

Manual of the Freiburg Vision Test ‘FrACT’, Version 3.7

For those who don’t like to read manuals: at least check michaelbach.de/fract/checklist.html for mandatory settings.

This manual assumes that the user of FrACT has a working knowledge of the principles and practice of the assessment of human visual acuity. Besides acuity, FrACT3 also can assess the contrast threshold and vernier resolution. FrACT is freely available at michaelbach.de/fract/.

Important for acuity

Two things need to be calibrated:

- (1) The observation distance. Measure from screen to eye; enter value at the setup screen (see figure below). This allows the program to calculate the visual angle.
 - (2) The length of the blue ruler line on the setup screen. This allows the program to calculate the screen resolution (pixels per mm), necessary for visual angle determination.
- The “max VA” value (bottom right, green in the figure below, in decimal acuity units) tells you about the maximal acuity that can be obtained with your distance and screen resolution. To measure normal acuity correctly, this needs to be at 2.0 or higher (VA 2.0_{decimal} equals $-0.3 \log_{10} \text{MAR}$ or $20/10_{\text{Snellen}}$).

	<p>Red left rectangle: the length of the blue ruler line, measured in mm.</p> <p>Red middle rectangle: the distance from screen to eye, measured in cm.</p> <p>Green rectangle: the maximum acuity that can be measured; should > 1.6 (higher means better resolution at high VA).</p>
--	---

How to get rid of the annoying startup message “Note: Calibrate...”

Unfortunately, FrACT has too often been used without calibration. Thus from version 3.2 onwards a strong warning message appears on every start unless you have changed both the length of the blue calibration ruler entry and the observer distance entry (see preceding paragraph). Both are defaulted to numbers that are unlikely to occur in practice (399 cm and 169 mm). As long as one of these remains at the default value, they are highlighted in red and the obnoxious message appears upon every start of FrACT.

Acuity

There are many possibilities to measure the minimum visible, a common and sensible approach is to present an “optotype”, be it a letter, a tumbling E or a Landolt C. Letters have the advantage of offering many choices, but require literacy and the resolution limit is not identical for the different Sloan letters.

The basic procedure starts with a very large (= easy to recognize) optotype, and having the subject or patient indicate recognition (name the letter, name the orientation of the gap in the Landolt C). Depending on the correctness of the response, next an easier or more difficult to recognize optotype is presented, ultimately aiming to determine the spatial resolution limit or threshold. Since there is a gradual loss of likelihood to respond correctly with decreasing size, the threshold must be expressed as a probability. The best choice is to set the threshold recognition rate in the middle between 100% and the guessing rate (12.5% in the case of 8 choices), 56.25% for this example. This means that at the “acuity value” nearly half the optotypes are not recognized correctly. This may initially appear counter-intuitive.

An additional procedural detail is the “forced choice” principle. This means that the subject needs to respond even if they cannot even make out the optotype at all. They have to give their best guess, which may be a random guess. This is a way to reduce the influence of the “response criterion”, that is whether the subject is timid (only responding when absolutely certain) or dashing (making wild guesses). Thus incorrect responses will enter into the procedure, which also may appear counter-intuitive.

To control the sequence of optotype presented and arrive at a threshold estimate, FrACT employs the “Best PEST” procedure. This means that the program determines the most likely position of the threshold, given the optotype sizes and responses so far, and then presents the optotype exactly at the current threshold estimate, thus maximizing information gain.

Acuity with tumbling

The E shape in the tumbling E has the same basic dimensions as the Landolt C, but is only presented in one out of 4 possible orientations.

Acuity (Sloan) Letters

In ETDRS charts these 10 Sloan letters are used: CDHKNORSVZ. In FrACT, the letters are vector shapes derived from measurements of the Sloan font. As response the appropriate letter is typed. Any non-Sloan letter is ignored.

