

Annex E. Medical criteria and performance testing

E1. Introduction

Porton volunteers underwent various medical examinations before they participated in studies. On arrival a general medical examination was usually conducted to ensure each volunteer was fit to take part in studies. Additional medical tests were conducted before specific studies. These are commonly referred to as "screening tests": they were used to identify volunteers whose physiology was unsuitable for a particular type of study.

Apart from these checks Porton stipulated limits for various physiological functions, such as pulse, temperature, blood pressure, blood content and so on. Studies in which these functions were expected to be affected often involved their state being continuously monitored. If the pulse (for example) approached the stipulated upper limit the study was stopped and the volunteer allowed to recover.

The nature of the initial medical examination, the screening tests and the physiological functions which were normally monitored continuously during studies changed over the course of the period covered by the survey. In part that was because medical science advanced with more examination and monitoring techniques becoming available. The changes also reflected the advances in scientific understanding achieved by Porton's work.

Many studies sought to understand the effect on physical and mental performance of agents and treatments. Tasks were devised which volunteers performed so that their performance could be measured objectively. These tasks are sometimes referred to as "psychomotor" tasks. Some tasks measured physical performance (such as the ability to ride a bicycle ergometer) while others tested mental functions.

E2. Initial medical examinations

The nature of the initial medical examination is difficult to discern from the experimental records. Experimental logs covering World War II give no indication whether an initial medical examination was normally carried out. Records covering studies conducted in the late 1940s and 1950s usually list various medical tests conducted on volunteers but these tend to be screening tests for particular studies, for which the volunteer was paid. Volunteers were not paid for the initial medical examination. Ward diaries maintained from the mid 1960s list some elements of the initial medical examination but the references are sometimes vague: noting that a blood and urine sample had been taken, for example.

The following references to the initial medical examination have been found.

- Chest X-rays appear to have been taken from 1956 onwards but not all volunteers had one taken initially¹, suggesting that the X-ray formed part of an initial screening procedure. By 1959 almost all volunteers had a chest X-ray taken as part of the medical examination² and all volunteers were X-rayed from 1960 onwards.
- Blood samples were taken to analyse plasma and to check bilirubin and urobilin content from the late 1950s³. As time went on blood samples were used for many more tests, usually annotated in the ward diaries as biochemical analysis.
- EEG and ECG measurements were taken from 1958⁴ and became more prevalent in later years. Both were used before 1958 in particular studies.

¹ X-ray Index Book 1956 onwards.

² **Experimental Log MPG 62.**

³ **Experimental Logs MPG 63, MPG 68.**

⁴ **Experimental Logs MPG 62, MPG 66.**

- A description of the initial medical examination is contained in a note produced in 1961 reviewing the usual Service volunteer procedures and suggesting how they might be applied to civilian volunteers. Evidently, by 1961, the initial medical examination consisted of an interview on family and personal history, measurements of blood pressure and temperature, a chest X-ray, ECG measurements and "sometimes" an EEG was taken. Blood samples were taken for various analyses. This medical examination was noted as often taking two days to complete⁵.
- From 1965 any volunteer whose medical examination results suggested any form of liver dysfunction was rejected for studies involving "drugs of any kind", but was allowed to participate in physiological studies (of the effect of wearing protective equipment, for example)⁶.

From the 1960s to the end of the period covered by the survey, the nature of the initial medical examination appears from the ward diaries not to have changed fundamentally. Possibly deeper and broader analyses of fluid content were conducted as biochemical assay techniques improved but the ward diaries merely note volunteers providing blood samples when they arrived. In contrast, over the same period the medical screening tests for particular studies appears to have become more complex. This balance reinforces the impression that the initial medical examination was used mainly to ensure volunteers were fit, with much more detailed tests being conducted as part of the screening for particular studies.

