

Overview

This project investigates how threatening versus non-threatening expressions of emotion differentially modulate the precision and durability of face identity-location bindings in visuospatial working memory.

Experiments 1-4 comprise the main data and results of a visuo-spatial WM task in which participants (aged between 18-40 years) were asked to remember the identity and location of between 1 to 4 faces presented on a computer screen. After a maintenance period, a test face was presented in the centre of the screen and participants had to relocate this face to where it was. Faces during the encoding period conveyed emotion whereas the test face was neutral. In 4 experiments (Expts 1, 2, 3a/b/c, 4), we manipulated different parameters such as: the number of study faces (Expt 1), the duration of the maintenance period (Expt 2), the type and the number of emotions present at encoding (Expts 3 and 4).

In all experiments, behavioural data were recorded to assess how well participants relocated the test face to its original location. In addition, participants' eye-movements were also recorded in experiments 1, 2 and 4 with an Eye-link 1000 Plus tower-mounted device.

To assess the influence of mood, social skills, and anxiety on performance in this task, participants were also asked to respond to 3 questionnaires. The first questionnaire (Positive And Negative Affect Schedule, PANAS) was given prior to the main experiment. The second (autism-spectrum quotient, AQ) and third (Liebowitz Social Anxiety Scale, LSAS) questionnaires were given after the main memory experiment. All questionnaires were completed on a computer.

An additional experiment (Expt 0) was conducted early on to assess the influence of competing emotions at encoding on purely visual WM. Four faces each with a different expression (angry, fear, happy, sad) were shown for encoding and participants had to remember the identity of each face. After a 1000ms blank maintenance interval a single test face with a neutral expression was presented which either matched or did not match in identity to one of the four faces just seen. Participants pressed one of two keys on the keyboard to indicate whether they thought the face matched or not, this was not a speeded response. Eye movements were recorded using an Eye-link 1000 and the LSAS was administered to measure social anxiety.

Method

Stimuli and Apparatus

All faces were taken from the Radboud database (Langner et al., 2010). For Experiments 1-4 the same stimuli were used with the addition of 2 emotional expressions (sad and fear) in Experiments 3 and 4 (see folder named 'Stimuli-expts1-4.zip'). Eight Caucasian male faces, front view, were chosen, each showing each of the expressions used. A slightly different selection of faces from the same database were used for the earlier Expt 0 (6 identities, 4

emotions plus neutral; see folder named 'Stimuli-Expt0.zip'). The faces were cropped into an oval shape (no hair was visible) and set to greyscale.

In experiments 1-4, the faces were presented at random locations but at least 6° away from the centre of the screen and always with a minimal distance between themselves (for more details, see the section on results analysis). The size of the faces were 100 x 140 pixels in Exp 1 and 2, and 90 x 126 pixels in Exp 3 and 4. In Expt 0 four faces (size 73 x 101 pixels) were presented at encoding in a 2x2 grid with a distance of approximately 0.38 deg visual angle between the faces on the horizontal and vertical axes, and 1.67 deg on the diagonal axis. Face location in the grid was randomised.

In Experiments 1, 2, 3, 4, and 0 the WM tasks were generated in Experiment Builder (SR research, Canada). Experiments 1, 2, and 3 were conducted on a Dell Optiplex 7010 computer running Windows 7. Stimuli were shown on an EliteOne 800 touchscreen (50.9 x 28.7 cm, 72.91 x 41.01 deg), with a resolution of 1920 x 1080 pixels and a refresh rate of 60 Hz. The questionnaires were presented separately via E-Prime. Participants were positioned in a chin rest 40cm away from the screen. In Experiment 0 stimuli were shown on a Dell with a resolution of 1280 x 1024 pixels; a chin rest positioned 50cm from the screen was used. In Experiment 3a, 3b, and 3c stimuli were shown on a Dell Optiplex 760 with a resolution of 1280 x 1024. For most of the participants in Expt 3a/b/c, the distance to the screen was not constrained (there was no chinrest) and was around 57 cm. However, up to participant number 26 in Exp 3a, a chinrest was used and set 40 cm away from the screen.

Design

Experiment 1

In Experiment 1, we investigated how face-identity location binding is influenced by angry versus happy expression at encoding. Encoding displays were homogeneous with regard to expression (all angry or all happy) and heterogeneous with regard to face identity and location. Before the main WM experiment, participants were given the PANAS mood questionnaire, and at the end of the session they were given the social anxiety and autistic-traits questionnaires.

In the main WM task, each trial started with a fixation cross presented in the centre of the screen for 500 ms. Participants were then shown 1, 2, 3, or 4 faces (WM load manipulation, pseudorandomised) of different identities at random screen locations for 1500ms per face. After a blank maintenance interval of 1 sec one of the faces just seen was presented at the centre of the screen with a neutral expression (test face). Participants had to relocate this face to where it was first presented, matching the correct identity with the correct location. Participants used their finger on the touchscreen to touch and relocate the test face. There was no time limit but participants were told to be as precise as possible. They were allowed to change the relocation placement as many times as they wished. When they placed the face in the location of their final choice, they pressed the spacebar on the computer keyboard in order to end the trial.

