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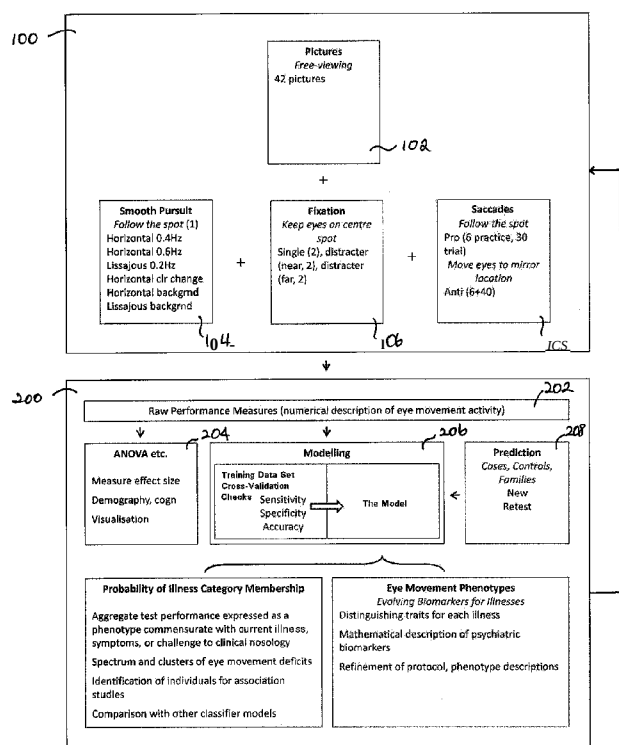
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(54) Title: AN APPARATUS AND A METHOD FOR PSYCHIATRIC EVALUATION

Figure 2



(57) Abstract: Apparatus (1) for use in a method for psychiatric evaluation comprises: memory means (4) for holding a store of pre-selected images; display means (12) for displaying a succession of said images to a patient; eye tracking means (6) for tracking eye movement of a patient; recording means (8) for recording eye movement data corresponding to a patient's eye movement in response to the display of said succession of images; control means (2) for controlling the display means to display the images to the patient, and for controlling the recording means to record said eye movement data and displayed image data; and evaluation means (10) for evaluating said eye movement data and displayed image data for use in identifying a psychiatric profile of the patient.

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An Apparatus and a Method for Psychiatric Evaluation

[001] This invention relates to an apparatus and a method for use in psychiatric evaluation, more particularly
5 to such a psychiatric evaluation based on analysing eye movements of a patient.

[002] In this regard, many efforts have been made to date to identify traits, bio-markers, behaviour, and symptoms
10 associated with particular psychiatric illnesses in order to assist in distinguishing affected individuals.

[003] For example, a discovery of abnormal eye movements present in a proportion of unmedicated psychotic
15 patients was made over 100 years ago. However, in spite of this early discovery, efforts to identify stable trait markers associated with illnesses such as schizophrenia that can accurately delineate sufferers from normal control test participants (control subjects) have met with limited
20 success.

[004] Furthermore, only very limited analysis of the multiple and subtle variations embedded in the many components that define eye tracking performance in
25 schizophrenia have been performed, despite the apparent robustness of the many individual deficits in eye movement performance reported in schizophrenics and their relatives.

[005] Whilst scientists are achieving a better
30 understanding of the human mind and have more advance technologies at their disposal for analysis, it remains difficult to readily and accurately identify and diagnose current or potential affected individuals.

35 [006] In this connection, psychiatric diagnoses are in

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practice currently symptom-based with only face validity, essentially without biomarkers that can externally validate a diagnosis of mental illness. This is especially problematic where individuals and patients do not display the core
5 features by which the most likely diagnosis is defined or they display features that are shared with more than one diagnostic category. Furthermore, in such cases, the diagnosis may not become apparent until the individual has been expertly assessed by careful observations over an
10 extended period of time. Genotypic information may in the future help with some of these uncertainties but at present they are no better than clinical evaluation at predicting risk of specific disorders. Clinical evaluations require a significant amount of time, expertise and hence cost. There
15 also remains the uncertainty as to whether an illness can in any event be diagnosed without the full diagnostic criteria being met.

[007] In this connection, studies to date into eye
20 movement abnormalities have not been able to define features that in psychiatric patients are either sensitive enough or specific enough to be of clinical value. Although there are group differences there is too much overlap between affected cases and control subjects and between the different
25 diagnostic categories within the affected cases. For example, there is considerable evidence that individuals with schizophrenia and their biological family members perform poorly on Smooth Pursuit Eye Movements (SPEM) tests. However, when the sensitivity is set high, even a proportion of
30 control subjects perform poorly, ie there is an inverse correlation between sensitivity and specificity.

[008] A further example of a general trait of individuals with schizophrenia is in relation to saccades.
35 In general, anti-saccades tests have been used to try to

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identify schizophrenia cases: however, such tests are well known to be very difficult to perform by both cases and control subjects. These tests have consequently been consistently error-prone with considerable variation in the results/error rates between studies and individuals. It is known that such tests have also been significantly affected by the age of the participants.

[0009] Furthermore, individuals with schizophrenia are also known to have poor fixation control. They have trouble with gaze stability and glissades. However, currently available tests are not able to produce consistent confirmatory results.

[0010] In relation to above, many studies have also found that schizophrenia's eye movements are frequently confined to a limited area of the stimulus or are concentrated on selected features, and scanning is atypical in contextual perception, recognition, search and free-viewing tasks.

[0011] Relatives and siblings have also showed the trait of restricted atypical scanning. However, the abnormal fixation combined with scanning tasks in schizophrenia have not been studied and no substantial findings have emerged. In consequence eye movement tests such as SPEM, anti-saccades, fixation/gaze maintenance and exploratory scanpaths are historically known to only partially discriminate schizophrenia cases from control subjects. Such poor discrimination between psychiatric patients and control subjects means that these tests have not been viewed as clinically/diagnostically useful since the rate of mis-diagnosis was unacceptably high.

[0012] Accordingly it is an object of the present

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invention to overcome the above problems associated with such known apparatus and methods.

[0013] According to an aspect of the present invention,
5 there is provided apparatus for use in a method for psychiatric evaluation comprising: memory means for holding a store of pre-selected images; display means for displaying a succession of said images to a patient; eye tracking means for tracking eye movement of the patient; recording means for
10 recording eye movement data corresponding to a patient's eye movement in response to the display of said succession of images; control means for controlling the display means to display the images to the patient in a predetermined order and for a predetermined period of time, and for controlling
15 the recording means to record said eye movement data and displayed image data over said period of time; and evaluation means for evaluating said eye movement data and displayed image data to produce a first results data set which, in combination with a second results data set obtainable from
20 performing one or more of smooth pursuit tests, fixation tests and saccade tests, is for use in identifying a psychiatric profile of the patient.

[0014] In this connection, the present invention is
25 concerned with developing apparatus which can be used to help to diagnose and classify individuals with psychiatric symptoms using criteria that are not based on face validity but rather have validity which is external to the symptoms themselves. This newly developed apparatus can as such
30 exploit a statistical combination of performance measures from a collection of interactive tests to classify individuals .

[0015] In this connection, the apparatus uses the
35 fundamentals of a free-viewing test to ensure that the

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influence of factors other than physiological conditions of the test participants can be minimised so as to reduce noisy data within the results. Under a controlled test environment, the patient is simply asked to look at the succession of
5 images being displayed so that while viewing takes place the eye movements can be tracked. This aspect differs from other known tests in that the patients are not required to perform particular tasks which could introduce unnecessary noise into the data. The applicants have found that adaptation of the
10 free view test in this particular application affords highly effective results for use in evaluating a psychological profile of a patient. The images shown to the patient are specifically chosen to be of neutral emotion, namely images whose content is intended to have a low risk of evoking
15 raised emotions. The images have a moderate, undisturbing tranquil quality. Such images have proven to be particularly effective in the context of the present invention in producing extremely highly performing data.