Volunteers were sent back to their units if they were found by the initial medical examination to be unfit. Two volunteers were returned in 1948⁷, this being the earliest instance found in the experimental logs. From the 1960s volunteers who were found to be unfit, or to have medical problems, were returned to their unit and the results of the medical examinations (X-rays, ECG and EEG readings) were usually sent to their unit medical officers.⁸ It was Porton's general policy not to allow servicemen under the age of 18 to volunteer for trials and there are examples in the records of those who were found during the initial medical examination to be under 18 being returned to their unit⁹. That said, entries have also been found in the record books indicating that 17 year old volunteers were used in trials, including nerve agent trials, although in one case a volunteer performed administrative duties for a couple of days after first arriving and joined the remainder of the volunteers on his 18th birthday¹⁰.

E3. Medical screening for specific studies

E3.1. Introduction

Medical screening tests sought to establish that a volunteer was suitable for a particular type of study. Some screening tests were used initially to monitor the change induced in physiology during studies and later were adopted for screening. An example of this might be measurements of ChE activity in nerve agent tests. To begin with, ChE activity was used as a metric of the effect of nerve agent; later, minimum ChE activity levels were identified and, if any volunteer was found during screening to have ChE below that level, he was excluded from the study.

Sometimes a test graduated from being used as a metric in studies to a screening test and thence to part of the medical examination: ECG is one example. In 1952 it was used to monitor physiological changes in atropine studies and later it was used as a screening test for

⁵ **Civilian volunteers. Med/TG1009/1664/61 10 Aug 61.**

⁶ COSHE 12th meeting 3 Feb 65.

⁷ **Experimental Log MPG 59.**

⁸ Experimental Logs MPG 69, MPG 70, MPG 73.

⁹ Experimental Logs MPG 59, 60, 61, 69, 70, 73.

¹⁰ Experimental Log MPG 67.

atropine and nerve agent studies. Eventually it was adopted as part of the initial medical examination.

E3.2. Nerve agent studies

In addition to ChE activity, ECG and chest X-rays were used to screen volunteers for nerve agent studies from 1956¹¹. When the BC approved gentle exercise in GB studies in 1958 it stipulated that ECG and X-rays should continue to be used as screening tests¹². Other screening tests that were being used for nerve agent studies were listed in COSHE in 1966: any man with a history of chest illness, eye disease or serious skin disease was excluded from nerve agent studies¹³.

Screening tests of volunteers for studies of miosis induced by nerve agents are difficult to identify. As mentioned in the nerve agent chapter dealing with GB studies from 1954 onwards, some volunteers with myopia had taken part in miosis studies in 1945 and 1971. In 1972 COSHE decided that volunteers with "less than 6/18 vision" should be screened out of miosis studies¹⁴ and the experimental logs record volunteers being rejected because of poor vision (when they were not wearing their glasses) or myopia¹⁵. Ophthalmic screening tests were improved in 1982 (as recounted in the main text) following advice from medical consultants.

As explained in the main text, some nerve agent studies in the 1980s involved the use of SFEMG to measure the effect on nerve fibres. Despite the uncertainty about how to interpret SFEMG measurements the MC decided in 1987 that SFEMG should be a screening test for GB studies¹⁶.

E3.3. Psychological incapacitating agent studies

The main programme of work with psychological incapacitating agents prompted Porton to develop a battery of screening tests to ensure that volunteers were suitable to participate in studies. The psychiatric and psychological screening tests, arising from advice from external experts in 1960, used at Porton are listed below¹⁷.

- Maudsley Personality Inventory to assess emotionality and extroversion.
- Medical interview, normally conducted by Service psychiatric specialist, to elicit any family history of mental conditions and the personal history of the volunteer (education, habits, interests, previous illnesses, occurrences of head injuries and concussion).
- Raven's Progressive Matrix to assess intelligence.
- Archimedes Spiral test to assess hysteria and level of anxiety in volunteers. The test measured how long visual-after images were experienced.
- Sedation Threshold test, which was not given to volunteers who had a history of head injury or concussion nor to alcoholics or those being treated with barbiturates. The test involved the administration to the subject of sodium amytal (a sedative) by slow intravenous injection. During the injection the subject would be asked to perform a series of simple tests (typically, he would be told a random number and asked to speak out a number twice its value) until he fell asleep, at which point the injection was stopped. The test prompted much discussion as

¹¹ **Experimental Log MPG 62, MPG 63.**

¹² WO195/14321. BC 20th meeting 20 Mar 58.

