LEVERHULME TRUST

APPLICATION FORM - Early Career Fellowship

Applicant: Dr Samantha Gregory	ID/Ref: ECF-2018-130
Project Title: Memory enrichment by social context: A virtual reality EEG research project.	
Submission Date: 26 February 2018	

Applicant Details

Title	Dr	**Address**	
Forename(s)	Samantha		
Surname	Gregory		
Honours			
Gender	Female		
Date of Birth			
Institution	Aston University		
Department	Psychology	**Telephone No.**	
		Email Address	s.gregory1@aston.ac.uk

Host Institution	Aston University

Career Details

Employment

Start Date	End Date	Job Title	Employer
02/2017	-	Post-doctoral Research Associate	Aston University
01/2013	09/2013	Research Assistant	Bangor University

Education Details

Degrees

From	To	Degree	Subject	Class	Institution
09/2008	07/2011	BSc	Psychology	First Class hons	Bangor University
09/2011	09/2012	MSc	Psychological Research	Merit	Bangor University

Doctoral Degrees

From	To	Degree	Title of Thesis	Supervisor	Institution
09/2013	03/2017	PhD	The Influence of Social and Non-Social Cues on Orienting Attention and Working Memory.	Dr Margaret Jackson	University of Aberdeen

Further Applicant Details

Has your doctoral thesis been submitted? Yes

Submission date of doctoral thesis: 30/01/2017

Have you been or are you currently a Principal Investigator on a 3-year post-doctoral research project, or have you held or do you currently hold a comparable 3-year post-doctoral position to pursue your own research?

No

Date current position/funding ends: 31/01/2019

Proposed start date for Fellowship: 01/02/2019

Any other matters you wish to bring to the attention of the Committee

Research and Publications

Title of research proposal: Memory enrichment by social context: A virtual reality EEG research project.

Fields of study: Experimental Psychology

Abstract

When an experience is shared, it is enriched by the presence of the other individual. Research has indicated that this enrichment can result in a measurable change in how the event is processed. Examples include changes in processing speed, changes in appraisal of objects, and growing evidence of changes in memory for objects. Research conducted to date has been key in providing evidence of a social effect on memory, yet the nature and mechanism of this effect remains unclear. The research proposed here aims to advance our understanding of how and when social contexts enrich memories.

Details of current and past research

Currently I am working as a postdoctoral research associate investigating systematic discrepancies in students' memory for assignment feedback (Leverhulme Grant RPG-2016-189). I also use eye tracking to examine related attention-based effects.
Past research: For my doctoral thesis, I investigated how attention and visual working memory could be influenced by simple central social and non-social cues that had no predictive value or task relevance. Uniquely, I assessed the effects of these cues on working memory. I also expanded on past research into cues effects on attention. The cues consisted of a face whose eyes shifted left or right, an arrow that pointed left or right, and a line that moved left or right. The cues were chosen based on their levels of meaning and social value, with gaze having the strongest meaning and social value. I measured their influence on attention using a Posner based cuing task, where participants had to respond quickly with the location of a target presented after the cues movement. I investigated working memory using a task where participants were presented with coloured squares, which they had to remember, either in the cued location or in the uncued location. I found that different cue types had distinct, context dependent, influences on attention and memory. Of most interest was a uniquely social influence of eye gaze on working memory, whereby items encoded under shared attention were remembered better than items encoded without shared attention- the arrow and moving line cues did not modulate memory accuracy.

Detailed statement of proposed research

Samantha Gregory

Background: Although we experience the world with our own individual senses, we often share these experiences with others. This involves what is known as shared or joint attention, and this social act can change how an object or event is processed (Shteynberg, 2017). For example, another person's eye gaze can influence looking behaviour (Frischen, et al, 2007), make items more likeable (Bayliss,et al, 2006), and, importantly, has been shown to enhance item memory in both long term memory (Dodd, et al, 2012) and working memory (Gregory & Jackson, 2017). Here I am specifically interested in the influence of eye gaze on working memory. Working memory is central to everyday behaviours such as pursuing goals and is particularly important during social interaction, where people need to keep track of variables related to the other individual as well as themselves. Therefore it is important to understand how the social interaction itself, specifically sharing gaze, influences working memory. Currently, understanding of the mechanisms of the influence of social factors on working memory remains limited and the studies conducted to date have been highly artificial. A number of researchers are currently calling for use of