Contrast

Like the Pelli-Robson or the Mars charts, contrast is not assessed selective per spatial frequency using sine-wave gratings. Rather, the large Landolt C optotype is composed of a mixture of low to medium spatial frequencies. Contrast sensitivity at high spatial frequencies and acuity tap the same physiological bottleneck and thus would be redundant. Since disease effects are not specific for spatial frequency, assessing the mixture contrast sensitivity besides visual acuity best preserves precious measurement time.

Contrast format

Of the 4 different contrast definitions in use, FrACT reports Michelson and Weber values in the thresholding contrast test. Contrast based on the Michelson formula:

$$\text{contrast}_{\text{Michelson}} = 100\% \cdot (l_{\text{max}} - l_{\text{min}}) / (l_{\text{max}} + l_{\text{min}}),$$

where l_{max} & l_{min} are the luminances of the bright and dark parts, respectively. Contrast based on the Weber formula:

$$\text{contrast}_{\text{Weber}} = 100\% \cdot (l_{\text{max}} - l_{\text{min}}) / l_{\text{max}}.$$

Conversion Michelson ↔ Weber:

$$\text{contrast}_{\text{W}} = 2 \cdot \text{contrast}_{\text{M}} / (1 + \text{contrast}_{\text{M}}),$$

$$\text{contrast}_{\text{M}} = \text{contrast}_{\text{W}} / (2 - \text{contrast}_{\text{W}}).$$

Thus for low contrasts, the Weber contrast is 2× the Michelson contrast. For automatic export the Michelson format is used, the Weber value can be calculated from that (see appendix).

Grating

Starting with version 3.7.1, a grating test has been added by request. This is currently in an experimental phase, feedback welcome. Since the grating test does not use anti-aliasing (yet), ceiling effects are to be expected in normal subjects around the peak of the CSF. The grating is presented in a circular window with a narrow Gaussian taper. Gratings are always presented in 1 of 4 orientations; spatial frequency (in cpd) and stimulus extent (in degrees diameter) are selected under **Settings** in the second column.

Response keys: for vertical use cursor up or down, for horizontal left or right; for oblique directions the corresponding choices on a numerical keypad (as depicted on the main screen, right).

Contrast Screening

This type of contrast assessment follows the rules for German traffic licensing. The resultant value is the “contrast ratio” $\text{contrast}_{\text{Ratio}}$, yet another measure for contrast other than Michelson or Weber (see appendix). Landolt-Cs corresponding to an acuity of $0.1_{\text{decimal}} = 1.0 \text{ logMAR}$ are presenting in a descending sequence with up to 5 presentations per contrast level. The number of orientations of the Landolt-C (4/8) is controlled via the appropriate Settings entry. The criterium for “seen” is 3 of 5 correct responses. Aiming for rapid assessment, and following the DOG (Aulhorn) rules, only the following levels are tested: 1:23, 1:5, 1:2.7, 1:2, 1:1.67, 1:1.47, 1:1.25, 1:1.14. To achieve DOG luminance levels, an appropriate neutral density filter has to be placed in front of the screen or worn by the subject. To convert to Michelson/Weber contrast (also see appendix):

$$\text{contrast}_{\text{Weber}} = 1 - 1/\text{contrast}_{\text{Ratio}}$$

$$\text{contrast}_{\text{Ratio}} = 1 / (1 - \text{contrast}_{\text{Weber}})$$

The DOG units actually are formatted as the inverse ratio as follows:

$$\text{contrast}_{\text{DOG}} = 1 : \text{contrast}_{\text{Ratio}}$$

Calibration (Luminance Linearization) is mandatory. To check on contrast calibration, hold the shift key while pressing the “Contr. Screening” button. A contrast staircase appears, allowing to measure contrast levels with a spot-meter. Any key-press returns you to the main screen.

[Contrast Screening is disabled by default and can be enabled in the Settings screen.]

Vernier acuity

Vernier acuity is nearly 10× better than optotype acuity. In FrACT, Vernier acuity is based on two-line-segment-alignment. Since only 2 choices are possible, many trials are necessary; the default setting is the lowest limit, more is better. Enter the displacement of the upper line relative to the lower line through the cursor keys or the digits 4 / 6.

