue that both clarity and consistency across these different literatures can be achieved by considering that working memory comprises a range of specialised components that are deployed strategically in concert to support task performance. This will be illustrated with experimental evidence from studies of visual mental imagery, visual temporary memory and visual feature binding in healthy and brain-damaged individuals.

Thursday 10th July, 3.30pm

Rehearsal and the development of verbal working memory

Chris Jarrold, University of Bristol

In their 1974 paper, Baddeley and Hitch proposed a 'phonemic buffer' whose workings might be understood by manipulations of word length and acoustic similarity effects, and which "will probably justify considerably more investigation" (p. 79). Forty years on there has been considerable research into the phonological component of working memory, with many researchers using word length and phonological similarity effects to measure the extent to which participants use subvocal rehearsal to maintain information in verbal short-term memory. In addition, in the developmental literature the absence of these effects in young children has led to the generally accepted claim that children do not rehearse before the age of 7.

In this talk I challenge this view, and suggest that the absence of phonological similarity and word length effects in young children does not provide evidence that they are not rehearsing. This, in turn, has implications for studies of these effects in adult populations, and particularly among adult neuropsychological patients. This claim also raises the question of how to determine whether children are rehearsing. I suggest that one way of measuring rehearsal in children is by examining the impact of verbal and visual distraction on recall of lists of different lengths. Results from such work suggest that children of any age will rehearse a list whose length is within their verbal short-term memory span.

3.50-4.30pm Refreshments

Thursday 10th July, 4.30pm

Mechanisms of forgetting in short-term and working memory

Stephan Lewandowsky (University of Bristol and University of Western Australia) and Klaus Oberauer (University of Zurich)

Some models of short-term memory (STM) ascribe an important role to temporal decay and forgetting due to the passage of time alone. Other models propose that forgetting arises not from decay or the passage of time per se, but from interfering activity during the retention interval. We review the most recent evidence on this issue and report some new data that can help adjudicate between those two possibilities. With verbal memoranda, we consistently find that if articulatory and attentional means of rehearsal are precluded, the mere passage of additional time does not cause further forgetting, which speaks against the inexorable decay of memory traces over the short term. With nonverbal memoranda, a contribution from temporal decay cannot be ruled out. Overall, we argue that progress on this issue requires moving beyond demonstrations of qualitative effects and focusing instead on testing quantitative predictions of computational models.

Thursday 10th July, 4.50pm

What are chunks, and where are they?

Dennis Norris, MRC Cognition and Brain Sciences Unit

Everybody knows that 'chunking' helps STM – but how? It's hard to find clear formal statements of what a verbal chunk might be, nor how chunking improves performance. A common view is that chunking somehow makes it possible to pack more information into STM. I'll report data from experiments where participants have to remember lists containing previously learned pairs of words – 'chunks'? Not surprisingly, lists containing more learned pairs are recalled better, but the pattern of performance on other list items that are not part of learned pairs remains unchanged. Chunking some list items doesn't seem to free up capacity that can be used to remember other items. Perhaps there are no chunks in verbal STM after all? Or maybe we're just stuck with the chunks we've got.

Thursday 10th July, 5.10pm

The role of temporal factors and long-term phonotactic knowledge in verbal short-term memory

Satoru Saito, Kyoto University (with Yuki Tanida, & Masataka Nakayama)

It is well established that long-term phonological knowledge contributes to short-term retention of verbal sequences. Recent studies indicate that lexical prosody also affects phonological short-term memory performance. Prosodic features of languages are founded on temporal structures of verbal items (e.g., word length) and should be implemented with such temporal structures. The present study examined whether temporal factors influence usage of long-term phonotactic knowledge in two sets of immediate serial recall experiments. The first set compared recall performance for two types of nonword lists, sharing the same bi-mora frequency as lists but consisting of a mixture of high- and low- frequency bi-morae (a mora is a Japanese subsyllabic unit). In the first type of list, temporal gaps were inserted at low-frequency bi-mora positions, creating temporal grouping. In the second type, temporal gaps were inserted at high-frequency bi-mora positions, for which we expected a disconnection of the two morae, which otherwise possessed a strong association. The latter manipulation reduced the effect of bi-mora frequency on recall performance. The second set of experiments manipulated position-specific and position-free bi-mora frequency - both affected recall performance. The results indicated the presence of two types of long-term phonotactic knowledge implementation, one being more and the other being less sensitive to temporal structure.

Thursday 10th July, 5.30pm

The phonological loop 40 years on: a mildly controversial view on what it is and what it's for

Dr Mike Page, University of Hertfordshire

Some 40 years after its birth, and 20 years after we first became acquainted, I will give a personal and only mildly controversial view of what the phonological loop is and what it is for. I will maintain that it is a decaying, ordinal store that sits at the nexus of speech perception and speech production. Essentially, it temporarily stores (in order) the last few things you heard or read to yourself, in a form that prepares you to repeat them back. As a lexical-level driver of speech production, it is subject to speech errors - this is otherwise known as the phonological similarity effect. The loop is able to store order in several streams simultaneously, though not without resource implications – this is sometimes known as the irrelevant sound effect. Hearing the same sequence repeatedly (and better still repeating it back repeatedly), leads to gradual recall improvement as the repeating sequence is lexicalized. This is a process that Miller (1956) called chunking, others of us have called the Hebb effect (after Hebb, 1961), and yet others have called word learning.

5.50pm Close

Friday 11th July, 9.30am

Working memory training, what training?