more realistic paradigms when exploring social attention, so that results can be more widely applied (Gobel, et al, 2017; Risko, et al, 2016). Therefore, the project proposed will investigate how social factors can interact to influence working memory for complex objects in realistic social environments. Virtual reality (VR) will be used to create controlled but realistic scenarios in which participant memory is tested while data is collected on participant's behavioural and neural responses. This use of VR will allow control of the experimental environment, giving certainty that findings relate to the experimental variables, while giving the participant a more realistic social interaction. The virtual social partner will be created using the latest innovation from computer science to ensure that they behave as humanly as possible. This will be done by using high quality software and up to date knowledge to design and present the avatars, for example, using motion capture from real people to ensure realistic motion, and using current findings from computer science and psychology on how to present avatars so that eye gaze behaviour is realistic. It is not yet known how eye gaze influences the neural representations of objects and events seen during a social experience. This research will thus investigate the influence of sharing attention on specific neural frequencies that are known to relate to cognitive performance, specifically to attention (alpha) and memory (theta) (e.g. Klimesch, 1999) and, in particular, to memory and attention in a social context (e.g. Bögels, et al, 2015). It is predicted that changes in these frequencies will be observed in relation to memory (theta) and/or attentional processing (alpha) due to the specific, "enriching" social factors investigated. Knowledge of this will therefore further understanding of what it is about eye gaze that is 'special'. Finally, in order to control for the possibility that effects are due to non-social factors, a directed 'stick', which points towards or away from crucial items, will be used as a non-social control cue. This novel control cue differs from the arrow usually used as a control (Frischen et al., 2007) due to certain potential biases in attention to arrows related to the overlearned nature of the cue (e.g. Hommel, et al, 2001; Ristic & Kingstone, 2006). The movement of this stick may be believed to have a social component and so this will be assessed with a manipulation check. However, the most important aspect of the 'stick' is that it does not have the social presence of a person, for example eye gaze is a key part of social interaction (Frischen et al., 2007).

Aims: This project aims to advance understanding of how and when sharing attention affects higher cognition, specifically working memory, using highly realistic avatars in VR scenarios.

Objectives

1. To create realistic avatars in realistic situations to use as social signallers in subsequent studies.
2. To measure the influence of social signals on working memory for information received during a social encounter.
3. To measure the influence of social signals during a working memory task on alpha and theta waves (using EEG).
4. To understand further the social nature of the interaction using a control cue ('stick').
5. To understand how the social reward value of the social event affects the nature of the influence on working memory.

Methodology: *Note, all equipment and software mentioned is already available at Aston University however, a powerful computer will be needed to run the virtual reality software required for building environments and avatars.*

Creation of avatars, control cue and environments. Avatars, and control stimuli, will be created in Reallusion's iClone 7 software suite. Motion capture software (Axis Neuron Pro, using the Perception Neuron body suit) will capture how different people sit at a table while looking at and interacting with items. The control 'stick' cue will closely replicate the pattern of cuing made by the gaze cue. The environment and experimental structure will be created with Unreal Engine 4.

EEG recording: An eego™ sports EEG system will measure cortical oscillations in the alpha and theta band during item encoding, maintenance and retrieval, with relation to avatar/ 'stick' condition.

General method: All experiments will follow a basic delayed-match-to-sample (DMTS) procedure: The participant will sit in front of an empty table (in VR), which has a chequered grid pattern to allow location information to be known. In Avatar present conditions, an avatar will sit opposite them, and first look at the participant (or stick points at participant). After 1000ms, 4-items (e.g. coffee cup) appear on the table, presented on the left or the right side of the table, in 4 of the 6 possible locations (chequered squares) within that area. The avatar then looks (or stick points) at the area the items have appeared in or looks away to the empty area of the table. After 2000ms, a screen will occlude the items and the avatar/ stick. After 1000ms the screen is removed and a single item is presented without the avatar/ stick in either a previously occupied position (50% of trials) or a new position (50% of trials). The participant is asked if this item had been in this position initially, and an additional question related to the nature of the item, e.g. was the coffee cup full. The key experimental manipulation will be whether items were presented under the shared attention of the avatar and observer or not (observer alone). There will be 40 trials per condition, pseudorandomised, to allow for sufficient signal-to-noise ratio in EEG recordings. This visuo-spatial working memory task is used due to the importance of being able to attend and locate objects relevant to others and ourselves.