Since Vernier acuity is so high, the considerations in “Note on display resolutions” (below) are particularly pertinent – you may need 10× higher distance to your display unit.

Nomenclature

There exist too many traditions to format visual acuity; FrACT caters for a number of them. The Snellen fraction or Snellen ratio or Snellen acuity indicates both the distance where the optotype was recognized and the distance where a normal observer would have recognized it. While this detail is welcome, there are disadvantages:

- Depending on whether basing distance measures on feet or yards, marked rounding errors occur.
- Ensuring a logarithmic progression of acuity values can lead to awkward Snellen fractions.
- It is difficult to average Snellen fractions.

When dividing the Snellen acuity, that is recognizing the Snellen fraction as a fraction, a single number results: the decimal acuity. So a decimal acuity of 1.0 corresponds to a Snellen acuity of 20/20 and is usually considered normal (although young normals typically have nearly twice this value when measured correctly). A disadvantage of the decimal acuity is that its progression is not logarithmic, and while seemingly easy to average this should not be done, the geometrical mean would be correct. Another measure of acuity is “logMAR”. Since MAR = the Minimum Angle of Resolution is just the inverse of decimal acuity, logMAR is the logarithm (base 10) of this. This measure has the advantage that it has the right logarithmic progression built-in and it can be easily averaged. A major disadvantage is that the better acuity the lower the logMAR

value, quite counter-intuitive. A pity that “logVA” has not been chosen. logVA is just the negative of logMAR and has all of its advantages without the disadvantage.

Whichever of these measures you prefer, they can be easily converted into each other when distance is known.

Limitations in accessible acuity

There are technical limits on the highest and lowest acuity, which depend on the display resolution in pixels per inch and on the distance. For distances of ≥ 3 m the standard monitor resolution is fine.

Lower distances only work with devices with very high spatial resolution (e.g. OLEDs) or in low acuity situations, see the “Note on display resolutions” below. If you want to assess low vision (0.1 = 20/200 and below) a distance to the display of 0.5–1.0 m is sufficient (possibly necessary).

Limitations in contrast

Assessment of the contrast threshold requires good gamma correction (display linearization). The best approach is to use a dedicated screen calibrator (e.g. Spyder by DataColor) to set system gamma to 1.0 and then set FrACT’s gamma to 1.0 as well (on the screen Setup>Luminance linearization). Distance is not so critical as for acuity, since the optotype’s size typically is markedly above the spatial resolution limit. 1 m or more is fine.

Options on the Setup screen

Numerous options have been added to FrACT over the years, often on user request. The following list follows the sequence in FrACT's "Settings" dialog.

- **# of choices (for acuity and contrast)**

The number of optotype directions (or response choices) for Landolt Cs can be selected between 4 and 8, and the threshold algorithm accordingly selects a guessing rate of 25% or 12.5%, respectively. Tumbling E has always 4 choices, Sloan letters always 10, Hyperacuity always 2 choices. *{Default: 8}*

- **# of trials {for 2 / 4 / 8 choices}**

The number of trials can be set to any reasonable number. A multiple of 6 (e.g., 18 or 24) is preferred so that the last trial is a "bonus trial" (see next item below), leaving the subject with a success experience for the last trial. The number of trials is separate for the 4 vs. 8 direction condition, because the latter will require fewer trials for comparable accuracy. For the hyperacuity test, there are only 2 possible choices, and consequently even more trials are necessary. Tumbling E will use the 4 choices selection, the trial number of the Sloan letters will be based on the 8 choices selection (because the guessing rate of 12.5% and 10% does not differ much). *{Default: 42 / 30 / 18}*

- **'easy trials' / bonus trials**

These are trials where the presented optotype is 3 times the currently assumed threshold. When enabled, every 6th trial (starting with trial 12) is such a bonus trial (or every trial, which was a special request). While this motivates many subjects, these trials do not gain much information on the threshold. The number of 6 was chosen on informal experience. Bonus trials increase the test value by 3 for acuity and contrast, and by 5 for hyperacuity (Vernier). *{Default: every 6th}*