20 [0016] Conveniently, the control means provides that a total of 42 images are displayed. The total number of images used in the test may change depending on the need of the tests, however, once the total number is set then it should be maintained for each of the free-viewing tests performed.
25 This will maintain validity of the results data for evaluation. Nevertheless, the total of 42 images have been proved to produce a satisfactory result in relation to providing schemata for schizophrenia biomarkers. Conveniently, the images are presented in a predetermined
30 sequence.

[0017] Conveniently, the apparatus further comprises a memory means for storing a plurality of neutral images, and said control means provides that each of said images from
35 said memory means are displayed in turn in a predetermined

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sequence .

[0018] Preferably, the control means provides that the images are displayed for a period of 5 to 10 seconds. In
5 general individuals with schizophrenia take longer than unaffected individuals to begin engaging in picture viewing. Therefore, shorter durations may not yield sufficient eye movements and alternatively, longer durations might adversely affect engagement with the images and will certainly increase
10 the duration of the test causing unnecessary fatigue.

[0019] Preferably, the control means further controls the apparatus to additionally perform one or more of smooth pursuit tests, fixation test and saccade tests. Each of these
15 tests are modified and enhanced to simplify the test so that virtually all patients and control subjects can undertake these successfully. These simplified tests focus and capitalise on overlooked and misused earlier discovery of abnormal eye movements in association with a particular
20 mental disease/disorder, excluding any unnecessary reliance on cognitive behaviours of the test participants. Therefore the apparatus enables an alternative method of measuring eye movements to the currently used approaches in a much more cost-effective way to diagnose participants.

25

[0020] Conveniently, the control means takes results data from said one or more smooth pursuit tests, fixation test and saccade tests, and uses them to refine said first results data. In this regard, after collecting results data
30 from different tests and using them in the analyses, the integrity of the data will be enhanced as it is cross validated across the tests for determining the possible traits. The distinctions between the sufferers and the control subjects are as a result shown more readily.

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[0021] Preferably, the control means uses an algorithm to attribute relative importance to the results of the first results data set, and result data sets from said one or more smooth pursuits tests, fixation test and saccade test. As
5 such, the respective results are given a relative importance in the overall psychiatric evaluation. Training efficacy can be monitored using cross-validation to ensure a fair description of accuracy is obtained.

10 [0022] In preferred embodiments, the algorithm uses measures from 3 tests, namely free (picture) viewing, Lissajous 0.2Hz pursuit and fixation stability. Conveniently, the algorithm uses 10 such measures.

15 [0023] For a model based on a group comprising control + schizophrenia + bipolar + major depressive disorder, such measures are 1) Free Viewing (fixation dispersion), 2) Pursuit-Lissajous 0.2Hz (gain horizontal), 3) Pursuit-Lissajous 0.2Hz (gain vertical), 4)
20 Pursuit-Horizontal 0.4 Hz (saccade duration), 5) Pursuit-Lissajous 0.4Hz (saccade frequency), 6) Free viewing (saccade average velocity), 7) Fixation-Distracter (scanpath length), 8) Free Viewing (saccade peak velocity), 9) Pursuit-Horizontal 0.4Hz (saccade peak velocity), and 10)
25 Pursuit-Horizontal 0.4Hz (gain horizontal).

[0024] For such a model, the importance attributed to each measure out of 100 is given as: 1) 100, 2) 66.9, 3) 58.0, 4) 41.9, 5) 33.2, 6) 31.4, 7) 31.3, 8) 27.7, 9) 27.6
30 and 10) 25.8. In this respect, the relative importance of the Free Viewing (fixation dispersion) measure is apparent.

[0025] In preferred embodiments, the importance weighting of the Free-viewing (fixation dispersion) measure
35 is from 85 to 100 out of 100.

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[0026] According to a further aspect of the present invention, there is provided a method for use in a method for psychiatric evaluation comprising: displaying a succession of different neutral images to a patient whilst simultaneously tracking eye movement of the patient; recording a patient's eye movement as eye movement data in response to the display of said succession of images; wherein said images are displayed to the patient in a predetermined order and for a predetermined period of time; and collecting said eye movement data to produce a first results data set for use in combination with a second results data set obtainable from performing one or more of smooth pursuit tests, fixation test and saccade tests, in identifying a psychiatric profile of the patient.

[0027] This is in essence a method based around a free viewing test. The images are neutral or bland, namely they are intentionally chosen so as not to provoke a strong emotional response. They have a moderate, undisturbing tranquil quality. This has proven to be highly effective in producing extremely highly performing data.

[0028] Preferably, a total of 42 images are displayed. Conveniently, said images are stored and selected in turn in a predetermined sequence and the images are displayed for a period of 5 to 10 seconds, preferably 8 seconds.

[0029] Preferably, the method further comprises carrying out one or more of a smooth pursuits test, fixation test and saccade test. Results data are preferably taken from said one or more smooth pursuits test, fixation test and saccade test, and used to refine said first results data.

[0030] The control means preferably uses an algorithm

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to weight the first results data set, and the result data set from said one or more smooth pursuits test, fixation test and saccade test.

5 [0031] Preferably, the method further comprises attributing an importance weighting to measures of the first results data set, and second result data set from said one or more smooth pursuit tests, fixation test and saccade tests .

10

[0032] Conveniently, 10 measures are used for building an evaluation model.

[0033] The measures preferably include a free viewing
15 (fixation dispersion) measure.

[0034] Conveniently, said free viewing (fixation dispersion) measure is given an importance weighting of 85-100 out of 100.

20

[0035] Preferably, the method further comprises refining the results data sets using preselected statistical methods.

[0036] The method may further comprise: repeating the
25 method to obtain a number of sets of data from different patient groups; building a data bank for modeling purposes using at least two different statistical modeling techniques; and cross-validating the models. In this connection, a classification model is built from the sets of results data
30 obtained from the free-viewing test and one or more smooth pursuit tests, fixation test and saccade tests.

[0037] Preferably, the modeling techniques comprise Gradient Boosted Decision Trees (GBDT) and Probabilistic
35 Neural Networks (PNN) . Currently the PNN method is most able

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to describe the eye movement data and capable of providing reliable and accurate models. These methods are readily available, being in the public domain, and are implemented in public domain packages such as R, and in
5 commercially-available packages such as DTREG.

[0038] In preferred embodiments, 9 median measures are taken for the free-viewing test, from (1) fixation number (frequency of fixations); (2) fixation duration (ms); (3)
10 saccade number (frequency of saccades); (4) saccade duration (ms); (5) saccade amplitude (degrees); (6) saccade average velocity (deg/s); (7) saccade peak velocity (deg/s); (8) scanpath length (deg); (9) fixation dispersion (how clustered or dispersed the fixations made during the test).

15 [0039] Conveniently, the method performs smooth pursuit tests, further comprising steps of: displaying a moving stimulus against a predetermined background in the middle of a display for a predetermined duration T ; obtaining a set of
20 eye movement measurements from the duration T excluding 1 second from the start and the last 1 second of a test; and estimating median values for Signal-to-Noise Ratio (SNR), Root Mean Square error (RMSE) and tracking gain (eye speed divided by stimulus speed). Conveniently, T is 20 seconds.
25 If $T > 20$ seconds then the patient is likely to feel fatigue; if $T < 20$ seconds then calculation of the performance measures is prone to error.

[0040] The moving stimulus may be a red circle or a spot
30 which changes colour (red, blue) at random intervals. The spot is 0.5 degree diameter.

[0041] The predetermined background can comprise a colour, black or a random backdrop of spots. When used, 100
35 spots are normally adequate to provide a textured backdrop.

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The position of the spot on the display is determined by random coordinates drawn from the Uniform Distribution.

