**Stag Hunt Study design**

**Background and research questions**

Neuroimaging studies have implicated several brain regions as important in social decision making, including the orbitofrontal cortex and ventral striatum, as well as areas involved in Theory of Mind (ToM) such as the medial prefrontal cortex (mPFC), posterior superior temporal sulcus (pSTS) and temporoparietal junction (TPJ) (Lee and Harris 2013, Seo and Lee 2012, Yoshida et al 2010, Hampton et al 2008). Given the range of brain areas and processes involved, it is to be expected that several factors can affect activation in these areas, and influence the decisions we make, often without our conscious knowledge.

For example, studies of race have found that participants’ brains are activated differently in response to in-group (same race) and out-group (different race) faces (for review see Kubota et al 2012). Such differential activation is consistently found in the amygdala, ACC, DLPFC and fusiform face area (FFA); areas involved in emotional learning, response competition and control, executive function and face recognition respectively. Interestingly, participants in these studies elicited no explicit preference towards a particular race, however, implicit association tests frequently revealed an unconscious bias towards in group individuals.

We investigate the idea of bias in social decision making by conducting a functional MRI study utilising a version of the Stag Hunt (SH) task. The SH task is adapted from a story by Rousseau, in which two individuals embark on a hunt and must decide to work cooperatively to hunt a stag, with a consequent large pay off for both hunters, or to individually hunt a hare resulting in a lower and individual pay off (Skyrms and Irvine 2001). The task involves making a decision about the other person’s intentions, since the only reason to hunt a hare is if one believes the other participant will do the same. The greater gain for both is to work cooperatively, but the SH illustrates that such cooperation can fail.

Yoshida et al (2010) found that players of the SH were more likely to cooperate (ie hunt a stag) if they had an understanding of the other player’s strategy or intentions. It is reasonable to assume that decisions made during such a cooperative game will be modulated by social factors, however, there is very little research to support this. Certainly, there are no studies which investigate social decision making with regards to national bias, and none which include a social cue in the SH. We therefore aimed to explore if nationality can have an effect on how we perceive others’ intentions, and how this may influence the decision to cooperate (or not) in the SH task.

Scottish nationals, who had previously stated that they identify as being Scottish by way of questionnaire, completed a version of the SH task while in the MR scanner. They were informed of their “opponent’s” nationality (which was actually a computer programme) by presentation of a national flag – either the Saltire, St George’s Cross, Union Jack, or EU – which remained present throughout. After an intial round with no flag present, each participant completed the task four times, once each with an opponent from each nationality, the order of which was counterbalanced across participants.

**Hypotheses**

* Participants will perform differently on the task depending on the nationality of their opponent. More specifically, they will be more likely to cooperate with in group opponents (Scottish Nationals) than others.
* Brain areas involved in ToM and reward will be activated in response to the task (mPFC, orbitofrontal cortex, ventral striatum), and will be activated differently depending on opponent.
* Brain areas involved in emotion processing (amygdala, insula) will be activated differently depending on opponent.

**Participants**

Button et al (2013) have noted the under-powered nature of many fMRI studies. These have are often been conducted on very small sample sizes. The most difficult aspect of estimating how many subjects are required is the challenge of estimating the critical parameters (Desmond and Glover 2002). Mumford and Nicholls (2008) have produced a method for power calculations but acknowledge its limitations as effect sizes are not normally known (Mumford 2012). Twenty to twenty five participants are required, at a minimum, for an fMRI study if it is to be repeatable and representative of the population (Friston, Holmes, & Worsley, 1999; Thirion, 2007). When effects are more variable or weaker, it has been argued that thirty participants are required (Seghier et al, 2008). Additional participants are required to replace scans that need to be excluded due to movement artifacts, neuroanatomical anomalies, and technical problems.

31 healthy adult volunteers were recruited from the general population who were identified as being Scottish nationals. As the UK is a multi-national state, in which a resident of Scotland might identify as primarily Scottish or as British (or indeed as both) participants were pre-screened using the following question: ‘If you were forced to choose only one, you would identify yourself as: [Scottish/British/European/Other/English/Welsh/Northern Irish].’

Only those who self-identified primarily as Scottish were included in the study. Participants were not aware that this response was required for study inclusion, and relevant questions were embedded within a multi-focussed questionnaire designed to ascertain the suitability of participants for MR scanning. All participants provided written informed consent and were made aware that they may withdraw from the study at any time, and be at no disadvantage if they choose to do so.

*Inclusion criteria*

Scottish national

Physically healthy

Anatomically normal brain

Right handed

Normal or corrected vision

*Exclusion criteria*

Pregnancy

Mental illness

Neurological conditions

Ferro-magnetic prostheses

Claustrophobia

BMI > 35kg/m2

*Recruitment*

Participants were recruited from existing research databases, and via adverts distributed widely to a representative cross section of the community.