Participants: All studies will be within subjects design, with 60 subjects for each experiment initially (i.e. Gregory & Jackson, 2017). However, as this paradigm is new, data will be analysed using Bayesian analysis methods. Here, researchers are able to look at their data and determine if more participants are necessary to come to an adequate conclusion (Rouder, 2014), therefore limiting the occurrence of type one or type two error.

Individual differences: Autistic traits, social anxiety and empathy will be measured to control for related effects.

Analysis: Relocation accuracy and item nature accuracy will be analysed as the dependent variable. Bayesian ANOVAs will be conducted in JASP (JASP Team, 2017) with avatar looking or stick pointing conditions, and in studies 3 and 4 avatar status, as the independent variables. Follow up t tests (Bayesian) will be conducted to investigate any key variables based on predictions. From the EEG data, changes in alpha and theta waves with relation to avatar/ 'stick' condition will be analysed using the MATLAB® toolbox Fieldtrip, which offers powerful pre-processing and robust statistics methods, for which extensive expertise exists at Aston University.

Study 1A. *Testing the influence of joint attention with an avatar on working memory.* **Procedure:** In addition to the basic DMTS procedure we will vary three avatar conditions. **1.** Avatar looks at space with items **2.** Avatar looks at space with no items. **3.** No avatar present (control). It is predicted that memory for the items will be better when the avatar also looks at them compared to both when the avatar looks away and when there is no avatar. This could further be reflected by increased theta memory-

and/or alpha attention-signatures when the avatar looks at the items, indicating whether the effect is primarily due to differences in attention (alpha effects only) or memory (theta effects only) or both.

Study 1B. Replicates study 1A using a stick in place of the Avatar – the stick points at items/ points away, this will allow understanding of whether basic effects are due to the social factors, or simple cuing.

Study 2A: *Is gaze necessary or is interacting with an object sufficient?* Study 2 investigates whether there are additive benefits on memory of interaction with the objects beyond gaze. This relates to research on mimicry, where humans are prone to copy actions of others, potentially to aid learning (e.g. Wang & Hamilton, 2012), as well as research that shows similar neural responses for action observation and action execution (Bach, et al, 2010). **Procedure:** The main procedure matches the general methods. The avatar conditions are as follows, **1.** Avatar just looks at items (replicating condition 1, study 1). **2.** Avatar looks at and touches the object. **3.** Avatar just touches the object – avatars eyes are hidden behind sunglasses and avatar maintains a central head position. **4.** Control condition – no avatar present (replicating condition 3, study 1). It is predicted that the condition with interaction and gaze will show the largest memory effect compared to both gaze alone and hands alone, along with the strongest oscillatory signatures of attention and/or memory.

Study 2B: Partially replicates study 2A using a stick in place of the Avatar – stick points at items/ touches items/ no stick.

Study 3 and 4: *Avatar status.* The purpose of studies 3 and 4 is to investigate the influence of the social status of the avatar on working memory. This is crucial to understand the mechanism of the effect, because if status is important then the effect can be attributed to deeper processing of the social information. If, however, the effect is not modulated by the social status of the avatar, then the effect can be considered related to the surface social processes based on the presence of the social cues alone (gaze and/or action). Trustworthiness and perceived social status will be manipulated. This is a crucial manipulation whether or not the control cue (stick) replicates the avatar in studies 1B and 2B.

Study 3: *Avatar Trustworthiness*. The influence of faces used in gaze studies can be modulated by manipulating face trustworthiness (e.g. King et al. 2011), **Procedure:** Two avatars, trustworthy and untrustworthy, manipulated using a tested prior manipulation (e.g. King et al., 2011 – character description) will be used in the basic DMTS paradigm (Expt. 1). It is predicted that items looked at by the trustworthy avatar will be remembered better and show stronger oscillatory signatures.

