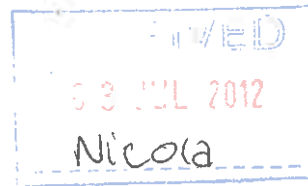


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Final report and expenditure summary for Bial Award 40/10.

Part One: Scientific Report

Part Two: Expenditure Report

P.I. Prof. E. Wilding., R.A. Ms. Lucy Sykes.

Scientific Report

Background: The initial award from the Bial Foundation included Dr Andrea Greve as a named post-doctoral researcher who would take day-to-day responsibility for the progress of the research. In the period between the application submission and the award decision, Dr Greve's circumstances changed and the Foundation kindly agreed to allow me to appoint a researcher at graduate level to complete the work on the award in place of Dr Greve.

Ms. Lucy Sykes was appointed as the researcher on the project and the work started on June 20, 2011. Ms. Sykes has now completed two experiments, as outlined in the program of work, with the focus being on the principal question that motivated the initial application: *Under what circumstances is there electrophysiological evidence that the processes supporting successful judgments about context change over the course of a retrieval task?*

This question was raised by serendipitous findings in previous studies where evidence for this kind of change was observed in one experiment but not in another. We hypothesised that the

electrophysiological changes reflected processes linked to interference resolution, because these were likely to be required to a greater degree in the experiment where the electrophysiological change was evident in comparison to the experiment where it was not. Specifically, the changes in neural activity (hence presumably changes in cognitive operations) were evident when the stimuli employed were words shown in one of two different colours. Comparable changes were not evident when the stimuli were words spoken in either a male or a female voice. We hypothesised that there were few dimensions along which the coloured visual stimuli differed, and consequently the likelihood of interference between stimuli would increase over the course of encoding and retrieval phase of an experiment in which multiple stimuli were shown. According to this argument, the evidence for the engagement of different processes over the first and second halves of the retrieval phase of the experiment reflects the greater need for interference resolution as the retrieval phase progresses. The absence of evidence for this kind of processing change when auditory stimuli were used is explained by the possibility that the number of dimensions on which spoken words might differ (e.g. intonation, speech rate, inflection etc..) is greater than for words shown in words of two colours, hence lower demands on interference resolution.

Experiments: The experiments we conducted were designed to test the interference resolution account in tasks designed specifically for that purpose: the experiments yielding the preliminary findings described above were conducted initially for other purposes.

In the first experiment, participants each completed two sessions, stimuli were words, and the sizes of the colour sets in which words were presented at study varied across sessions. In both sessions, all test stimuli were shown in black. In one session, study stimuli were shown in one of two colours (an equal number in each colour). In the other session, study stimuli were shown in one of four colours. These parameters, along with stimulus numbers and experiment detail were determined during extensive pre-experiment piloting. The total numbers of study and test stimuli were equal in the two sessions and the order in which sessions were completed was counter-balanced. If the interference account given above is correct, then the degree of interference should be greater in the two-colour session, hence electrophysiological evidence for changes in processing over the course of the session should be most pronounced in this case.

This prediction was upheld: changes over the course of a session were more pronounced in the two- than in the four-colour session. In so far as interference resolution was required to a greater degree in the two-colour condition, this finding encourages a functional account of the changes in electrophysiological signatures of successful retrieval over the course of the task in terms of processes that are engaged to overcome the build-up of interference between similar (hence competing) stimuli as a retrieval task progresses. These outcomes were presented at the Cognitive Neuroscience Society in Chicago in April, 2012. The abstract submitted and accepted for the Cognitive Neuroscience Society Meeting is appended to this report.

Another important element of the findings in this experiment came to light during subsequent analyses when the data were compared for individual participants and separated according to how their performance changed over the course of the experiment. Only for those participants for whom there was evidence of performance change was there also evidence of electrophysiological change. This is important because it suggests a causal role for the change in the neural signature of

successful source recovery. The process of finalising write-up of this paper for submission for peer-review will take place in Summer, 2012.

In the second experiment, the pre-award hypothesis was tested in a different way. The intuition underlying the experiment was that memory traces degrade and become less distinctive over time. Presumably this means that the likelihood of stimuli interfering with each other increases when the interval between study and test is varied. The allied electrophysiological prediction is that evidence for changes in neural activity over the course of the experiment should be greater when the interval between study and test is larger.