Participants were trained on 16 practice trials, and the main experiment comprised 256 trials in total (50% angry 50% happy). There were 32 angry and happy trials per WM load condition.

There were 12 versions of the experiment in order to counterbalance the experimental factors, the facial identity of the test face, the number of times each face identity was presented in a given experimental condition, and the mirror-reversing of face placement along the horizontal axis of the screen in order to control for presentation side. Four participants were tested in each version per experiment (N=48).

Prior to the WM task, each participant underwent a randomised nine-point calibration and validation procedure. Recalibrations were performed during the task if necessary. Before each trial a single-point calibration check was applied as the participant fixated a dot in the centre of a white background.

Experiment 2

In Experiment 2 the same design was used as in Expt 1, except now always 4 faces were shown at encoding (WM load was constant) and the blank maintenance interval was manipulated to be 1s, 3s, or 6s (pseudorandomised). There were 192 trials in total (50% angry, 50% happy) with 32 trials per maintenance interval (12 practice trials preceded the main task). All task parameters and response methods were the same as in Expt 1. N=48.

Experiment 3

In Experiment 3, we investigated how different facial expressions compete in visuospatial working memory. Before the main WM experiment, participants were given the PANAS mood questionnaire, and at the end of the session they were given the social anxiety and autistic-traits questionnaires.

In the main WM task, each trial started with a fixation cross presented in the centre of the screen for 300 ms. Participants were then shown 4 faces of different identities at random screen locations for 6s. Of these 4 faces, 2 faces carried one emotion while 2 other faces carried a different emotion. The 6 possible emotion pairs were chosen from Happy, Sad, Angry and Fear expressions.

After a blank maintenance interval of 1 sec (Exp 3a, N=36), 3 sec (Exp 3b, N=36) or 6 sec (Exp 3c, N=36), one of the 4 faces was presented at the centre of the screen with a neutral expression (test face). Participants had to relocate this face to where it was first presented, matching the correct identity with the correct location. The computer mouse was used to relocate the test face.

Participants were trained on 12 trials and tested on a total of 192 trials. The 6 possible pairs of emotion were tested 32 times. For each pair, (e.g. 2 happy faces with 2 angry faces) half of the trials (16) tested memory for one emotion (e.g. the test face was happy in the encoding period) and half of the trials tested memory for the other emotion (e.g. the test faces was angry in the encoding period).

Experiment 4

This experiment (N=36) was the same as Experiment 3a but using the touchscreen set-up that was used in Experiments 1 and 2. Each participant's head was resting on a chinrest 40 cm away from a touch-screen computer while their eye-movements were recorded. They reported their response using a touch-screen (1920 x 1080), exactly as in Expts 1 and 2.

Experiment 0

Experiment 0 was designed to examine how competing emotions at encoding influenced purely visual WM for face identities – there was no spatial component to this task. The design was similar to Jackson, Linden, & Raymond (2014; Cognition & Emotion).

Each encoding display comprised 4 faces of different identities, each with a different emotional expression (angry, fear, happy, sad). They were displayed in a 2x2 grid for 4000ms followed by a blank maintenance interval of 1000ms. Then a single test face with neutral expression was presented which either matched or did not match in identity to one of the four faces just seen. Participants pressed the key 'p' if they thought it matched and key 'q' if they thought it did not match, and there was a 3000ms response window in which to do this.

After 15 practice trials, participants completed 128 trials in total, split into 4 equal length blocks. Ninety-six trials were match trials (24 per emotion) and 32 trials were non-match trials. On match trials, the test face matched one of the other 4 expressive faces equally (25% of trials each; pseudorandomised). The location of the matched face was counterbalanced to have occurred across all 4 grid positions. At the end of the task participants were given the Liebowitz Social Anxiety Scale.

Instructions

Experiment 1

Visual memory experiment with touch screen

In each trial, you will see 1, 2, 3 or 4 happy or angry faces.

Try to memorise the identity and position of all faces on the screen.

The faces will briefly disappear, then one of the faces you just saw will be presented again in the centre of the screen (but now with a neutral expression).

Your task is to touch this central face with your right index finger and drag it to its original precise position.

Try to be as precise as you can when relocating the test face.

You may lift and replace your finger at any point during the moving process.

When you are happy with your response, press any key of the keyboard to start the following trial.

Experiment 2

Visual memory experiment with touch screen

In each trial, you will see 4 happy or angry faces.

Try to memorise the identity and position of all faces on the screen.

The faces will briefly disappear for a variable time, then one of the faces you just saw will be presented again in the centre of the screen (but now with a neutral expression).

Your task is to touch this central face with your right index finger and drag it to its original precise position.

Try to be as precise as you can when relocating the test face.

You may lift and replace your finger at any point during the moving process.

When you are happy with your response, press any key of the keyboard to start the following trial.

Experiment 3

Visual memory experiment

In each trial, you will first see a central cross, that you will have to fixate.