[0042] Preferably, the stimulus moves in a horizontal
5 sinusoid having a temporal frequency between 0.2 Hz to 0.6 Hz.

[0043] Conveniently, the stimulus can move in a 2D
sinusoidal Lissajous pattern across the height and width of
10 the screen having a temporal frequency between 0.2 Hz and 0.4 Hz.

[0044] In preferred embodiments, 10 median measures are taken for the smooth pursuit test, from (1) fixation number
15 (frequency of fixations - interpreted as a period of continuous accurate pursuit or glissade); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade duration (ms); (5) saccade amplitude (degrees); (6) saccade average velocity (deg/s); (7) saccade peak
20 velocity (deg/s); (8) signal-to-noise ratio (amount of accurate smooth pursuit compared with 'noisy' brief saccadic errors and adjustments); (9) root-mean-square-error (average positional error of the eye relative to the position of the target); (10) gain (ratio of overall speed of the eye during
25 pursuit to the speed of the target) .

[0045] In preferred embodiment where the stimulus moves in a 2D sinusoidal Lissajous pattern, 10 median measures are also taken for the smooth pursuit test for vertical eye
30 movement behaviour.

[0046] The method can perform a fixation stability test comprising further steps of: displaying a central target, or a central target together with a flanking distracter for a
35 predetermined duration T2; obtaining a set of fixation eye

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movement measurements; and calculating and obtaining median results from the fixation measurements separately for single and distracter conditions. Preferably, the predetermined duration T2 is 5 seconds.

5

[0047] In preferred embodiments, 5 median measures are taken for the fixation test, from (1) fixation number (frequency of fixations); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade amplitude
10 (degrees); (5) scanpath length (deg) .

[0048] The method can perform a saccade test comprising the further steps of: displaying a movable central target; obtaining a set of eye movement measurements; and calculating
15 and obtaining a set of results data.

[0049] In preferred embodiments, 13 median measures are taken for a single saccade test. A saccade test is either a pro-saccade task or an anti-saccade task. A task can be one
20 or both variants of gap and step conditions. This a maximum 65 measurements are available, from (1) blink frequency; (2) number of saccadic adjustments prior to first response saccade; (3) latency (ms) of first response saccade; (4) number of first saccades after target movement; (5)
25 amplitude of first response saccade (ratio of saccade amplitude to amplitude of target movement); (6) number of correct first saccades (task dependent); (7) number of saccadic adjustments after first response saccade; (8) latency (ms) of return saccade; (9) number of return saccades
30 after target movement; (10) amplitude of return saccade (ratio of saccade amplitude to amplitude of target movement) ; (11) number of saccadic adjustments after response saccade; (12) gaze duration held after first response saccade (ratio of final fixation period to actual target period); (13) gaze
35 amplitude after first response saccade (ratio of final

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fixation position to actual target position) .

[0050] Preferably, the method additionally performs smooth pursuits and fixation tests, and combines measures
5 consistent across these tests.

[0051] In a further aspect of the present invention there is provided a system for identifying and classifying a psychiatric illnesses of a patient the system comprising: -
10 using the apparatus as defined above in a method defined above to build an anonymous database of eye information data on individuals with psychiatric disorders and control subjects, using the apparatus in the method to test said patient and comparing the patient's test results
15 against the database for identifying and classifying psychiatric illness.

[0052] Conveniently, the method or system is controlled by software running on a computer.
20

[0053] Preferably, the invention encompasses a computer program for carrying out the above method or system or a computer usable medium having control logic stored therein for causing a computer to carry out the above system or
25 method.

[0054] An example of the present invention will now be described with reference to the accompanying drawings, of which :-
30

Figure 1 is a schematic drawing showing the apparatus in accordance with the present invention in use; and,

Figure 2 is a flow diagram in accordance with the
35 present invention.

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[0055] The apparatus 1 for psychiatric evaluation comprises a control means 2 and a display means 12 where the control means 2 is also connected to an accessible memory means 4 which holds a store of pre-selected images (the stimuli of a test). These images are carefully chosen generic pictures with a consideration of the cultural influences, so that they are non-evocative and neutral to the participants. They may for example be landscapes, people, faces, or objects. They are not moving images, but simply images of neutral emotion. Furthermore, based on these images a free-viewing test 102, where the participants need to look at the image, is prepared.

[0056] As shown in Figure 1, the control means 2 is also connected to the display means 12 so that the images can be displayed on the display means 12 according to the set up of the test. These images are displayed in a predetermined order and for a predetermined period of time.

20

[0057] The display means 12 may be a 19-inch (48cm) computer display (either as a 19-inch TFT display, or 21-inch CRT device with visible image scaled to match). There is no limitation to the size or the type of display units to be used, however, it is important that the presentation of the stimuli must be standardised.

[0058] For example, as illustrated in Figure 1, during the test the display means 12 is viewed from 70cm (distance (d) from screen to observer's eye) which can be measured by using a tape measure or if in a fixed environment measured from a head rest. The viewing distance (d, measured in degrees of visual angle) and the size of image/stimuli is kept constant so that the stimulus may subtend a constant visual area (28.1 h x 21.4v) thereby stimulating a

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standardised amount of visual cortex in the brain. This can be appreciated in terms of the number of eye movements required to inspect a 30cm square photograph viewed from 5 meters (i.e. virtually none) compared with inspection of the
5 same photograph viewed from 0.5 meters (i.e. many) .

[0059] Using the control means 2 and the memory means 4, the pre-selected images are automatically scaled to the native resolution of the display means 12. There may be
10 discrepancy in the appearance of the images as the resolution of the images may vary depending on the size and the quality of the original image, however as long as the viewing distance (d) of the test is kept this will not affect the test .

15 [0060] In a modified free viewing part of the test, the order of presentation of the stimuli type is fixed, after choosing a predetermined number of images from the memory means 4. A total of 42 images may be used for each test run.
20 This number has proved effective.

[0061] Each of the selected images is presented on the display means 12 for 5 to 10 seconds. A duration of 8 seconds has proven most effective to capture sufficient eye
25 movements of the participants. When setting up the test this duration must be kept consistent throughout the free-viewing test for each of its runs. Practice trials are not used for free-viewing tests. However, calibration procedures are allowed .

30 [0062] During the test period, the control means 2 which is further connected to eye tracking means 6 and recording means 8, utilises these components to track and to record the eye movement of the test participants. Raw eye position data
35 may be acquired between 120Hz and 1000Hz. A data rate at

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250Hz or 500Hz has proven effective in collecting necessary data from the test. Once selected, the rate must be also kept consistent throughout the tests. Higher rates such as 1000 or 2000Hz may not afford any benefit, as the
5 stimuli/task do not require very high resolution data. However, rates below 120Hz are not advisable because this may not sample eye position often enough to capture the fine details of eye movements induced by the stimuli.

10 [0063] The apparatus 1 may involve a helmet system with no head rest or a system where a chin and head rest are provided. This may depend on whether the participants can keep still during eye movement recording. The display means
12 may vary depending on which set-up is being used.

15 [0064] The apparatus 1 further comprises a plurality of similar themed stimuli/images which may be stored in the memory means 4, and the control means 2 takes images in turn in a predetermined sequence. As discussed, the images are
20 provided on the display means 12 wherein themes of these images include landscapes, faces and common everyday objects. The images are intended to be neutral and the display order preferably remains consistent.

25 [0065] From the free-viewing test, 9 median measures can be taken: (1) fixation number (frequency of fixations); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade duration (ms); (5) saccade amplitude (degrees); (6) saccade average velocity (deg/s); (7) saccade
30 peak velocity (deg/s); (8) scanpath length (deg); (9) fixation dispersion (how clustered or dispersed the fixations made during the test) .

[0066] As shown in Figure 2, the control means 2 further
35 controls the apparatus to perform one or more of smooth

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pursuit tests 104, fixation test 106, and saccade tests 108 along with the free-viewing test 102.