- **Which test on '5'**

For extended measurements, it can be useful to control everything through the remote keypad (see the note on response keys below). This setting selects which test is started by pressing the central '5' key. Options are:
«VA Landolt C | VA tumbling E | VA Sloan letters | Contrast | Contrast screening | Vernier | none».
{Default: Landolt C}

- **Timeouts**

There are two timeouts, one controls the time the optotype is visible, the other limits reaction time.
– display time can be limited to a certain number of seconds from 0.1 to 999; when exceeded, the optotype disappears.
– response time can be limited to a certain number of seconds from 1 to 999, e.g. 10 s; when exceeded, an incorrect response is assumed and a new trial is started. Such time limitation was required for a European traffic expertise (not any more). Ten seconds can already be challenging for elderly subjects. *{Defaults: 30 s / 30 s}*

- **Position**

The optotype can be displaced relative to the center of the screen. This allows for systematic variation of eccentricity.
{Default: (0°, 0°)}

- **Optotype contrast**

For acuity testing, the contrast value of the optotype must be near 100% for the standard definition of visual acuity. Its value can be set from 1%–100% for special studies; for precise high contrast values any stray light must be reduced. Contrast is given in Michelson format, see "Contrast format" above for the definition or appendix.
Negative values give an inverted optotype (light Landolt C on dark background).
{Default: 100%}

- **Optotype color (fore- & background)**
The color for the Landolt C (“foreground”) and the color for the background can be separately selected. Since this is difficult to match correctly to the **Optotype contrast** setting (immediately to the left), the following rule applies: whenever the colors are changed, the contrast is set to 100%. Whenever the contrast is set, the colors are reset to black and white.
{Default: black on white}
- **Contrast-C: dia(meter)**
The diameter for contrast testing, measured in arc minutes. The Pelli-Robson letters are suggested to be used at 0.5° full letter width.
{Default: 30' (before version 2.0.3: 60')}
- **Contrast-C: polarity**
The optotype can be shown **dark-on-light** or **light-on-dark**.
{Default: dark-on-light}
- **Full screen**
Controls whether FrACT will cover the full screen or stay in window mode. {Default: on}
- **Display transformation**
To manipulate observation distance, mirror arrangements (high-quality front surface, of course) or afocal telescopes can be used. Since these will flip the orientation, transformations can be applied (actually: not the display is transformed, but the response directions). Options are: «normal | mirror horizontally | mirror vertically | rotate by 180°». {Default: normal}
- **Show trial info**
When on, shows current trial number, total number of trials, and the current threshold (acuity: in decimal) in tiny letters at top left.
{Default: on}
- **2x '5' aborts**
To abort any run at any time by pressing the key '5' twice (once would not be enough, could be pressed accidentally losing valuable data). For some situations, users wanted to disable this feature. {Default: on}
- **Crowding inducers**
Options are:
«none | row of optotypes | frame (square) | frame (ring)».
The distance to the flankers is set at 2·gapsize.
{Default: none}
- **Results → clipboard**
To facilitate in-depth analysis, all trial-by-trial results can be copied to the clipboard at the end of a run. Then one can –without quitting FrACT– switch to a concurrently running spreadsheet program and paste in the run details. They comprise date, time, and final acuity. When the “full history” option is chosen, also for each trial the presented orientation, responded orientation and reaction time is provided. See below for a full format specification. The clipboard is the place in the computer where any copy or cut operation places its result, ready to be pasted elsewhere. For correct transfer of data, you need to set the appropriate character for the decimal point beforehand. Copying to the clipboard does not work when FrACT is embedded in a browser window (a security restriction), only stand-alone. Options are: «no | final results only | full trial history». {Default: off, to be less invasive on the host computer system}
- **Visual feedback**
Feedback can be given on the correct position by an enlarging target. Options are: «none | growing optotype». {Default: «none»}