Susan E. Gathercole, MRC Cognition and Brain Sciences Unit

After several years of disputes about the potential of working memory training to modify the underlying construct, there is an emerging consensus that the priority is to map systematically the transfer of training gains. This requires greater statistical power than most studies have provided, as does robust evaluation of the impact of individual differences on responsiveness to training. To address these issues, Cogmed training data from 150 children with a consistent set of transfer measures have been analysed. Adaptive training was associated with highly specific enhancements of a subset of transfer tasks that largely (although not exclusively) overlap with the structure of training activities, and not the construct. Responsiveness to training was modulated by individual differences in working memory. This provides preliminary evidence that training programmes should be tailored to meet individual needs.

Friday 11th July, 9.50am

Working memory impairments and training in children with language difficulties

Joni Holmes, MRC Cognition and Brain Sciences Unit

Impairments in working memory are a common feature among many cognitive developmental disorders of learning, including ADHD and dyslexia. The underlying cause of these deficits may lie in the working memory system itself, arise from input processing difficulties or represent part of a broader disturbance to the executive function system. Understanding the cause of these problems is vital for providing tailored interventions and for developing our theoretical understanding of developmental disorders. This study is the first of a series that will attempt to establish whether responsiveness to working memory training varies with the underlying cause of the memory problem. Sixteen children with language difficulties (LD) and a matched comparison group completed assessments of working memory and related processes before and after 20 sessions of adaptive working memory training. The LD group were characterised by significant impairments in the ability to maintain and manipulate phonological information relative to the comparison group prior to training, suggesting the working memory impairments commonly reported in LD likely arise as secondary consequence of impaired phonological skills. Training gains for the LD group were very limited for verbal aspects of working memory demonstrating that training is not sufficient to compensate for difficulties in phonological processing and storage.

Friday 11th July, 10.10am

Consolidating working memory: Enhancing cognitive performance through effective encoding

Donna M. Bayliss, University of Western Australia (with Jade Bogdanovs and Christopher Jarrold)

Short-term memory consolidation refers to the process of transforming fragile perceptual traces into more durable memory representations that can withstand interference and are available for delayed report (Jolicœur & Dell'Acqua, 1998). Although recent studies have provided evidence of a process of consolidation in relation to the encoding and immediate recall/recognition of single arrays of to-be-remembered items (e.g. Woodman & Vogel, 2005), the contribution of short-term consolidation to working memory span performance has been largely overlooked. In three experiments with young adults, we demonstrated that manipulating the opportunity that individuals had to consolidate each memory item before the onset of a distractor processing activity produced systematic differences in working memory performance. In particular, when individuals were presented with an unfilled delay interval immediately following the presentation of each to-be-remembered item and before the onset of the processing activity, working memory performance was enhanced relative to when the same delay interval was presented after participants had completed the processing activity. In addition, the beneficial effect of providing an opportunity for consolidation was unaffected by manipulations of processing difficulty (Experiment 1), processing pace (Experiment 2), and articulatory suppression (Experiment 3). This suggests that the process of consolidation is separable from articulatory rehearsal and attentional refreshing. Moreover, these results are difficult to account for in terms of cognitive load, temporal distinctiveness, and/or distractor removal and suggest that current models of working memory may need to be modified to take into account the temporal parameters associated with the initial consolidation of memory items.

10.30-11.50am Refreshments and Poster session III

Friday 11th July, 11.50am

A core brain system in assembly of cognitive episodes

John Duncan, MRC Cognition and Brain Sciences Unit

In human fMRI studies, a common or multiple-demand (MD) pattern of frontal and parietal activity is associated with diverse cognitive demands, and with standard tests of fluid intelligence. In complex behaviour, goals are achieved by assembling a series of sub-tasks, creating structured mental programs. Based on behavioural, neuropsychological, fMRI and single unit data, I suggest that MD cortex plays a key role in defining and controlling the parts of such programs. The proposal is illustrated with a series of experiments addressing "goal neglect" in novel behaviour and its link to fluid intelligence. By dividing complex tasks into a series of cognitive or attentional episodes, I suggest, the MD system provides a neurophysiological basis for intelligent thought and action.

Friday 11th July, 12.10pm

Towards a working memory system with distributed executive control

André Vandierendonck, Ghent University, Belgium

Most theories of working memory attribute a central role to executive or attentional control processes. The present talk develops the view that these control processes are deployed in the context of goal-directed behaviour to provide maintenance and protection of the current goal, and to select the most suitable course of action to attain the goal. On the basis of findings on the limited role of working memory in task switching, it will be argued, that the working memory system contains a memory module dedicated to the representation of active goals and the means to attain them. Such a module maintains current goals, courses of action to attain the goals, and other task-execution related information. The processes operating on these memory contents form the basis of executive functions (e.g., set shifting, memory updating, inhibition, …). The question which processes perform executive control thus becomes an empirical question which can be tested in controlled experimental research. The talk will review some of the evidence available and will discuss the implications for future research in working memory will be discussed.

Friday 11th July, 12.30pm

Working memory for the amount of change in an array

Nelson Cowan, University of Missouri

In many studies of visual working memory, an array is presented and is followed by a probe that is either identical to one array item, or differs from all of them. In contrast, when people compare two objects or scenes, it is often possible for multiple elements to differ between the two. To begin to approach this kind of ubiquitous real-world situation, we presented on each trial an array of N colored squares to be remembered (N=5 or 7), followed by a second array resembling the first except that 1, 2….N items had changed to new colors that were not present in the first array. The task was to indicate the number of items that had changed to a new color. I will explain a formula designed to estimate the number of items held in working memory in this situation. Also, on some trials, participants were first asked a metamemory question, specifically how many of the colors they thought they had in working memory. The results show limited awareness of the contents of working memory. The findings will be discussed in terms of the deployment of the human focus of attention in working memory tasks.

1pm Conference closes