A simple approach to reducing session-dependent behavioural effects in multi-session fMRI studies

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TARGET AUDIENCE: this work will be interesting to anyone performing multi-session fMRI studies.

AIM: To identify whether performance in multi-session fMRI studies is dependent on a participant's previous experience in an MRI scanner and whether it is possible to reduce or remove this effect by conducting an initial training session that recreates the important features of an MRI scan, without needing to use an expensive MRI simulator.

INTRODUCTION: The fMRI technique is frequently used to monitor the response (both behavioural and neural) of participants to tasks in different conditions. These different conditions may, for example, be brought about by the administration of behaviour-altering drugs, and involves performing repeat scans of the participants under each condition; the brain activity patterns and task performance are then compared. Many studies (particularly those in paediatric imaging) have reported that subjects behave differently in MR scans if they have previously taken part in a conditioning session in a MRI simulator [1,2]. This suggests that a "session effect" may exist in all multi-session fMRI studies that do not include a mock scan session [3,4]. It is likely that the magnitude of the effect will be subject-dependent and this increased variation can complicate the fMRI analysis and may mask important subtle effects. Furthermore, some studies are unable to counterbalance the different conditions between sessions (for example those studies performed before and after clinical intervention). In such cases, the participants' responses will include a session effect in addition to an effect from the differing session conditions intended by the researcher.

When subjects first go in the MRI scanner, they are confronted with 2 new aspects: 1) having to perform a cognitive task lying down using a response handset that cannot be seen, whilst wearing headphones and 2) carrying out the task in a new and possibly frightening or distracting environment. Both of these aspects are particularly relevant during the **first** session. In this work, we explore whether it is possible to remove inter-session fMRI effects by familiarizing participants to these aspects directly without using a costly MRI simulator.

METHODS: Fourteen participants were recruited equally into 2 groups. Participants were all female, aged 18-23 and had never had a MRI scan. Group 1 (the mock scan group) underwent a sham MRI session where they are trained for the task under scanner-like conditions: lying on their back in a dimly-lit room using a replica response pad, wearing headphones and with the scanner noise played out. Group 2 (the control group) conducted the task training on a computer under normal office conditions. Both groups then underwent genuine fMRI tasks in 2 separate sessions, separated by less than 2 weeks. Both sessions involved an identical card sorting task, similar to that used in [5]. In addition to the MRI, the participants were asked to complete the State-Trait Anxiety Inventory (STAI) before and after each fMRI session.

RESULTS: Participants in the mock scan group showed reduced anxiety prior to their first fMRI scan compared to the control group ($p<0.05$). There was no significant difference in anxiety throughout the study for the mock scan group. On the other hand, the control group were much more anxious prior to their first MRI scan. This anxiety was not replicated in session 2. There was no significant difference in anxiety between the mock scan group and the control groups in the second session (Fig 1). The fMRI data reveals that during a card sorting task there is increased activity in the superior parietal lobe among the control group in session 1 only (Fig 2). No differences in brain activity are observed in the second session. Accuracy in the card-sorting task was significantly increased in the control group, session 1: 94.5%; session 2: 97.4% ($p=0.003$), but there was no significant difference in performance among the mock scan group, session 1: 95.6%; session 2 95.9% ($p=0.39$).

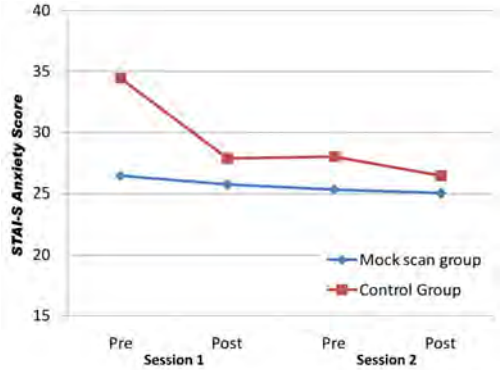

Figure 1 Plot of group-averaged anxiety pre- and post-scan for the two fMRI sessions. The group who underwent the mock scan report lower anxiety in the first session.

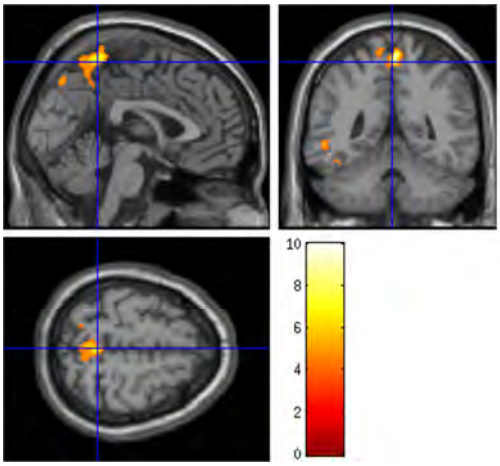

Figure 2 Activation maps showing increased recruitment of superior parietal lobe among the office-trained group, compared to the experimental group in a card sorting task. This difference is present in the first session only ($p<0.001$ uncorrected).

DISCUSSION: This study demonstrates that the response of participants (both neurally and behaviourly) is influenced by a session effect in multi-session fMRI studies. Anxiety levels only appear to be elevated in the first session and reach a baseline for the second session. If this first session is a mock MRI session then anxiety levels do not change significantly for all fMRI sessions. The increased anxiety in the control group appears to have an effect on brain but in the second session there are no statistical differences in brain activation between the groups. Task performance is also modulated by session effects: the control group showed a marked increase in accuracy on the task in the second session, presumably a result of familiarity with the procedure. The mock scan group did not improve, suggesting that they were already familiar with the procedure.

CONCLUSION: Participants show neural and behavioural differences in their first fMRI sessions. Therefore, in multi-session fMRI studies, a mock fMRI training session should precede genuine data acquisition, especially where counterbalancing the session conditions is not possible.

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