- **Auditory feedback**

It is unclear how feedback might affect the threshold outcome; Lew Harvey (personal communication) opined that feedback can improve criterion stability for inexperienced subjects, but may increase criterion fluctuation for highly experienced observers. Herzog MH & Fahle M (1997) [The role of feedback in learning a vernier discrimination task. *Vision Research* 37:2133–2141] does not sufficiently clarify it either. We recently found that there is more (or faster?) learning with feedback [Heinrich SP, Krüger K, Bach M (2011) The dynamics of learning an optotype acuity task. *Graefe's Arch Clin Exp Ophthalmol* (in press)]. So you have the choice: The subject's response can be acoustically announced through a short tone, options are:

«none | always | on correct | with info». Should be 'none' if your computer has no sound. "With info": two different sounds.

{Default: «on correct»}

- **Auditory feedback when done**

"Success sound" when the last trial has been responded to. Should be off if your computer has no sound. Options are: «off | on».

{Default: «on»}

- **Mask on response**

There was justified criticism that immediate replacement of one optotype by the next one can convey hyperacuity cues. So a 200 ms intervening mask can be chosen. The mask is either the background color or a random pattern.

Options are: «none | 200 ms background | 200 ms random».

{Default: «none», for historical reasons, but 200 ms background is recommended}

- **Threshold definition**

A bracketing threshold strategy (called "psychometric" as one option) will result in a higher threshold than an ascending strategy (as typical for chart testing, and detailed in EN ISO 859). Furthermore, in EN ISO the threshold criterion is "6 of 10" or 60%, whereas the Best PEST assumes 56.25% (for 8 directions). Assuming a typical psychometric slope, both effects lead to a slight underestimation of "psychometric acuity" by the EN ISO strategy, which can be corrected for by multiplying the results of the bracketing strategy by 0.892. {Default: DIN/ISO corrected}

- **Max displayed acuity**

Due to the laws of chance, un-physiologically high results can occasionally obtain ("lucky responders"). Not all users have a deep background in statistics, and they might see this as a defect of FrACT. So an "acuity ceiling" can be applied, from 1.2 to unlimited (conventional acuity charts implicitly also have such ceilings). The clipboard export will always contain the unlimited value. {Default: 2.0}

- **Allow uncertified Sloan letters**

The test variant "Acuity letters" presents Sloan letters rather than Landolt Cs. Since I have not yet formally certified this option, it is disabled by default; use at your own discretion.

The letter C from the Sloan font is identical in shape to a Landolt C, in FrACT it is also identical in size. Sloan letters are scaled exactly like Landolt Cs, and the corresponding acuity can be derived through the letter C (gap height is 1/5th letter height).

- **Allow uncertified Contrast Screening**

This test variant was introduced in April 2011 and needs to be formally certified.

- **Allow experimental Face acuity**

This test was used by [McCulloch DL, Loffler G, Bruce N, Dutton G, Bach M (2011) The effects of visual degradation on face discrimination. *Ophthalmic Physiol Opt* 31:240–248].

- **Acuity formatting**

There exist too many traditions to format visual acuity; still FrACT attempts to cater for them.

Available are «decimal VA | logMAR | Snellen [m] | Snellen [ft]».

“Snellen” is shorthand for the Snellen fraction.

The best measure IMHO would be logVA, which is simply $-\log\text{MAR}$. Like logMAR, logVA has the desirable property of approximately normal distribution, but has an intuitive direction (larger = better). If all formats are deselected, decimal VA is re-selected.

{Default: decimal VA + logMAR}

Snellen denominator 20 ft:

The Snellen fraction only makes real sense, if the true distance is put into the denominator.

However, many are so attached to the “20” scheme, that they use it even with reading acuity. Thus I added this setting on request against my better judgment ;-).

- **Character for decimal point**

Different countries use different number formatting; furthermore different post-processing programs can require different formatting. The setting for the decimal point, a dot or a comma, applies both to the clipboard export and to the large result display after a finished run.