[0067] In the smooth pursuit test 104, the participant
5 is required to follow a target as smoothly as possible with their eyes, once it starts moving. The target stimulus may be a solid red circle shown against a black background. The target stimulus may be a red spot or a spot which changes its colour into such as red or blue at random intervals.
10 Viewed from 70cm the target is 0.5 deg in diameter.

[0068] The stimulus preferably moves in a horizontal sinusoid in the middle of the display, and in a 2D sinusoidal Lissajous pattern across the height and width of
15 the screen.

[0069] At the experimenter's discretion participants are encouraged to undertake each of:

1. Horizontal 0.4Hz
- 20 2. Horizontal 0.6Hz
3. Lissajous 0.2Hz
4. Horizontal 0.4Hz changing (red/blue) target
5. Horizontal 0.4Hz against random 100-spot background
- 25 6. Lissajous 0.2Hz and 0.4Hz against random 100-spot background

[0070] Each trial lasts 20 seconds, however, the first and last 1 second of the trial are excluded in analysis so
30 that the analysis is not affected by any pursuit initiation error, fatigue or anticipation of end of trial. There are no practice trials. Unlike other known smooth pursuit tests, no distinction is made amongst different types of saccades such as overshoots, catchup and backup. Only a tally is kept of
35 the saccade events that have been observed during the smooth

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pursuits test 104. Furthermore, when the test results in poor pursuit data, the parameter estimation using an alternative epoch is performed at the evaluation stage 200.

5 [0071] From the smooth pursuit test, 10 median measures are taken: (1) fixation number (frequency of fixations - interpreted as a period of continuous accurate pursuit or glissade); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade duration (ms); (5) 10 saccade amplitude (degrees); (6) saccade average velocity (deg/s); (7) saccade peak velocity (deg/s); (8) signal-to-noise ratio (amount of accurate smooth pursuit compared with 'noisy' brief saccadic errors and adjustments); (9) root-mean-square-error (average positional error of the 15 eye relative to the position of the target); (10) gain (ratio of overall speed of the eye during pursuit to the speed of the target).

[0072] In the case the smooth pursuit test involves 20 pursuing a 2D sinusoidal Lissajous pattern across the height and width of the screen, then 10 additional median measures of the above categories are taken for vertical eye movement behaviour .

25 [0073] The fixation test 106 requires the participant to maintain steady gaze only on a central target and to ignore flanking distracter targets when they are present. The central target may be 0.5 deg circular target. These distracter targets appear either to the left or right of the 30 central target. The position of the distracter targets may be off to 1.43 or 2.86 deg on either side of the central target. Each condition is repeated twice. The target may be black on a mid-grey background.

35 [0074] The order of the test is fixed to:

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1. Single
2. Distracter present close left
3. Distracter present close right
4. Distracter present far left
- 5 5. Distracter present far right
6. Single

[0075] These stimuli are pre-rendered as images and presented in exactly the same way as images in the free-viewing test 102. The fixed images are stored in the memory means 4. Each trial lasts 5 seconds and there are no practice trials.

[0076] From the fixation test, 5 median measures are taken: (1) fixation number (frequency of fixations); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade amplitude (degrees); (5) scanpath length (deg) .

20 [0077] There are two types of tests relating to saccade 108. For a pro-saccade test, the participants are required to keep their gaze on a target, and to follow the target when the target moves to the side and when the target returns to the centre of the screen.

25 [0078] For an anti-saccade test, the participants are required to move their gaze to the mirror location on the opposite side of the screen when the spot moves to one side, and to wait for the target to return to the centre.

30 [0079] From the saccade test, 13 median measures are taken: (1) blink frequency; (2) number of saccadic adjustments prior to first response saccade; (3) latency (ms) of first response saccade; (4) number of first saccades after target movement; (5) amplitude of first response saccade

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(ratio of saccade amplitude to amplitude of target movement) ;
(6) number of correct first saccades (task dependent); (7)
number of saccadic adjustments after first response saccade;
(8) latency (ms) of return saccade; (9) number of return
5 saccades after target movement; (10) amplitude of return
saccade (ratio of saccade amplitude to amplitude of target
movement); (11) number of saccadic adjustments after response
saccade; (12) gaze duration held after first response saccade
(ratio of final fixation period to actual target period) ;
10 (13) gaze amplitude after first response saccade (ratio of
final fixation position to actual target position) .

[0080] The test presentation depends on the type of the
participant being assessed. For example, the performance on
15 the gap step and overlap conditions in dyslexia normally
requires about 30 trials of each, in a pre-determined random
order) . With the psychiatric patients, for the same
performance about 20 trials of each are required. There are
equal numbers of left and right displacements and equal
20 numbers of displacements at medium (300 pixels) and far (400
pixels) distances. The test lasts 4 seconds on average and
there are 8 practice trials. A normalised saccade
displacements data is collected so that eye movement
performance is independent of stimulus properties. This also
25 allows to obtain Signal to Noise Ratio (SNR) and gain which
have been obtained in the smooth pursuit test 104.

[0081] In all four tests described above, the lower
fixation duration threshold is 80 ms whereas the upper
30 threshold is unbounded. Furthermore, it is noted that any
alteration to the test durations may have an adverse effect
on the success of the modeling. Therefore consistency
throughout the tests and collection of the data for the
analysis is required.

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[0082] In addition, the preference is to analyse data from the volunteer's dominant eye (which could be assessed using tests such as the 'hole-in-the-card ' or keyhole test) . Whenever possible binocular data can be obtained as a backup.

5 However, the analysis may compensate for monocular recordings regardless of the dominance of the eye used due to problematic setup or calibration of the eye tracker.

[0083] As shown in Figure 2, once all tests 100 have
10 been carried out, the sets of results data 202 from each of the test is passed onto the evaluation stage 200. The evaluation is carried out by building classification models 206 using supervised machine learning techniques. In addition, traditional methods such as analysis of variance
15 204 can also be used. Examples of such learning techniques are Gradient Boosted Decision Trees (GBDT) and Probabilistic Neural Networks (PNN) methods. Obtaining large data sets aids in tweaking the parameters of the analyses to be less critical. The parameters such as variable weighting can be
20 adjusted depending on the purpose of the tests.

[0084] Each build of the model to incorporate new patient groups will alter the importance of individual tests and test measures.

25

[0085] In this connection, the control means attributes an importance weighting to the results data set from the modified free viewing test, and the results data set from said one or more of smooth pursuit tests, fixation test and
30 saccade tests.

[0086] Examples of how the models are built are illustrated with reference to the following models 1, 2, 3 and 3a. As shown, each build of the model to incorporate new
35 patient groups will alter the importance of the individual

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tests and test measure. The relative importance of measures is given for a number of builds. The models shown in tables 1, 2 and 3 use 5 tests (free-viewing, fixation stability, and 3 pursuit tasks) .