¹³ **COSHE 28th meeting. 15 Sep 66.**

¹⁴ **COSHE 80th meeting. 31 May 72.**

¹⁵ **Experimental Logs MPG 69, MPG 73.**

¹⁶ **MC meeting 26 Mar 87.**

¹⁷ **Porton Note 166 Screening tests prior to administration of psychotomimetic drugs in human subjects. 7 Sep 60 (U).**

the subject would take at least a day to recover from it and one in twenty subjects suffered from headaches, nausea and vomiting after it. However, the Royal Victoria Hospital considered it the only test to detect psychosis¹⁸.

- Final interview by medical officer. Only at this stage was the final decision made about the safety of allowing the subject to participate in experiments with psychological incapacitants.

Porton gained experience in using these tests by administering them to humans in 1960 and 1961. The Maudsley and Raven tests were given to all volunteers reporting to Porton between August 1960 and November 1961¹⁹. The volunteers were found to be more extrovert than the general population (but no more so than other Servicemen) and significantly more neurotic than the general population and the rest of the Servicemen population. They were also found to be more intelligent than the general and Service population.

In a fore-runner to these tests another questionnaire was used to assess personality. Between November 1959 and February 1960, 117 volunteers were asked to complete a modified Cornell Medical questionnaire²⁰; 63 men attending a course at the Joint School of Nuclear and Chemical Ground Defence at Winterbourne Gunner also completed the questionnaire to give a measure of "normality". The questionnaire was not included in the normal battery of screening tests but this work revealed an above average proportion of "neurotic" and introverted people in the volunteer population.

Over time the psychiatric and psychological screening tests were modified. By 1965 several changes had been made²¹.

- The Minnesota Multiphasic Personality Inventory and the Heron Inventory were used as well as the Maudsley test.
- The Archimedes Spiral test was not conducted as it proved to be not as reliable as first thought.
- The sedation threshold was "mainly" administered but sometimes replaced by simple observation of volunteers by Porton medical staff
- An electro-cardiogram had been suggested originally to screen out epileptics but this was found unnecessary as personal history and medical record cards were "now available for all [volunteers]".

E3.4. Treatments

Over the period covered by the survey many thousands of volunteers took part in studies of methods to protect the skin from mustard gas and ways to treat mustard gas burns. The nature of these studies is explained in the main text. Volunteers who were sensitive to mustard were unsuitable for these studies. It was standard practise by 1939²² to test the sensitivity of all volunteers to mustard gas when they first arrived at Porton. The H sensitivity test involved a small drop of liquid H (of concentration 1 in 10,000) being placed on the arm, left for a short while and the reaction of the skin noted over the following 24 hours. This test (which dates back to at least 1931²³) was used until mustard gas work ceased in the late 1970s.

¹⁸ WO195/15077. Biology Committee 25th meeting 9 Nov 60.

¹⁹ WO189/377. Porton Technical Paper 857. A study of personality and intelligence of Service volunteers at CDEE. 10 Jun 63.

²⁰ **Porton Note 173. Volunteer personality response to a modified Cornell Medical Index health questionnaire. Nov 60 (U).**

²¹ WO195/16132. The screening procedure - present practice. Ptn/TA2502/5732/65 1 Nov 65.

²² **Experimental Log MPG 48.**

²³ **Mustard gas sensitivity tests MPG 24.**

Screening tests for studies of treatments for nerve agent poisoning included some tests used as screens for nerve agent studies: ECG was used as a screen in atropine studies, ChE activity and ECG as screens for studies with pyridostigmine²⁴. Kidney and liver function screening tests were introduced for studies with nerve agent treatments²⁵. Volunteers with a history or predisposition to glaucoma were screened out of studies with physostigmine and hyoscine²⁶.