{Default: ‘.’}

Exporting results

There are a number of ways to export the results obtained for further processing. Obviously, they are depicted in large friendly letters on the testing screen in a format that you select in the Setup screen. I strongly believe that experimental results should never be manually typed somewhere, rather automatically transferred in an efficient way. So currently the following three options exist:

- **Export to clipboard after each run**

This is controlled from the Setup screen by way of the “Results → clipboard” setting. For details on the format of the “full history” see below.

[Does not work when FrACT is embedded in a browser for security reasons.]

- **Export to clipboard last 10 runs (persistent history)**

This is a “hidden” export option, designed for having a subject run a series of runs, then exit the program. Later you can start FrACT again and collect the results in one sweep. Format is “full history”, in addition there is a line with the test name and another with an ever-incrementing run count. This “persistent history” (persistent because it survives FrACT start/stop) is retrieved and placed on the clipboard by typing the letter ‘z’ without any obvious indication what has happened. This option is in an experimental phase, feedback welcome. Does not work when FrACT is embedded in a browser window (security).

- **HTTP transmit results**

This option transmits the run results by way of a HTTP GET protocol for immediate transfer to an on-line database (where a CGI script runs). The message consists of a self-descriptive key-value sequence. When enabled, buttons will appear so that after each run the message can be sent with info on eye (OS, OS, OU). There is also a case ID field with a time-out so that results from different patients are not intermingled.

Obviously this requires appropriate infrastructure which should be available from your competent IT persons. The details of target URL etc. are set on the “Transmit Results” screen which is reachable from the Setup Screen.

Format of the “results → clipboard” feature

If enabled in Setup (“Results → clipboard”), the results are copied to the system clipboard after every run, ready to be pasted into any spreadsheet pro-

gram. Be sure you have set the correct character for the decimal point beforehand. The format for the data exported to the clipboard is as follows:

Row 1					
Date [yyyy-mm-dd]		Time [hh:mm:ss]		Final VA result (decimal, not clipped to "max acuity")	
Subsequent rows					
Trial #	Acuity presented (decimal)	orientation angle presented [°]	orientation angle responded [°]	correctness (1=yes, 0=no)	reaction time [ms]

For Sloan letters, the letters rather than the angle are entered. For Vernier acuity, the threshold gap size in minutes of arc is reported in column 2.

Shortcuts

Key	Action
5	start a test as selected in setup
a	start <u>a</u> cuity Landolt C
e	start acuity tumbling <u>E</u>
l	start acuity <u>L</u> etters
c	start <u>C</u> ontrast
m	start <u>C</u> ontrast screening
v	start <u>V</u> ernier
g	start <u>G</u> rating
u	settings (was: <u>setup</u>)
b	<u>a</u> Bout
h	<u>H</u> elp
t	<u>T</u> est calibration
q	<u>Q</u> uit = Exit
z	full history of last 10 runs → clipboard

A note on display resolution and possible acuity values

A severe limitation for all computer tests is set by the properties of the VDU (visual display unit). Typical CRTs (cathode ray tubes) and LCDs (liquid crystal displays) have a “dot pitch” (the distance between the centers of two pixels) of around 0.2 mm. Acknowledging that the smallest Landolt C has 1 pixel gap size, the highest possible acuity (VA_{max}) depends on pixel size s_{min} and distance d as follows:

$$VA_{max} = 1 / (60 \cdot \arctan(s_{min}/d))$$

or, easier and for the small angles related to acuity good enough:

$$VA_{max} = d / (s_{min} \cdot 3438).$$

As an example, assume a VDU with a pixel size of 0.2 mm at a distance of 1.35 m. Thus the smallest possible optotype would correspond to $VA=2.0$ or 40/20 Snellen fraction. Thus this VDU would be perfectly fine at 1.35 m and above, especially for standard testing distances of 4 m (EN ISO) or 20 feet, and even high acuities would be well resolved. However, for near vision (e.g. at 30 cm), the smallest possible optotype would correspond to a VA of $0.3/1.35 = 0.2$ or 20/1000, clearly not sufficient for normal subjects.