5

[0087] Model 1 relates to controls and Schizophrenia. Classification performance for training and leave-one-out cross validation procedures are shown below. Average sensitivity, specificity and accuracy values are given in
10 italics. Cross-validation was used to examine how well the model might generalise when presented with new data. More aggressive methods of cross validation such as 10% hold back can be used. However, there is a risk that important information (participant variance) would be lost as much as
15 weaknesses in the model might be highlighted, when it is applied to the modest sample sizes used in this model. Nevertheless, these steps are necessary to limit the risk of the model being over-fitted to noisy data. Training set performance alone does not adequately reflect the model's
20 efficiency or success, and had there been a perfect classification under cross validation then it is likely that there is a fault in the method. Schizophrenia cases include data from patients we tested in Germany (n=27) . The top-10 most influential measures in determining model structure are
25 also shown in a table.

con = undiagnosed controls, scz = schizophrenia, Sens = sensitivity, Spec = specificity, Acc = accuracy

30

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5	Training	Actual	Predicted		Sens	Spec	Acc
			con	scz			
			con	scz			
		con	95		100.0	100.0	100.0
		scz		87	100.0	100.0	100.0
10					100.0	100.0	100.0

15	Cross-Validation	Actual	Predicted		Sens	Spec	Acc
			con	scz			
			con	scz			
		con	94	1	99.0	99.0	99.0
		scz	1	86	99.0	99.0	99.0
20					99.0	99.0	99.0

25	Test	Subtest	Measure	Importance
	Free-viewing		Fixation dispersion	100.0
	Fixation	Distracter	Scanpath length	33.2
	Pursuit	Lissajous .2Hz	Saccade amplitude	23.2
	Pursuit	Horizontal .4Hz	Saccade peak velocity	16.7
	Free-viewing		Fixation duration	16.3
	Pursuit	Lissajous .4Hz	Gain (vertical)	15.1
	Pursuit	Lissajous .2Hz	Gain (horizontal)	14.0
30	Free-viewing		Scanpath length	7.0
	Pursuit	Lissajous .2Hz	Fixation duration	6.7
	Pursuit	Lissajous .2Hz	Saccade average velocity	6.5

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[0088] Model 2 relates to controls, Schizophrenia and Bipolar Disorder. The sophistication of the network modelling approach allows bipolar cases to be distinguished from schizophrenia with high accuracy. These results suggest that there may be unique eye movement phenotypes in these illnesses .

con = undiagnosed controls, scz = schizophrenia, bpad = bipolar affective disorder, Sens = sensitivity, Spec = specificity, Acc = accuracy

		Predicted			Sens	Spec	Acc
		con	scz	bpad			
		con	scz	bpad			
Training	Actual	con	95		100.0	98.6	99.2
		scz		87	100.0	100.0	100.0
		bpad	2	57	96.6	100.0	99.2
					98.9	99.5	99.5
		Predicted			Sens	Spec	Acc
		con	scz	bpad			
		con	scz	bpad			
Test - Validation	Actual	con	92	2	96.8	93.8	95.0
		scz	5	79	90.8	98.1	95.4
		bpad	4	54	91.5	97.8	96.3
					93.0	96.6	95.6

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	Test	Subtest	Measure	Importance
5	Pursuit	Horizontal .4Hz	Gain	100.0
	Pursuit	Lissajous .2Hz	Gain (horizontal)	96.5
	Pursuit	Lissajous .4Hz	Gain (vertical)	87.0
	Free-viewing		Fixation dispersion	85.0
	Pursuit	Lissajous .2Hz	Gain (vertical)	35.9
10	Fixation	Distracter	Scanpath length	19.2
	Pursuit	Horizontal .4Hz	Saccade peak velocity	18.9
	Pursuit	Lissajous .2Hz	Saccade amplitude	15.4
	Free-viewing		Scanpath length	11.5
	Fixation	Distracter	Saccade frequency	8.2

[0089] Model 3 relates to controls, Schizophrenia, Bipolar Disorder and Major Depressive Disorder. Data from 20 depressed cases (tabulated at the time of this report) are distinguished with surprising accuracy, with subtle consequences for the other categories. We want to recruit further MDD cases to improve the balance of sample numbers. Schizoaffective cases have not been included because supervised classification cannot learn enough about this group from a small sample size.

con = undiagnosed controls, scz = schizophrenia, bpad = bipolar affective disorder, mdd = major depressive disorder, Sens = sensitivity, Spec = specificity, Acc = accuracy

		Predicted				Sens	Spec	Acc
		con	scz	bpad	mdd			
30	con	95				100.0	99.4	99.6
	scz		87			100.0	100.0	100.0
	bpad	1		58		98.3	100.0	99.6
	mdd				20	100.0	100.0	100.0
						99.6	99.9	99.8

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		Predicted				Sens	Spec	Acc
		con	scz	bpad	mdd			
Cross-Validation	Actual	con	94	1		99.0	97.0	97.7
		scz	2	83	1	95.4	98.3	97.3
		bpad	3	2	52	88.1	99.0	96.6
		mdd			1	95.0	98.8	98.5
						94.4	98.3	97.5

Test	Subtest	Measure	Importance
Free-viewing		Fixation dispersion	100.0
Pursuit	Lissajous .2Hz	Gain (horizontal)	66.9
Pursuit	Lissajous .2Hz	Gain (vertical)	58.0
Pursuit	Horizontal .4Hz	Saccade duration	41.9
Pursuit	Lissajous .4Hz	Saccade frequency	33.2
Free-viewing		Saccade average velocity	31.4
Fixation	Distracter	Scanpath length	31.3
Free-viewing		Saccade peak velocity	27.7
Pursuit	Horizontal .4Hz	Saccade peak velocity	27.6
Pursuit	Horizontal .4Hz	Gain (horizontal)	25.8

[0090] Model 3 can be modified to use only 3 tests (picture viewing, Lissajous 0.2Hz pursuit, fixation stability) with a view to refining the testing procedure. Model 3a shows such simplified network model relating to controls, Schizophrenia, Bipolar Disorder and Major Depressive Disorder. Even in such case, separation of cases and controls remains impressive using performance measures from just three tests.

55

con = undiagnosed controls, scz = schizophrenia, bpad = bipolar affective disorder, mdd = major depressive disorder, Sens = sensitivity, Spec = specificity, Acc = accuracy

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Training	Actual	Predicted				Sens	Spec	Acc
		con	scz	bpad	mdd			
		con	scz	bpad	mdd			
	con	95				100.0	100.0	100.0
	scz		87			100.0	100.0	100.0
	bpad			59		100.0	100.0	100.0
	mdd				20	100.0	100.0	100.0
						100.0	100.0	100.0

Cross-Validation	Actual	Predicted				Sens	Spec	Acc
		con	scz	bpad	mdd			
		con	scz	bpad	mdd			
	con	89	3	3		93.7	97.6	96.2
	scz	1	83	2	1	95.4	96.6	96.2
	bpad	3	2	51	3	86.4	94.6	92.7
	mdd		1	6	13	65.0	98.3	95.8
						85.1	96.8	95.2

Test	Subtest	Measure	Importance
Free-viewing		Fixation dispersion	100.0
Pursuit	Lissajous .2Hz	Gain (vertical)	71.6
Pursuit	Lissajous .2Hz	Gain (vertical)	37.3
Fixation	Distracter	Fixation duration	34.5
Free-viewing		Saccade amplitude	33.8
Free-viewing		Saccade average velocity	26.7
Fixation	Distracter	Scanpath length	20.9
Fixation	Distracter	Saccade amplitude	16.7
Free-viewing		Scanpath length	14.4
Fixation	Single	Scanpath length	10.8

[0091] Models 3 and 3a show that, even if the number of

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tests has changed the importance of free-viewing (fixation dispersion) test remains 100.0 whereas the importance of Lissajous 0.2Hz pursuit and fixation stability has been adjusted. Furthermore, There can be 55 different measures, 5 which can be obtained by going through all the tests to build a model. However, amongst these 55 measures free-viewing fixation dispersion has highest influence values with the median 96.96 with the range of 66 to 109.

10 [0092] In the preferred embodiments, 10 measures are hence chosen for use in the formulation of the models. Of these, the free viewing (fixation dispersion) measure has a consistently high importance weighting, with the remaining measures generally contributing to diminishing degrees in an 15 algorithm for determining the evaluation model.

[0093] Once the classification models are established, they are refined and used to predict an illness of an individual 208. In this connection, the models are refined 20 when new tests or retests are carried out on patients or control subjects. The patients and the control subjects who have been tested may be retested to check whether there have been any changes to their performance.