E3.5. Riot control agents.

Chest X-rays were part of the screening tests used for studies with riot control agents; volunteers who had any allergies or histories of respiratory infections, skin diseases and sensitive skin were screened out²⁷. Eye examinations, tests of cardiovascular and respiratory functions and ECG were used as screens²⁸. Safety limits for intra-ocular tension were obtained from a consultant ophthalmist in 1969 and applied to riot control studies.

In a study of CR in SPAD, an increase in blood pressure was observed in one of the volunteers but was felt to be a "normal reaction to a noxious stimulus and not cause for alarm"²⁹. Increases in blood pressure were observed in some of the volunteers who took part in studies in which CR in water cannon solutions was applied to large areas of the skin: maximum increases in blood pressure in these cases were 30 mm Hg (systolic) and 25 mm Hg (diastolic). As a result COSHE allowed CR drenching work to proceed with caution, limiting the initial drenching to the lower body only³⁰.

Experimental logs after the date COSHE made this decision (January 1972) suggest that blood pressure was used as a screen for CR studies. One volunteer was rejected in March 1972 because his blood pressure was 153/100 and another was rejected in July for being "hypertensive"³¹. Seven other volunteers are annotated in the experimental logs covering 1973-1975 as being unsuitable for CR studies because of hypertension³².

E4. Physiological limits.

In the main text dealing with physical incapacitating agents it is noted that Porton rejected as unsafe those agents which could incapacitate by inducing hypotension or hypertension. If blood pressure was induced to fall low enough to incapacitate a man by itself, it was felt that irreparable damage would probably be caused to the heart and the kidneys³³. If blood pressure was raised sufficiently to incapacitate, there was a possibility of aneurysms bursting and causing death.

As explained in the main text, the embargo on hypotensive and hypertensive agents did not mean that any agent/drug which might induce a change in blood pressure could not be studied; merely that incapacitating a man solely by affecting his blood pressure was deemed unsafe. The approach taken by COSHE to blood pressure was to define limits on the extent that it could be changed. In 1964 the COSHE instructed "in experiments in which cardiovascular tone is expected to be affected a careful watch must be maintained on systolic

²⁴ COSHE 72nd meeting 5 Jul 71.

²⁵ COSHE 126th 23 Apr 79.

²⁶ Ethics Committee 5th meeting 30 Nov 88.

²⁷ WO189/1071. Porton Technical Paper 757. Skin reaction and sensitivity to CS 3 Feb 61. WO189/438. Porton Technical Paper 930. A direct comparison between CS and T2806 as harassing agents 22 Mar 65. COSHE 18th meeting 6 Oct 65.

²⁸ COSHE proceedings. MACE-like devices: suggestions for tests with human volunteers. Med B/IT4010/3649/68 13 Dec 68.

²⁹ COSHE 54th meeting 1 Apr 69.

³⁰ COSHE 78th meeting 31 Jan 72.

³¹ Experimental Log MPG 73.

³² Experimental Logs MPG 70, MPG 69.

³³ WO189/15291. CDAB 50th meeting. 24 May 62.

blood pressure levels of less than 90 mm Hg³⁴ (no instruction was given in the document from which this quotation is drawn on increasing blood pressure but, from the previous section, some limit was prescribed for CR studies). Nalorphine was noted as an antidote to hypotensive effects later in 1964 and instructions issued in its use in treating reactions³⁵. Studies with T2833 were stopped in 1965 because one volunteer's systolic blood pressure fell to between 80 and 90 mm Hg³⁶.

This approach of specifying limits was adopted by COSHE for a range of physiological functions. Alongside the instructions for cardiovascular tone issued in 1964, the COSHE stipulated other limits which are detailed below³⁷.