Piloting for this experiment resulted in a design in which two colours were employed. The intervals between study and test sessions were 1.5 hours and 22-26 hours (participants returned to the lab for testing the day after the study phase, starting the test session within a 2-hour window either side of the time at which the study phase had commenced).

In contrast to the first experiment, in this experiment there was no electrophysiological evidence for more pronounced changes in retrieval processing during the course of the task in the 'high interference' (long study-test interval) group of participants. Of the possible contributing factors to this outcome, perhaps the most pertinent is differences at the time of test. In Experiment 2, the study-phase exposure was identical for participants in both groups – the interval manipulation was the critical difference. In Experiment 1, by contrast, study-phase exposures (in the two- and four-colour sessions) were not equivalent. It is reasonable to assume that the increased delay between study and test in Experiment 2 resulted in somewhat more similar representations (as a result of decay) at the start of the test session, but crucially within the test session for both groups, words were shown in only one of two colours. This means that there was less potential for differences in the build-up of interference as a result of test exposures across groups than in Experiment 1, where a greater number of highly similar stimuli were presented in the two- than in the four-colour condition.

It is important to emphasise that the null result in Experiment 2 is interesting because it is accompanied by the positive outcome in Experiment 1. As a result, it provides a basis for delineating conditions under which interference resolution might be required. This has the important practical implication – highlighted in the initial application for funding – of suggesting extant studies in which one might be concerned about the extent to which analysing data collapsed across the entirety of a retrieval session might not give an accurate reflection of the processes engaged during that session. While the only robust means of determining whether this is a concern in individual studies is to complete the appropriate analyses, it is also the case that null results of the kind identified in Experiment 2 can suggest classes of experiment for which concerns about misinterpretation based on inferences over broadly averaged data are not substantial.

Concluding Remarks: We have made some progress in understanding the functional significance of frontally distributed electrophysiological modulations. Experiment 1 has provided evidence to suggest that interference resolution is a plausible functional account for the changes in frontally distributed neural activity that are associated with successful retrieval and are observed under some experiment conditions only. We hope that this outcome will result in a published data set. Moreover, the outcomes in the two experiments in combination are an incentive for us to conduct further studies. If we can confidently associate frontally-distributed electrophysiological modulations

with interference resolution then we will have a powerful neural marker that we can exploit in pursuit of a detailed understanding of how and when processes important for overcoming interference are engaged during tasks that require recovery of information from memory.

Please contact me should you require anything further at this time.

Yours Sincerely



Professor E. Wilding



Qualitatively distinct memory retrieval processes engaged during the course of an episodic retrieval task (Bial Award 40/10).

Lucy Sykes, Lisa Evans, Edward Wilding: Cardiff University Brain Research Imaging Centre (CUBRIC), School of Psychology, Cardiff University, Cardiff, Wales, United Kingdom.

The objective of this experiment was to investigate changes in neural activity over the course of a memory retrieval task. The assumption was that the demands placed on monitoring the contents of retrieval would increase as the numbers of stimuli to which memory judgments were required also increased. We tested this by measuring event-related potentials (ERPs) during the test phase of a retrieval task, because ERPs index processes related to retrieval monitoring.

Participants first studied words in one of two colours. Studied and unstudied (new) words were then presented in a neutral colour. ERPs were acquired while people made old/new and then study colour judgments to the test words. The differences between ERPs associated with correct judgments to new words (correct rejections) and correct colour judgments to old words were compared for the first and the second halves of the retrieval task. The rationale for this first/second half separation was that the demands on monitoring would increase during the task and would be revealed by differences between ERP indices of retrieval monitoring over the course of the task.

The critical ERP indices differed qualitatively from approximately 1000ms post-stimulus, indicating that not entirely the same retrieval processes were operating in support of accurate memory judgments over the retrieval task. In combination with the absence of evidence for this change in another experiment where auditory rather than visual contexts were used at study, these findings suggest the outcome is not simply an effect of time on task. It is possible that the effects specific to the second half of the retrieval task index additional processes engaged as the demands placed on distinguishing between similar memory representations increase. Irrespective of the accuracy of this account, however, the findings indicate there are circumstances where making functional inferences about patterns of neural activity in brain imaging experiments based on data averaged over the entirety of retrieval tasks might lead to inaccurate functional characterisations.

Keywords: Retrieval Monitoring; Episodic Memory; Event-related potentials