**Methods & Materials**

*Questionnaires*

Prior to scanning, participants completed a pre-screening questionnaire to ensure they identify as being a Scottish National. Participants were not aware that this response was required for study inclusion, and relevant questions were be embedded within a multi-focussed questionnaire (Appendix 1). Participants also completed all relevant MR safety questionnaires and consent forms (Appendix 2 and 3). Following their MRI scan, participants completed a further questionnaire. This provided demographic data and allowed us to quantify the salience of national attachment, in this case attachment to Scotland, for each participant. According to Sinnot (2005), the most effective available measure of sub-national, national or supra-national level attachment is a combination of categorical self-identification with a question that rates the importance or salience of the identification involved. Having been pre-screened as Scots identifiers, participants were asked to rate (a) how attached they feel to Scotland and (b) how proud they feel to be Scottish (Appendix 4, questions 9 (a) and 10). This combined measure allowed us to control for the extent to which their Scottish national identity was a more important or salient factor for some individuals than for others. This questionnaire was presented after the scanning session was completed, to avoid alerting the participants to the national identity-related focus of the experiment. Following participation, participants were debriefed (see below).

*fMRI Scanning*

MR scans were conducted using a 3T Siemens Magnetom scanner at the Clinical Research Imaging Centre (CRIC), Royal Infirmary of Edinburgh, 47 Little France Crescent, Edinburgh, EH16 4TJ. Scanning consisted of a localiser, T1 structural image (MPRAGE), EPI sequence (fMRI). The localiser is a very short scan used to ensure head placement is optimal for subsequent scans. The structural scan takes approximately 5 minutes, and the fMRI sequence approximately 20 minutes.

*Procedure*

The study (E141333) was conducted at the Clinical Research Imaging Centre, and the Wellcome Trust Clinical Research Facility, at the University of Edinburgh, Queen Margaret’s Royal Infirmary, Edinburgh. On arrival at the scanning facility, participants were given a detailed overview of the study prior to their scanning appointment as well as a detailed participant information sheet (Appendix 2). Participants also completed all relevant MR safety questionnaires and consent forms (Appendix 3). Participants were reminded that they were free to withdraw from the study at any time without risk of personal consequence. They were then talked through the scanning procedure and allowed to change into appropriate clothing for their scan (for example, no metal elements). Participants were introduced to the CRIC radiographers. In the scanning room participants were allowed to familiarise themselves with the equipment and with the scanning environment. The procedures for communication with researchers and radiographers whilst in the scanner were explained and participants were reminded that they could ask to halt the study and to come out of the scanner at any point if they felt it necessary. Participants were made comfortable in the scanner and goggles were attached to the head coil through which the stimuli could be viewed. The emergency call button was placed easily in reach and in a known position, should the participant wish to contact the control room during scanning. The control room maintained in contact with the participant throughout scanning, between paradigms. . Prior to scanning, participants were allowed to test and practice the experimental paradigm outside the scanner until they felt comfortable with the instructions and the response method.

We adapted our experimental task from the code kindly made available to us by Wako Yoshida and previously tested in their research (Yoshida et al 2010). A two-dimensional grid was navigated by the participants to catch rabbits or stags. Rabbits could be caught by a participant acting alone, but catching stags required cooperation between our participant and their ‘opponent’. Catching a stag brought greater reward (20 points) than catching hares (10 points). Participants could choose whether to cooperate for greater reward or to defect and gain some award alone. A stag could not be caught be a participant alone. The computer degree of cooperativity (1 least cooperative, to 5 most cooperative) changed without notice and the order of this shift was randomized across flag conditions and between subjects. Likewise the order of appearance of the various nationalities of ‘opponents’ was counterbalanced across participants.

**Ethical considerations**

*Participants*

This study recruited only healthy volunteers. The study did not involve clinical care or access to clinical records and was approved by the Research Ethics Committees of the School of Social and Political Sciences and the School of Psychology, Philosophy and Linguistics at the University of Edinburgh, in accordance with the Research Ethics procedures of the Clinical Research Imaging Centre, University of Edinburgh. All procedures, including written consent, were in accordance with APA guidelines and the Declaration of Helsinki.

*Scanning*

There are no known risks associated with the scanning protocol. All anatomical scans were reviewed by a radiologist for abnormalities and the appropriate action taken in the case of any potential findings.

**Participant compensation fee**

Participants were given £20 compensation for their time and for any expenses associated with their participation in the study.