- Pulse: in studies designed to run for 30 minutes, the highest pulse permitted was 160 beats per minute; for studies designed for 10-30 minutes the highest pulse was 180; for studies of less than 10 minutes, 210 beats per minute.
- Temperature: for "long experiments" the highest temperature permitted was 103°F; for "short experiments" it was 104°F.
- A study would be terminated if a change in blood cell count of 20% was observed.
- The maximum weight loss due to dehydration permitted was 6%.
- Maximum metabolic loads were stipulated and maximum levels of salt loss.
- Limits were prescribed on bone marrow, liver and kidney functions (with studies being stopped if albuminuria, haematuria or oliguria occurred).

Physiological functions were monitored either by taking frequent fluid samples and analysing them or continuously measuring them during studies. If the limits were approached the study was stopped. Over the course of the year following the publication of the COSHE limits four volunteers taking part in studies of the effect of exercise while wearing protective clothing had their study stopped because their pulse was approaching the limits prescribed by COSHE³⁸. One study of the effect of taking atropine and exercising was stopped in 1968 because one volunteer's temperature reached 103°F.

COSHE monitored these limits throughout its history. In 1979 COSHE published a list of about 25 medical tests with normal values for the physiological functions they measured³⁹. As an aside, apart from considering physiological limits COSHE issued instructions on various aspects of safety and these are set out below.

- Nerve agent studies were to be carried out in 1964 only when the Assistant Director (Medical) was present at Porton⁴⁰ and, later, were to be conducted only if two medical officers were at Porton, one of whom had to have 12 months experience with GB studies⁴¹.

³⁴ COSHE proceedings. Memorandum on criteria and limits in human experiments. Ptn/IT4010/4335/64 4 Aug 64.

³⁵ COSHE proceedings. Use of nalorphine as an antidote to oripavine derivatives. Med/TA2001/1779/64 19 Aug 64.

³⁶ COSHE 12th meeting 3 Feb 65.

³⁷ Ibid (36), COSHE 6th meeting 1964.

³⁸ Experimental Log MPG 64.

³⁹ COSHE 127th meeting 4 Jun 79.

⁴⁰ COSHE 10th meeting 4 Nov 64.

⁴¹ COSHE 17th meeting 24 Sep 65.

- Nursing cover arrangements were reviewed, as was night time provision of medical care: for example, long term dosing studies with pyridostigmine were conducted initially only if a medical officer stayed overnight at Porton⁴².
- COSHE stipulated that a medical officer should be present in the climatic chamber or adjoining control room when volunteers were exercising in protective clothing⁴³. Similarly, one medical officer was to be present in the chamber with the volunteers during GB studies, with another medical officer in attendance outside⁴⁴. Comparisons of diazepam and TL4914 in studies of nerve agent treatment could be conducted only if a medical officer was on call through the MOD police⁴⁵.
- COSHE reviewed sterilisation procedures in 1974 and initially rejected the use of indwelling cannulae to draw blood samples because of the risk of thrombosis⁴⁶ (subsequent advice from Liverpool Hospital prompted COSHE to allow cannulae to be used).

E5. Performance testing

E5.1. Introduction

Many studies sought to assess the effect on performance of agents or treatments. Some studies explored performance in field trials, in which volunteers performed tasks which were relevant to their military duties. These field trials are covered in the main text but examples of the tasks performed in them are rifle firing, marching, map and compass reading, identifying military targets, digging trenches and conducting simulated anti-terrorist searches.

Other studies used psychomotor tasks in the laboratory to measure the effect of agents or treatments on performance. Again, these tasks are described in the main text. Some measured physical performance (exercise on a bicycle ergometer, stepping onto and off a stool). Others tested motor control (picking up ball bearings with tweezers, as an example), intellectual functions (reading, reasoning, doing anagrams and sums), reaction time and memory. Two particular pieces of work are covered in detail here. The work conducted to identify those psychomotor tasks which could be expected to measure reliably the effect on mental performance of psychological incapacitating agents, and studies of motivation.