Thus standard VDUs are fine to assess acuity at a distance of 2 m and higher.

For closer distances, especially reading acuity, special VDUs are required. Suitable CRTs are not manufactured any more, but the display chips developed for video projectors would have an adequate spatial resolution (in one of our setups we successfully employ an OLED micro-displays from eMagin, which resolves 800×600 dots on a $1.5 \text{ cm} \times 1.0 \text{ cm}$ display and thus easily allows an acuity of 4.0 at 30 cm observation distance, higher than necessary).

At the low acuity range the limit is that one optotype fills the entire screen (this may transcend the definition of acuity). Should you be interested in (ultra) low vision, make sure to note the lowest acuity that can be obtained, to classify such results accordingly thus recognizing possible floor effects.

For Vernier acuity, the same considerations apply, but are more stringent: Since the threshold angle for Vernier resolution is about 10 times smaller than that for standard acuity, one needs to aim for 10 times better angle resolution – higher distance, or smaller pixels.

A note on the response keys (remote response entry)

Especially for vision research experiments it can be advantageous if the subjects control the test themselves by pressing the appropriate buttons; if so, a remote numerical USB-keypad with extension cord is very useful.

See michaelbach.de/fract/ under button **Details**.

Another aspect: some subjects tend to press the keys for a prolonged time, triggering the keyboard auto-repeat, causing inadvertent response errors. So I suggest switching off keyboard repeat using the appropriate facilities of your operating system.

Calibration

Optotype size is measured in terms of visual angle, but rendered by the computer on a pixel raster. The two are easily related through resolution of the screen and observation distance, since VDUs typically have a sufficiently high spatial linearity. In the “Setup” dialog, a blue ruler line appears whose length is measured in mm, and the value entered in a field next to the observation distance in cm. FrACT calculates from these measures the highest obtainable acuity, assuming one pixel as the smallest gap size, and displays this next to the distance input field, thus immediately giving feedback whether the distance is suitable to the range of acuities to be measured. An optional calibration-check screen can draw an equidistant square grid in degree units to check on the aspect ratio –pixels must be square– and geometric screen linearity.

Michael Bach <michael.bach@uni-freiburg.de>,
<<http://michaelbach.de>>

Document History

2012-01-30 added response keys for grating (thanks, Olivier!)

2012-01-20 typo correction (Vernier section), and more stress on needs for VDU resolution (thanks, Ralf!)

2011-11-09 added details to result exporting

2011-10-27 corrected a few typos, stressed that pixel limitations apply to Vernier even more than to acuity

2011-09-28 added clipboard format for Vernier and appendix on contrast definitions

2011-06-30 added info on the contrast staircase, extended display transformation

2011-05-20 clarified contrast screening being disabled by default

2011-05-12 corrected contrast definition transformations

2011-05-03 overhaul for vs 3.7

2010-09-01 corrected Weber contrast (surround luminance in the denominator), vs 3.6.3

2010-07-28 added “show trial info” info (3.6.2) and stylistic improvements

2010-05-07 overhaul for vs 3.6

2010-03-23 added rationale for the type of contrast test

2010-02-12 added info on Sloan letters and Vernier response, various stylistic corrections

2009-12-13 added shortcut info

2009-11-24 modified for vs 3.5.5, reformatted

2009-10-29 modified for vs 3.5.4 (blue ruler line, more calibration hints, Weber contrast)

2009-07-21 modified for vs 3.5.2 (contrast polarity) and stylistic corrections

2009-05-27 added modifications for Vs. 3.5 (mainly Preferences → Setup)

2009-04-21 added modifications of Vs. 3.4.3 (display-timeout, mask, sound)