Study 4: *Avatar social status*. **Procedure** Two avatar types will be used, one is ignored during a game (e.g. Zadro et al., 2004), the other is included, thus manipulating perceived social hierarchy of the avatar. Like Expt 3, it is expected that items looked at by the higher-status avatar will be remembered better and show stronger oscillatory signatures.

Outcomes: It is expected that the research will generate at least 2 major publications in leading psychology journals. The project will also lead to a database of avatars for use in social paradigms that will be shared with the scientific community. Findings will be presented at two national and two international conferences where I will also network with leading researchers in the field and discuss the work in detail. I will engage in public dissemination, I have been in contact with the Millennium Point Science Centre in Birmingham, and they are keen to engage with research. In addition, I will engage with media such as The Conversation, and radio and newspaper media to make the research more publically accessible.

Time table: The first year of the project will focus on obtaining ethical approval, creating the avatars required for the project, learning to use software and equipment required, programming, piloting and beginning testing of the studies. Data collection for Studies 1A and 1B will commence in September/ October 2019 when there will be an influx of student participants. Year 2 will focus on Studies 2A, 2B and 3 with any remaining data collection, as well as collection for Study 4 being finished in the first half of year 3. Data analysis and coding will be ongoing throughout the project along with writing and dissemination.

Bach, P., Peelen, M. V., & Tipper, S. P. (2010). On the role of object information in action observation: An fMRI study. *Cerebral Cortex, 20*(12), 2798–2809.

Bayliss, A. P., Paul, M. A., Cannon, P. R., & Tipper, S. P. (2006). Gaze cuing and affective judgments of objects: I like what you look at. *Psychonomic Bulletin & Review, 13*(6), 1061–1066.

Bögels, S., Barr, D. J., Garrod, S., & Kessler, K. (2015). Conversational interaction in the scanner: Mentalizing during language processing as revealed by MEG. *Cerebral Cortex, 25*(9), 3219–3234.

Dodd, M. D., Weiss, N., McDonnell, G. P., Sarwal, A., & Kingstone, A. (2012). Gaze cues influence memory..but not for long. *Acta Psychologica, 141*(2), 270–275.

Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze cueing of attention: visual attention, social cognition, and individual differences. *Psychological Bulletin, 133*(4), 694–724.

Gobel, M. S., Tufft, M. R. A., & Richardson, D. C. (2017). Social Beliefs and Visual Attention: How the Social Relevance of a Cue Influences Spatial Orienting. *Cognitive Science*, 1–25.

Gregory, S. E. A., & Jackson, M. C. (2017). Joint attention enhances visual working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 43*(2), 237–249.

Hommel, B., Prat, J., Colzato, L., & Godijn, R. (2001). Symbolic control of visual attention. *Psychological Science, 12*(5), 360–365.

JASP Team. (2017). JASP.

King, D., Rowe, A., & Leonards, U. (2011). I trust you; hence I like the things you look at: Gaze cueing and sender trustworthiness influence object evaluation. *Social Cognition, 29*(4), 476–485.

Klimesch, W. (1999). EEG alpha and theta oscillations reflect cognitive and memory performance: A review and analysis. *Brain Research Reviews, 29*(2–3), 169–195.

Risko, E. F., Richardson, D. C., & Kingstone, A. (2016). Breaking the Fourth Wall of Cognitive Science: Real-World Social Attention and the Dual Function of Gaze. *Current Directions in Psychological Science, 25*(1), 70–74.

Ristic, J., & Kingstone, A. (2006). Attention to arrows: pointing to a new direction. *Quarterly Journal of Experimental Psychology, 59*(11), 1921–1930.

Rouder, J. N. (2014). Optional stopping: No problem for Bayesians. *Psychonomic Bulletin & Review, 21*(2), 301–308.

Shteynberg, G. (2017). A Collective Perspective: Shared Attention and the Mind. *Current Opinion in Psychology,* 1–5.