E5.2. Psychomotor tasks used with psychological incapacitating agents

Various tasks were used to assess the performance of men when they were under the influence of psychological agents. Some of the tasks were drawn from the screening tests, one example being the Archimedes Spiral test. Other tasks (some of which are mentioned in the main text) included solving anagrams, picking up ball bearings, sorting cards, reading and arithmetic. Many of these tasks had been used for long time at Porton, dating back to GB experiments in the 1950s.

However, the suitability of these tasks for measuring performance during human tests with psychological agents was not clear. Nor was it obvious how sensitive these tests were: could they be used to measure small changes in performance? Porton evaluated the tests in a series of trials in which volunteers were given alcohol⁴⁷. Judging from the COSHE minutes, which describe the experiments listed below, this work was carried out in 1965. Although alcohol was not a "true psychochemical" it did produce changes in behaviour.

⁴² COSHE 105th meeting 2 Feb 76.

⁴³ COSHE 32nd meeting 16 Feb 67.

⁴⁴ COSHE 24th meeting 10 Jun 66.

⁴⁵ COSHE 147th meeting 18 Jan 82.

⁴⁶ COSHE 96th meeting 18 Nov 74.

⁴⁷ WO195/16229. Some effects of alcohol on human performance. 6 Apr 66.

Ethyl alcohol was given orally in orange squash. Two amounts were used: 0.5 g/kg and 1 g/kg. These doses were equivalent to 4 single whiskies and 8 single whiskies respectively. A placebo, rum essence, in orange squash was also used. Five experiments were conducted.

I. On each of three successive days 9 men each drank either the placebo or 0.5mg or 1mg of ethyl alcohol. The experiment was arranged so that each man drank one of each of these three on different days. On each day the men completed the suite of psychomotor tasks which were being evaluated.

II. 12 men drank either the placebo or 0.5 mg ethyl alcohol.

III. 6 men drank either the placebo or 0.5 mg ethyl alcohol.

IV. 8 men drank either the placebo or 1 mg ethyl alcohol.

V. 12 men drank either the placebo or 1 mg ethyl alcohol.

The experiment was successful in identifying those psychomotor tasks which could detect changes in performance.

E5.3. Motivation assessments for Physical Incapacitants

Other tests were used to assess motivation. Highly motivated people might be able to withstand the effects of physical incapacitants and riot control agents more easily than less determined people. To get a clear idea of the value of a physical incapacitant from the results of human studies it was necessary to find out more about the subjects' motivation.

A multiple choice questionnaire, designed by Allport and Vernon, to assess social values was completed by 73 volunteers in 1965⁴⁸. Again, men attending training courses at Winterbourne Gunner also completed the questionnaire as representatives of the general Service population. Volunteers were found to have a greater interest in financial matters than aesthetic and ethical issues. This provided "grounds for hope that motivation [during tests of physical incapacitants] could be increased by provision of a suitable material award".

This conclusion was of more relevance to the testing of riot control agents than physical incapacitants generally. Rioters were likely to be highly motivated, so an accurate assessment of the value of riot control agents in work at Porton demanded that the volunteers involved in the tests were highly motivated as well. In experiments with riot control agents, volunteers were offered payments as an incentive to remain longer in an atmosphere contaminated with the agent⁴⁹.

Tests were also devised to assess different aspects of physical performance, particularly maximum effort and endurance. Bicycle ergometer tests were devised and 73 volunteers took part in them to establish normal levels of performance. The work also sought to find out if there was any link between physical performance and personality⁵⁰ but no conclusive link was found.

⁴⁸ WO189/167. Porton Technical Paper 950. Further studies of the Service volunteer at CDEE. 23 March 66.

⁴⁹ WO189/438. Porton Technical Paper 930. A direct comparison between CS and T2806 as harassing agents. 22 Mar 65.

⁵⁰ WO189/380. Porton Technical Paper 860. Training and personality as determinants of exercise hyperventilation - factors affecting the testing of physical incapacitance in man. 1 Jun 63 .