25 [0094] In the case where an individual cannot complete a test, this leaves missing data before modeling 206 can take place. In such a case, the traditional method replaces missing values with the mean or median of the relevant group's values for that variable. However, according to 30 present invention, surrogate splitters (GBDT) or surrogate variables (PMN) replace missing data at the evaluation stage 200. Surrogate values are interpolated from the individual's available data based on their group's characteristics. This allows incomplete test results data which are a feature of 35 clinical experiments to be reflected in the analysis.

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[0095] Each of the tests and the modeling can be customised depending on the individual participants, illnesses etc. In the example given, the apparatus and the method have applied to schizophrenia. However, in this regard, the same may be applicable for delineating other psychiatric phenotypes such as bipolar affective disorder, schizo-affective and major depressive disorders, obsessive-compulsive disorder, autism, ADHD and PTSD. Furthermore, dyslexia, which is probably neurodevelopmental in origin, but not technically a psychiatric disorder, may also be amenable to this approach.

[0096] The machine learning model using data from a limited number of psychiatric cases with various diagnoses together with normal control subjects shows remarkable predictive ability to correctly classify new cases and control subjects. Therefore, the memory means 4 can be designed to contain data from a large sample sizes with defined clinical psychiatric disorders as well as individuals with ill defined conditions, high risk family members and individuals with dyslexia etc. Furthermore, the memory means 4 can also be constantly added to and refined.

[0097] The information about the variation in patients and control subjects can be exploited by refining performance measurement and analysing these measures using sophisticated algorithms. This indicates an accurate trait or biomarker of risk of psychiatric illnesses using an eye movement phenotype is possible. The profile of the abnormalities detected may be able to stratify psychiatric illnesses into clinically relevant subcategories. With this in mind, the apparatus is designed in such a way that it can be used in a clinical setting with minimal training and be as compact as a personal laptop or desktop computer.

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[0098] In this connection, the apparatus and the method may be used for the clinical assessment, diagnosis and treatment of individuals with major psychiatric disorders and probably also dyslexia. Relevant treatment can also include drug trials by the pharmaceutical industry.

[0099] The apparatus and the method may also be used in the evaluation of individuals at high risk of psychiatric disorders who may be only at the time of assessment be demonstrating vague psychiatric symptoms. However if the presence of specific patterns of eye movement abnormalities put the individual into the ultra high risk category clinical intervention would probably be indicated. Furthermore, the apparatus and the method provides an anonymised database of eye movement information on large numbers of individuals with psychiatric and other neurodevelopmental disorders and control subjects with which new clinical assessments and screening tests etc can be compared.

20

[0100] In addition there are certain occupations where potential recruits are carefully screened for the absence of psychiatric disorders. These include the armed forces, airline pilots, offshore workers on oil rigs etc. The above described eye movement tests can be an invaluable adjunct to clinical history and examination. For example, with regard to the armed forces, they could be used not only to screen out individuals at high risk of psychiatric disorders but also used as baseline measurements among recruits themselves. This is possible because the tests are normally stable over time so that if there are any subsequent changes in baseline measurements this may provide biological evidence of traumatic brain injury (TBI) or post-traumatic stress disorder (PTSD) .

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[0101] As described above, any eye movement tests are likely to be used in combination with clinical evaluation and genotypic information.

5 [0102] It will be understood that the embodiment illustrated above shows an application of the invention only for the purposes of illustration. In practice the invention may be applied to many different configurations, the detailed embodiments being straightforward for those skilled in the
10 art to implement.

[0103] In this respect, off-the shelf hardware such as EyeLink I (provides a helmet system and no head rest) can be used for building the apparatus and EyeLink 2000 eye tracker
15 (provides a chin/head rest) which consists of a 'host PC' which acquires eye gaze data communicating with a 'subject PC' which presents the images can also be used.

[0104] In its broadest form, the invention comprises an
20 apparatus and a method for performing a specific form of a free-viewing test along with one or more further tests. In this regard, it has been found that this modified test affords high quality data for use in psychiatric evaluation. The invention encompasses a multivariate test, combining the
25 modified free-viewing test with one or more of enhanced smooth pursuits, fixation test and saccade tests. In this connection, it is preferred that in addition to the modified free-viewing test, a smooth pursuit and fixation test are carried out, with various median measures being taken from
30 each of the tests. It has been found that virtually all patients and controls can undertake such a multivariate test successfully .

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Claims

1. Apparatus for use in a method for psychiatric evaluation comprising:

5 memory means for holding a store of pre-selected images ;

 display means for displaying a succession of said images to a patient;

 eye tracking means for tracking eye movement of
10 the patient;

 recording means for recording eye movement data corresponding to a patient's eye movement in response to the display of said succession of images (and for recording displayed image data corresponding to the images displayed
15 by the display means);

 control means for controlling the display means to display the images to the patient in a predetermined order and for a predetermined period of time, and for controlling the recording means to record said eye movement data and
20 displayed image data over said period of time; and

 evaluation means for evaluating said eye movement data and displayed image data to produce a first results data set for use, in combination of a second results data set obtainable from performing one or more of smooth pursuit
25 tests, fixation test and saccade tests, in identifying a psychiatric profile of the patient.

2. Apparatus as claimed in claim 1, wherein the control means provides that a total of 42 images are
30 displayed.

3. Apparatus as claimed in claim 1 or claim 2, further comprising a memory means for storing a plurality of neutral images, and said control means provides that each of
35 said images from said memory means are displayed in turn in

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a predetermined sequence.

4. Apparatus as claimed in any preceding claim,
wherein the control means provides that the images are
5 displayed for a period of 5 to 10 seconds.

5. Apparatus as claimed in any preceding claim,
wherein the control means further controls the apparatus to
perform one or more of smooth pursuit tests, fixation test
10 and saccade tests.

6. Apparatus as claimed in claim 5, wherein the
control means takes results data sets from said one or more
smooth pursuit tests, fixation test and saccade tests, and
15 uses them to refine said first results data set.

7. Apparatus as claimed in claim 6, wherein the
control means attributes an importance weighting to measures
from the first results data set, and the second results data
20 set from said one or more of smooth pursuit tests, fixation
test and saccade tests.

8. A method for a psychiatric evaluation comprising:
displaying a succession of different pre-selected
25 neutral images to a patient whilst simultaneously tracking
eye movement of the patient;
recording the patient's eye movement as eye
movement data in response to the display of said succession
of images;
30 wherein said images are displayed to the patient
in a predetermined order and for a predetermined period of
time; and
collecting said eye movement data to produce a
first results data set for use, in combination of a second
35 results data set obtainable from performing one or more of

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smooth pursuit tests, fixation test and saccade tests, in identifying a psychiatric profile of the patient.

9. The method as claimed in claim 8, wherein a total
5 of 42 images are displayed.

10. The method as claimed in claim 8 or claim 9,
wherein said images are stored and selected in turn in a
predetermined sequence.

10

11. The method as claimed in any one of claims 8 to
10, wherein the images are displayed for a period of 5 to 10
seconds .

12. The method as claimed in any one of claims 8 to
11, wherein the method further comprises performing one or
more of smooth pursuit tests, fixation test and saccade
tests .

13. The method as claimed in claim 12, wherein
20 results data sets are taken from said one or more smooth
pursuit tests, fixation test and saccade tests, and used to
refine said first results data set.

14. The method as claimed in any one of claims 8 to
13, wherein the method further comprises attributing an
importance weighting to measures of the first results data
set, and second result data set from said one or more smooth
pursuit tests, fixation test and saccade tests.

30

15. A method as claimed in any one of claims 8 to
14, wherein 10 measures are used from the collected eye
movement data for building an evaluation model.

16. A method as claimed in claim 15, wherein said
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measures include a free viewing (fixation dispersion) measure .

17. A method as claimed in claim 16, wherein said
5 free viewing (fixation dispersion) measure is given an importance weighting of 85-100 out of 100.

18. A method as claimed in any one of claims 8 to 17 further comprising:
10 refining the results data using preselected statistical methods.