Wang, Y., & Hamilton, A. F. D. C. (2012). Social top-down response modulation (STORM): a model of the control of mimicry in social interaction. *Frontiers in Human Neuroscience, 6*, 153

Zadro, L., Williams, K. D., & Richardson, R. (2004). How low can you go? Ostracism by a computer is sufficient to lower self-reported levels of belonging, control, self-esteem, and meaningful existence. *Journal of Experimental Social Psychology, 40*(4), 560–567.

Major publications

Samantha Gregory

Major publications

In preparation

Socially and non-socially biased competition of attention and working memory

Orienting attention: Eyes, arrows and moving lines.

Submitted

Gregory, S. E. A., & Jackson, M. C. Barriers block the effect of joint attention on working memory: Perspective taking matters. Submitted to *Journal of Experimental Psychology: Learning, Memory & Cognition*.

Published

Nash, R. A., Winstone, N. E., Gregory, S. E. A., & Papps, E. (in press). A memory advantage for past-oriented over future-oriented performance feedback. *Journal of Experimental Psychology: Learning, Memory & Cognition.* (Word count 19174)

Gregory, S. E. A., & Jackson, M. C. (2017). Joint attention enhances visual working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 43*(2), 237–249. https://doi.org/10.1037/xlm0000294

Windle, G., Gregory, S., Newman, A., Goulding, A., O'Brien, D., Parkinson, C. (2014). Understanding the impact of visual arts interventions for people living with dementia: a realist review protocol. *BMC Systematic Reviews*, *3*(91) doi:10.1186/2046-4053-3-91.

Dementia Services Development Centre. (2013). Lost In Art Too... An evaluation of a 10 week programme of art sessions provided by Denbigh County Council for people with dementia and their carers. Bangor, Wales: Gregory, S. & Windle, G.

Gregory, S. & Windle, G. (2013). Lost in Art too: challenging perceptions of dementia. *Journal of Dementia Care*, *21*(5), 23-25.

Duration, Timing and Host Institution

Duration of Fellowship: 36

Percentage of time to be spent on the Fellowship: 100

Research relevant to your proposal being carried out in the host department

Professor Klaus Kessler researches the cognitive neuroscience of visual working memory and embodied (social) cognition using realistic virtual environments in the Aston Laboratory for Immersive Virtual Environments (ALIVE).
In ALIVE, Professor Tim Meese (Director) researches vision in virtual reality (VR), including social vision. Dr Ulysses Bernardet researches human-machine interaction, including creating autonomous avatars with human-like behaviour.

Analysis pipelines for MEG and EEG have been developed at the Aston Brain Centre (Director: Professor Amanda Wood) under the supervision of Professor Kessler.
Drs Charlotte Hartwright, Dan Shaw and Sarah Carrington have been recently appointed to conduct social neuroscience research at the ABC.

Additional reasons for selecting your chosen host department and institution

The Aston Laboratory for Immersive Virtual Environments (ALIVE) is a unique facility for creating virtual reality environments and scenarios, bringing ecologically valid research into the computer controlled environment of the laboratory. Its membership offers a large body of expertise that is relevant to my research, both technical (software development) and scientific (perception and social cognition) and regular journal clubs provide opportunities for dissemination and feedback. EEG and MEG expertise in the associated Aston Brain Centre will also support the data collection and analysis pipeline. The city centre location of the University provides good local and national accessibility.

Referees

Referee 1	
Department : Institution	
Position	
Email	

Referee 2	
Department : Institution	
Position	
Email	

Referee 3	
Department : Institution	
Position	
Email	

Previous and Current Applications

Previous Leverhulme applications and awards or pending applications to the Trust

Other awards received in the last 12 months related to this project

Applications you have made or intend to make to other bodies related to this research proposal

Research Budget

Give an indication of how you would propose to use the annual research allocation of £6000 for each year of the Fellowship. If the application is successful you will have the opportunity to revise these details. The Trust does not support FEC.