Then you will see 4 faces. They will convey 2 of 4 possible emotions (happiness, sadness, anger, fear). Try to memorise the identity and position of all faces on the screen.

The faces will disappear for a short period. Then, one of the faces you just saw will be presented in the centre of the screen with a neutral expression. Your task is to click on it with the mouse and drag it to its original precise position. Try to be as precise as you can when relocating the test face.

You may release and then click again with the mouse at any point during the moving process (you will not see the mouse cursor during this process).

Once you are happy with your response, press space to start the following trial.

If you have understood the instructions, press S to start the experiment.

If you have a question, ask the experimenter.

Experiment 4

Visual memory experiment

In each trial, you will first see a central cross, that you will have to fixate. Then you will see 4 faces. They will convey 2 of 4 possible emotions (happiness, sadness, anger, fear). Try to memorise the identity and position of all faces on the screen.

The faces will disappear for a short period. Then, one of the faces you just saw will be presented in the centre of the screen with a neutral expression. Your task is to drag it to its original precise position on the touchscreen. Try to be as precise as you can when relocating the test face.

You may release and drag the face again at any point during the relocation process.

Press space to confirm your response and start the following trial.

If you have understood the instructions, press S to start the experiment.

If you have a question, ask the experimenter.

Experiment 0

INSTRUCTIONS

This experiment is designed to test your working memory for emotional faces.

On each trial, 4 faces will be presented at the same time for you to try and memorise.

Each face will show a different emotional expression, but expression is irrelevant to the task. Your task is just to memorise the identity of each face. After 4 seconds these faces will briefly disappear.

Then a single (neutral) face will appear. YOUR TASK IS TO STATE WHETHER THIS PERSON WAS PRESENT OR NOT IN THE FACE ARRAY YOU WERE ASKED TO MEMORISE.

Respond 'yes' if you think the face was present, or 'no' if you think it was not present, using the labelled keys.

You have 3 seconds to make your response.

Press C to continue.

Project ES/L008912/1
Remembering who was where

Mood Questionnaire, PANAS

The following questionnaire will consist of a number of words and phrases that describe different feelings and emotions.

Read each item and then choose the appropriate number from the scale to indicate TO WHAT EXTENT YOU FEEL THIS WAY RIGHT NOW.

You will also be given the option to skip an item if you wish, by pressing 'n'.

If you are not sure what a word means, please ask the experimenter.

The following scale will be used to record your answers:

- 1 - Very slightly (or not at all)
- 2 - A little
- 3 - Moderately
- 4 - Quite a bit
- 5 - Extremely

Please press space to continue

Autism Quotient Questionnaire, AQ

This 50-item questionnaire aims to measure aspects of perception and cognition that are relevant to face processing skills.

Please read each question carefully and twice over before stating your answer.

Please answer each question truthfully.

To make a response, place the mouse arrow within a circle next to your chosen answer and CLICK ONCE.

While you are encouraged to answer all questions, you have the right to withhold an answer if you wish.

If you do not wish to answer a particular question, click the 'No Thanks' button.

Press the letter S to start.

(The possible answers that the participant was given were: definitely agree, slightly agree, slightly disagree, definitely disagree, No thanks)

Liebowitz Social Anxiety Questionnaire, LSAS

The Liebowitz Social Anxiety Scale assesses the way that social phobia plays a role in your life across a variety of situations.

Read each situation carefully and answer two questions about that situation.

- 1. The first question asks how anxious or fearful you feel in the situation.
- 2. The second question asks how often you avoid the situation.

If you come across a situation that you ordinarily do not experience, we ask that you imagine "what if you were faced with that situation?" and then rate the degree to which you would fear this hypothetical situation and how often you would tend to avoid it.

Please base your ratings on the way that the situations have affected you in the last week.

If you do not wish to provide an answer to a statement, press the letter N for 'No thanks'.

(The scale that was given for Fear was 0 – None, 1 – Mild, 2 – Moderate, 3 – Severe, and for Avoid: 0 – Never 1 – Occasionally, 2 – Often, 3 – Usually)

Working Memory Performance data

In Experiments 1-4 performance was assessed using two measures: the proportion of correct relocations ('accuracy') and the 'precision' of relocation for these correct responses (distance from the original face position). Accuracy: A response was considered correct (code 1) if the test face was relocated within a pre-determined 'face region', and incorrect (code 0) if it fell outside this region. This face region was the face surrounding area in which no other face was presented. For example, if in the experiment minimum 14° of visual angle separated the centre of two faces, the face region was 7° . Because of small differences between the 4 experiments (distance to the screen and size of the stimuli) the face region was 7° in Exp 1 and 2, 14° for participants with a chinrest in Exp 3a, 12° for the rest of the participants of Exp 3, and 12° for Exp 4. Precision: Precision was measured on correct trials in terms of degree of visual angle from the centre of the original face to the centre of the relocated test face. Swap errors were also measured, which is the proportion of trials the test face was relocated within the pre-determined 'face region' (versus a random relocation). We also computed the precision of incorrect relocations on these swap trials.

In Experiment 0, accuracy of the match/mismatch response was coded correct (1) and incorrect (0).