19. A method as claimed in any one of claims 8 to 18, further comprising:
15 repeating the method to obtain a number of sets of data from different patient groups;
building a data bank for modeling purposes using at least two different statistical modeling techniques; and cross-validating the models.

20. A method as claimed in claim 19, wherein the modeling techniques comprise Gradient Boosted Decision Trees (GBDT) and Probabilistic Neural Networks (PNN) .

21. The method of any one of claims 8 to 20, wherein
25 9 median measures are taken for the free-viewing test, from (1) fixation number (frequency of fixations); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade duration (ms); (5) saccade amplitude (degrees);
30 (6) saccade average velocity (deg/s); (7) saccade peak velocity (deg/s); (8) scanpath length (deg) ; (9) fixation dispersion (how clustered or dispersed the fixations made during the test) .

22. A method of any one of claims 8 to 21, wherein
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the method performs smooth pursuit tests, further comprising steps of:

displaying a moving stimulus against a predetermined background in the middle of a display for a
5 predetermined duration T_{TV}

obtaining a set of eye movement measurements from the duration T excluding 1 second from the start and the last 1 second of a test; and

estimating median values for Signal-to-Noise
10 Ratio (SNR), Root Mean Square error (RMSE) and tracking gain (eye speed divided by stimulus speed) .

23. The method as claimed in claim 22, wherein, T is 20 seconds.

15

24. The method as claimed in claim 22 or 23, wherein the moving stimulus is a red circle or a spot which changes colour and has a 0.5 degree diameter.

20 25. The method as claimed in any one of claims 22 to 24, wherein the predetermined background comprises colour, black or is formed of a random pattern of spots.

26. The method as claimed in any one of claims 22 to
25 25, wherein the stimulus moves in a horizontal sinusoid having a temporal frequency between 0.2 Hz to 0.6 Hz.

27. The method as claimed in any one of claims 22 to
25, wherein the stimulus moves in a 2D sinusoidal Lissajous
30 pattern across the height and width of the display having a temporal frequency between 0.2 Hz and 0.4 Hz.

28. The method of any one of claims 22 to 27, wherein
10 median measures are taken for the smooth pursuit test,
35 from (1) fixation number (frequency of fixations -

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interpreted as a period of continuous accurate pursuit or glissade); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade duration (ms); (5) saccade amplitude (degrees); (6) saccade average velocity (deg/s); (7) saccade peak velocity (deg/s); (8) signal-to-noise ratio (amount of accurate smooth pursuit compared with 'noisy' brief saccadic errors and adjustments); (9) root-mean-square-error (average positional error of the eye relative to the position of the target); (10) gain (ratio of overall speed of the eye during pursuit to the speed of the target).

29. The method as claimed in claim 28, wherein the median measures are taken for the smooth pursuit test for vertical eye movement behaviour.

30. The method as claimed in any one of claims 8 to 29, wherein the method performs a fixation stability test comprising further steps of:

displaying a central target, or a central target and a flanking distracter for a predetermined duration T2; obtaining a set of fixation eye movement measurements; and calculating and obtaining median results from the fixation measurements separately for single and distracter conditions .

31. The method according to claim 30, wherein the predetermined duration T2 is 5 seconds.

32. The method as claimed in 30 or 31, wherein median measures are taken for the fixation test, from (1) fixation number (frequency of fixations); (2) fixation duration (ms); (3) saccade number (frequency of saccades); (4) saccade amplitude (degrees); (5) scanpath length (deg) .

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33. The method as claimed in any one of claims 8 to 32, wherein the method performs a saccade test comprising further steps of:

- 5 displaying a movable central target;
 obtaining a set of eye movement measurements; and
 calculating and obtaining a set of results data.

34. The method as claimed in 33, wherein 13 median
10 measures are taken for the saccade test, from (1) blink frequency; (2) number of saccadic adjustments prior to first response saccade; (3) latency (ms) of first response saccade; (4) number of first saccades after target movement; (5) amplitude of first response saccade (ratio of saccade
15 amplitude to amplitude of target movement); (6) number of correct first saccades (task dependent); (7) number of saccadic adjustments after first response saccade; (8) latency (ms) of return saccade; (9) number of return saccades after target movement; (10) amplitude of return saccade
20 (ratio of saccade amplitude to amplitude of target movement); (11) number of saccadic adjustments after response saccade; (12) gaze duration held after first response saccade (ratio of final fixation period to actual target period); (13) gaze amplitude after first response saccade (ratio of final
25 fixation position to actual target position) .

35. The method of any one of claims 8 to 34, wherein the method uses measures that are consistent across the different tests.

30

36. A system for identifying and classifying a psychiatric illnesses of a patient the system comprising: -
 using the apparatus according to any one of claims 1 to 7 in a method according to any one of claims 8
35 to 35 to build an anonymous database of eye information data

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on individuals with psychiatric disorders and control subjects,

using the apparatus according to any one of claims 1 to 7 in a method according to any one of claims 8 to 35 to

test said patient and comparing the patient's test results against the database for identifying and classifying psychiatric illness.

10 37. A system according to claim 36, as controlled by software running on a computer.

38. A computer program for carrying out the method or system of any one of claims 8 to 37.

15

39. A computer usable medium having control logic stored therein for causing a computer to carry out the system or method of any one of claims 8 to 37.