**MRI data acquisition**

Imaging data was acquired using a 3T Siemens Magnetom Verio Syngo whole-body MRI system (Siemens Medical Systems, Erlangen, Germany). Scanning consisted of a very short localiser scan to ensure head placement was optimal for subsequent scans. Structural images were acquired using a T1-weighted magnetisation-prepared rapid gradient echo (MPRAGE) sequence (TR 2300ms, TE 2.98ms, 256mm 93.8% FOV, 1mm slice thickness) and functional images were acquired using a T2\*-weighted gradient echo echo-planar imaging (EPI) (TR 2180ms, TE 27ms, 192mm 100% FOV, 3mm slice thickness, flip angle 90°) to acquire functional images.

**Stag hunt fMRI task script**

*MR screening form*

Hello, welcome

Have you ever had an MRI scan before? OK, well I will explain to you what we’re going to be doing today. I will talk you through the scanning procedure and tell you a bit about the task you will be doing. I will give you quite a lot of information so if you have any questions at all while we’re going through it just let me know.

Today whilst in the scanner you’re going to be playing an interactive game. When we position you in the scanner, we will place a plastic helmet across your head, so that we can attach a pair of goggles that you will be able to look through. Through these goggles you will see a computer screen, and we will give you response buttons in your hands, just like playing any other computer game.

The scanner can get quite noisy, so we will give you ear plugs as well as headphones, to minimise the noise so that it doesn’t distract you. When we are positioning you in the scanner, we have lots of different cushions and pads so if anything doesn’t feel comfortable, or you would like to try out a cushion, just let one of us know – it’s not a problem at all. Likewise, the goggles are fully adjustable, so if the screen doesn’t look completely in focus or you’d like the position changed just let us know.

There are three different scans that we do while you’re in the scanner. The first lasts just ten seconds, and is so we can see the position of your head in the scanner, to make sure we are getting your whole brain in all of the pictures. The second is a structural scan, so you don’t have to do anything at all, just lie as still as you can. And finally we will do the scan where you will be playing the game. Altogether you will be in the scanner for about 35 minutes. The scanner might continue for a couple of minutes after the game has finished, but don’t worry about that.

There is an intercom system in the scanner, so we will talk to you in between scans to make sure you’re happy and that you know what is coming up. As well as that, we will give you a call button, which will lie just across your stomach. So if at any time you want to talk to us, or you feel like you want to come out of the scanner, just give that a squeeze and we can come and get you.

Do you have any questions so far?

OK, so I’ll explain to you a little bit more about the game and let you have a practice.

*Show computer screen with stag hunt still*

This is what you will see when you look through the goggles. There are going to be two players – you, over here, and another player, here. You are both hunters, and are aiming to gain as many points as possible. You will play alongside four different hunters, and you will win a reward, between £16 and £21 for your performance in one of these games. The small squares represent hares, and are worth ten points if you catch them, and the large square represents a stag and is worth twenty points. However, in order to catch the stag, you have to team up with the other player, as it can move around the board. So you can choose to either hunt a hare, which doesn’t move, by yourself and get ten points, or team up with the other player to surround the stag and get twenty points each.

*Run practice game to demonstrate. As game is running, explain*

In each game, the stag will move first, then you, and then the other player. You will know when it’s your turn to move as the white circle appears next to your icon. On the laptop you can use the arrow keys to move around the board, but in the scanner you will have response grips, and there will be four buttons – one at each index finger and one at each thumb. Before the game you will be able to assign a direction to each button, so you can decide which button you want to move you up, down, left and right.

Once you have selected your buttons there is a little practice game for you to play, just to get you used to moving about the board. Your scores won’t be recorded for this so just have a play about and make sure you’re comfortable with everything. After that there is another practice game, but this time you should play it as if it was the real thing, as you can still win a reward. Then after that the real games will start, and you will play alongside the four other hunters in turn.

*Let participant practice main game on laptop (but do not let it get to flat stage)*

*Complete consent form*

*Select card for reward*

*Phone control room to let them know we are ready*

**Debrief**

Thank you for completing the survey. The last step is a quick debrief of your experience throughout the study. Could you please tell me your thoughts on the following:

Overall perception of the study:

Perception of the other participant:

Thoughts on the survey:

Any other thoughts about the study?

What did you think the study was about?

In order to conduct the study, a minor level of deception was used and you were not told from the beginning exactly what we are researching. We are interested in whether your behaviour in the game or the pattern of brain activity that we observed would shift if you were playing with a Scottish, British or English citizen or with another EU citizen. We could not tell you ahead of time because we were afraid that knowledge would bias the study. Your participation was a very important part of a larger experimental attempt to assess identity politics in Spain and the UK. These findings will be used in academic work and will help to further our knowledge of the effect of identity on public behaviour.

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