2008-11-16 added explanation of the warning message at startup

2008-11-12 added advice on deactivating keyboard repeat

2008-09-18 corrected an outdated link from this manual to the site

2008-04-26 began to extend this to a full manual by writing the preamble, some changes because of FrACT3

2007-11-27 corrected and extended the formula for max acuity, added info on decimal point

2007-11-19 added contrast definition and bonus for contrast & hyperacuity

2007-06-21 added information about negative contrast for acuity

2007-06-06 added information on new preferences and micro-displays

2007-05-24 editorial corrections

2006-09-13 added clipboard format

2006-04-19 corrections

2005 begun, former file name “FrACT_Options.rtf”

Contrast values based on contrasting contrast definitions						
Luminance examples (constant surround)		Prof. Michael Bach, Vs 2011-09				
Luminance _{Target}	Lumance _{Surround}	Contrast _{Michelson}	Contrast _{Weber}	logCS _{Weber}	Contrast _{Ratio}	C _{Aulhorn}
99,9 cd/m ²	100,0 cd/m ²	0,050 %	0,1 %	3,00	1,001	
99,010 cd/m ²	100,0 cd/m ²	0,50 %	1,0 %	2,00	1,010	
97,56 cd/m ²	100,0 cd/m ²	1,235 %	2,4 %	1,61	1,025	
95,24 cd/m ²	100,0 cd/m ²	2,44 %	4,8 %	1,32	1,05	
87,72 cd/m ²	100,0 cd/m ²	6,54 %	12,3 %	0,91	1,14	1 : 1,14
80 cd/m ²	100,0 cd/m ²	11,1 %	20,0 %	0,70	1,25	1 : 1,25
68,03 cd/m ²	100,0 cd/m ²	19,0 %	32,0 %	0,50	1,47	1 : 1,47
59,88 cd/m ²	100,0 cd/m ²	25,1 %	40,1 %	0,40	1,67	1 : 1,67
50 cd/m ²	100,0 cd/m ²	33,3 %	50,0 %	0,30	2,0	1 : 2,0
37,0 cd/m ²	100,0 cd/m ²	45,9 %	63,0 %	0,20	2,7	1 : 2,7
20,0 cd/m ²	100,0 cd/m ²	66,7 %	80,0 %	0,10	5,0	1 : 5,0
4,35 cd/m ²	100,0 cd/m ²	91,7 %	95,7 %	0,02	23	1 : 23
1 cd/m ²	100,0 cd/m ²	98,0 %	99,0 %	0,004	100	
0,1 cd/m ²	100,0 cd/m ²	99,8 %	99,9 %	0,0004	1000	

Conversion between contrast definitions

Prof. Michael Bach 2011-09

$$\text{contrast}_{\text{Michelson}} = 100\% \cdot (L_{\text{max}} - L_{\text{min}}) / (L_{\text{max}} + L_{\text{min}})$$

$$\text{contrast}_{\text{Weber}} = 100\% \cdot (L_{\text{max}} - L_{\text{min}}) / L_{\text{max}}$$

$$\text{logCS}_{\text{Weber}} = \log_{10}(1/\text{contrast}_{\text{Weber}}) \quad [\text{CS: contrast sensitivity}]$$

$$\text{contrast}_{\text{Ratio}} = L_{\text{max}} / L_{\text{min}}$$

$$\text{contrast}_{\text{Aulhorn}} = 1:\text{contrast}_{\text{Ratio}}$$

Target def.	Entry definition			
	Michelson	Weber	Ratio	logCS _{Weber}
Michelson	1	$W / (2 - W)$	$(R - 1) / (R + 1)$	$[\log(1/W(M))]^{-1}$
Weber	$2 \cdot M / (1 + M)$	1	$1 - 1 / R$	$1/(10^{\log\text{CSW}})$
Ratio	$(1 + M) / (1 - M)$	$1 / (1 - W)$	1	$[\log(1/W(R))]^{-1}$
logCS _{Weber}	$\log(1/W(M))$	$\log(1/W)$	$\log(1/W(R))$	1