Figure 1

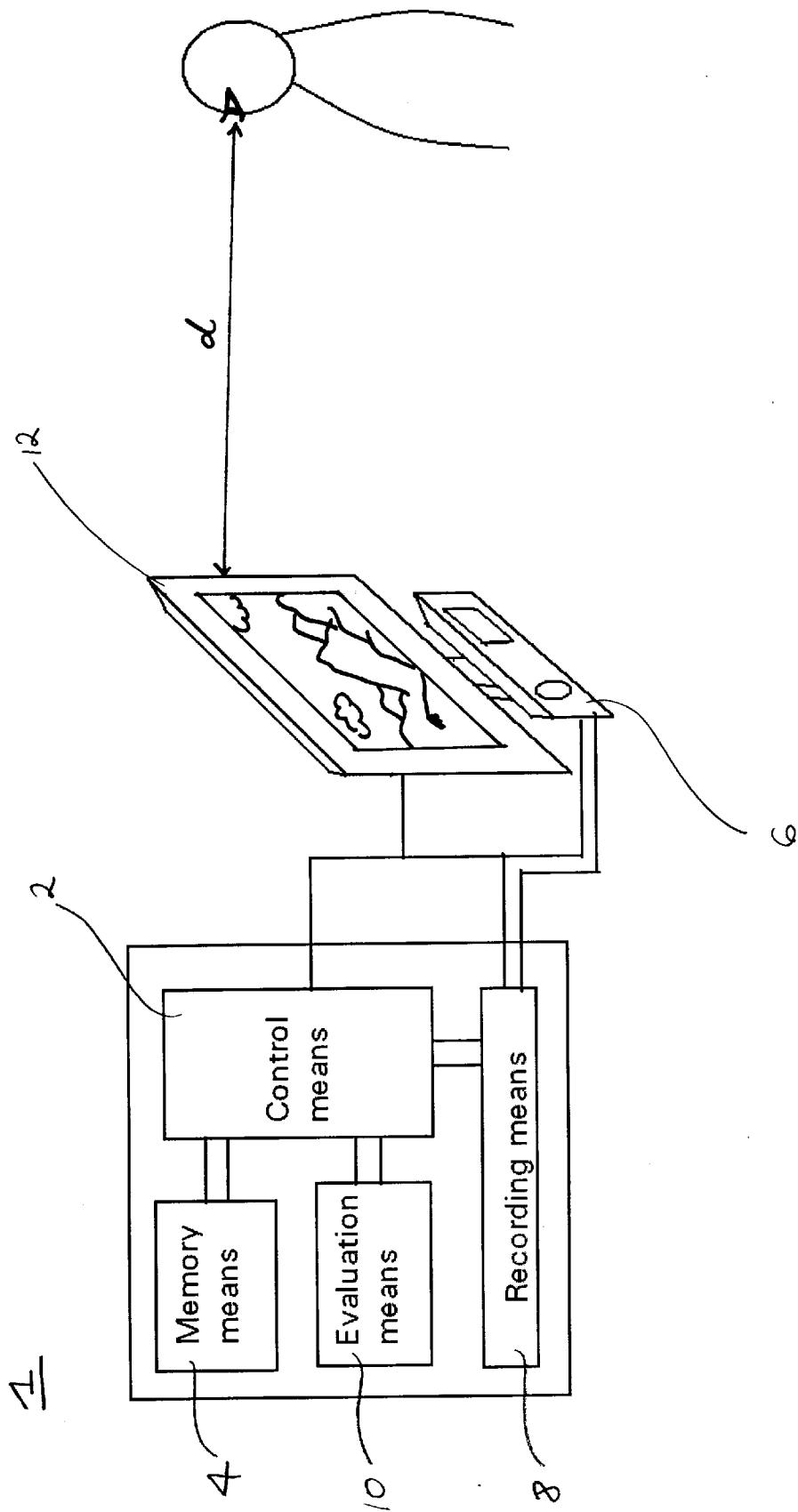
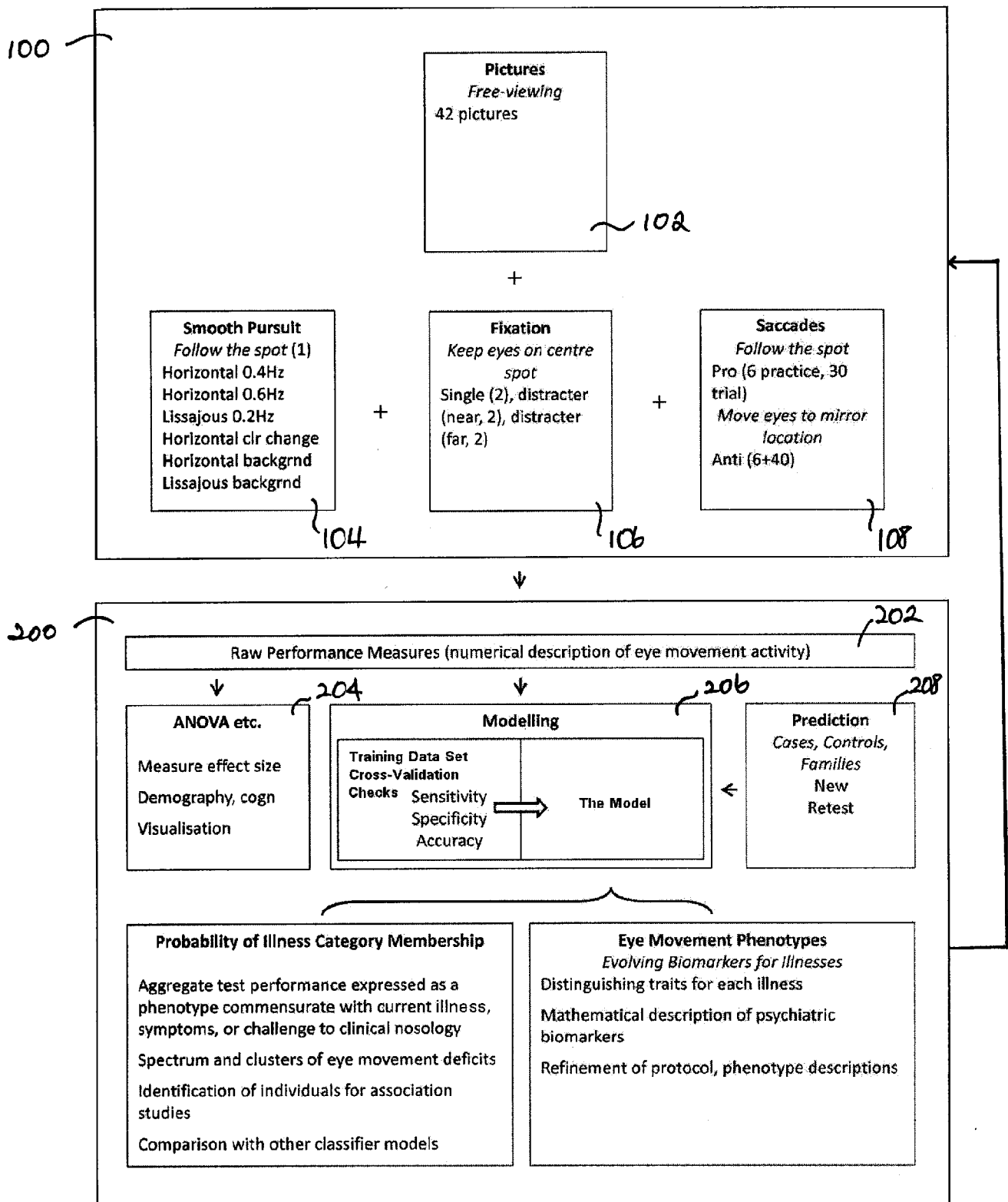


Figure 2



INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2013/050016

A. CLASSIFICATION OF SUBJECT MATTER
 INV. A61B5/00 A61B5/16
 ADD. A61B3/113

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	BESTELMEYER P E G ET AL: "Global visual scanning abnormalities in schizophrenia and bipolar disorder" , SCHIZOPHRENIA RESEARCH , ELSEVIER, NETHERLANDS, vol . 87, no. 1-3 , 1 October 2006 (2006-10-01) , pages 212-222 , XP027976460, ISSN : 0920-9964 [retrieved on 2006-10-01]	1-7
A	the whole document in particular: abstract chapters 2.2-2.5 page 221 , right-hand column , lines 12-17 ----- -/- .	38,39



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

19 April 2013

Date of mailing of the international search report

02/05/2013

Name and mailing address of the ISA/

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Authorized officer

Al brecht, Ronald

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2013/05Q016

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 8-37
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Diagnostic method practiced on the human or animal body
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050016

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	BENSON P J ET AL: "MULTIVARIATE EYE MOVEMENT PSYCHOPHYSIOLOGY ACCURATELY DIFFERENTIATES SCHIZOPHRENIA CASES FROM UNAFFECTED CONTROLS", SCHIZOPHRENIA RESEARCH, ELSEVIER, NETHERLANDS, vol . 117, no. 2-3, 1 April 2010 (2010-04-01), pages 248-249, XP026979778, ISSN: 0920-9964, DOI: 10.1016/J.SCHRES.2010.02.383 [retrieved on 2010-03-20] the whole document	1-7
X	Sarah A Beedie: "ATYPICAL VI EWING BEHAVIOUR IN SCHIZOPHRENIA", ETHOS, 1 January 2009 (2009-01-01), XP055059304, Retrieved from the Internet: URL: http://ethos.bl.uk/OrderDetails.do?doi=1&uin=uk.bl.ethos.499304 [retrieved on 2013-04-11]	38,39
Y	chapters 3.2.2, 3.2.4, 3.2.5, 4.6.3, 7.2.3.1, 7.2.3.2, 7.2.4.2, 7.3.2, 7.4.1	1-7
Y	BEEDIE: "Smooth pursuit and visual scanpaths: Independence of two candidate oculomotor risk markers for schizophrenia", WORLD JOURNAL OF BIOLOGICAL PSYCHIATRY, INFORMA HEALTHCARE, UK, vol . 13, 1 January 2012 (2012-01-01), pages 200-210, XP008161394, ISSN: 1562-2975, DOI: 10.3109/15622975.2011.566628	1-7
A	abstract chapter "Oculomotor measures" chapter "Smooth Pursuit" chapter "Discussion", in part. p. 207, right-hand column, 1. 19-21	38,39