Year 1

- £1000 to buy a powerful, VR-ready computer required to run the software that will allow creation of the Avatars and experimental VR scenarios. This is beyond the capabilities of a standard PC.
- £100 - computer motherboard capable of running VR
- £400 - graphics card capable of running VR software

- £100 - memory (RAM)
- £150 – HD Monitor to enable clear display while building in VR
- £250 Solid state hard drive to ensure high processing speed
- £1800 Participant payment (120 participants, 2 experiments paying £10/hour)
- £1000 for extended lab visit, travel + accommodation for 1-2 weeks. I have contacts at UCL, UEA,, Stirling University and The University of Aberdeen.
- £200 consumables, e.g. EEG gel, hygienic covers for Oculus Rift

Year 2

- £2200 Conference attendance (2)
- £1800 Participant payment (120 participants, 2 experiments, paying £10/ hour)
- £1800 Gold access publication fees
- £200 consumables, e.g. EEG gel, hygienic covers for Oculus Rift

Year 3

- £2500 Conference attendance (2)
- £1800 Gold access publication fees
- £1500 Participant payment (100 participants, finalising experiments, paying £10/ hour)
- £200 consumables, e.g. EEG gel, hygienic covers for Oculus Rift

Institutional Approver Details

Important Note: Applicants can view these details to see what information is required from the host institution in order to provide Institutional Approval. Applicants may not complete any of these details themselves but should ensure that their prospective host institution is aware of what details are needed.

Department Head

Institution	Aston University
Full Name	
Department	
Email Address	

Why is your department the best place for the applicant to undertake their research project?

The School of Life and Health Sciences hosts the Aston Laboratory for Immersive Virtual Environments (ALIVE) which is a unique facility for creating the virtual reality environments and scenarios specifically required by the proposed project. A large body of expertise is present that is relevant to the research, both technical (software development) and scientific (perception and social cognition). Expertise at the Aston Brain Centre will also support Samantha in data collection and analysis. Further, the dynamic research culture of the department will be beneficial to Samantha's continued academic career.

Why would you like the applicant to be hosted by your department and what are the benefits to your institution by acting as their host?

We would like to host the applicant because we will benefit from the presence of a strong early career researcher who has the benefit of having got to know the department in her role as a postdoctoral researcher. We will further benefit from her undertaking a unique and innovative project, and her gaining expertise in what is a relatively new method of research to share with other researchers in the department. We will also benefit from the research, which will make use of the facilities at ALIVE, demonstrating the capacity of the lab and stimulating other new research.

How will the applicant be mentored by colleagues in your department?

Professor Klaus Kessler will act as mentor for the duration of the grant. He has research expertise in the cognitive neuroscience of visual working memory and embodied (social) cognition using realistic virtual environments. Additionally, the director of ALIVE, Professor Tim Meese, and Dr Ulysses Bernardet will provide expertise in Virtual reality and creation of Avatars. Researchers in the Aston Brain Centre will provide expertise required. Further, there is a general culture of support in the department, with Samantha already knowing the department well as a current postdoc. Samantha will also benefit from the professional development courses provided by the institution.

How might the applicant contribute to teaching and the wider intellectual life of the department?

Samantha would become an expert in the methods used in the project and would disseminate the expertise. She would also help to supervise student projects, and have the opportunity to contribute to teaching, for example providing guest lectures on currently running courses. She would have many opportunities to attend and present her research at departmental research meetings such as regular journal clubs and within the Basic and Applied Neurosciences Group (BANG). She would also attend and contribute to staff meetings.

Details of facilities and relevant resources the Fellow will be provided with by the host department

The extensive facilities and expertise in the Aston Laboratory for Immersive Virtual Environments (ALIVE) will be fully accessible, these provide the major equipment and space required for this project. Further facilities and expertise at the Aston Brain Centre are also available. Research space, office space and student participants will also be available, as will training courses and full access to library facilities.

Starting Salary	
Spine / Scale Point	
London allowance	0
National Insurance	
Superannuation	
Total	

Source of matching funding

50% matching funding will be contributed by the School of Life and Health Sciences at Aston University and I can confirm that these will be drawn from generally available funds and are/will not associated with any other grants received by the institution.

I confirm on behalf of the host department and the host institution that:

- The candidate named above will be accepted to work in the host department and will be treated in every respect as a full-time member of the department and as a normal employee
- The host institution will accept the Trust's contribution of 50% (up to £25,000 per annum) of the Fellow's total salary cost for the duration of the Fellowship and undertakes to match this for each year of the award.

Name	
Position	
Email	