

REAL TIME COGNITIVE RESPONSE RECORDING

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ABSTRACT

This paper describes software that can be used to collect continuous responses to music and other audio and multimedia stimuli using a computer. It supplants EmotionSpace Lab, which collected continuous 2-dimensional emotional responses to music. The new software—Real Time Cognitive Response Recorder or RTCRR ('arty-car')—incorporates some features of EmotionSpace Lab, but also provides numerous customizable settings, such as changing the labels used for the axes (meaning that responses do not have to be restricted to emotions), faster sampling rates, and adjustable display shapes (such as the response space itself). The program then exports the responses to the user's preferred spreadsheet or statistics program for analysis. The software is freely available (empa.arts.unsw.edu.au/em/downloads/rtcr.sitx) and runs on Macintosh OS X computers. RTCRR complements the multiuser continuous response tool pARF (Stevens, et al, 2007) because it allows continuation of data collection after a live performance, without having to set up the hardware required by pARF.

1. INTRODUCTION

Collection of continuous responses to music, speech and multimodal events such as dance and film is becoming more frequent (e.g. [1]) in the research community for two main reasons: (1) The recognition that these stimuli are mostly time-varying as are the psychological responses to them. This means that moment to moment response is an important consideration, and can considerably enhance the quality and subtlety of data collected from 'post-performance' responses alone; (2) Personal computers now offer sufficient speed, memory and processing power to allow the application of (1). As a result several continuous response recorders are becoming available, some of them in software form—requiring no extra hardware or peripherals, and some of these are freely available. This paper describes one such program.

The Real Time Cognitive Response Recorder (RTCRR - or 'arty-car') allows recording of continuous responses as a stimulus unfolds in time (such as a piece of music) along the axis (up to 2 aligned orthogonally) as determined by the 'Experimenter' or user (as distinct from the experimental participant, who will be referred to here as the 'participant'). The program was written in SuperTalk, a Macintosh OS X based authoring language. RTCRR is a standalone application that can be installed without requiring any additional hardware (just a mouse, keyboard and display monitor), software or frameworks.

2. BACKGROUND AND ACKNOWLEDGEMENTS

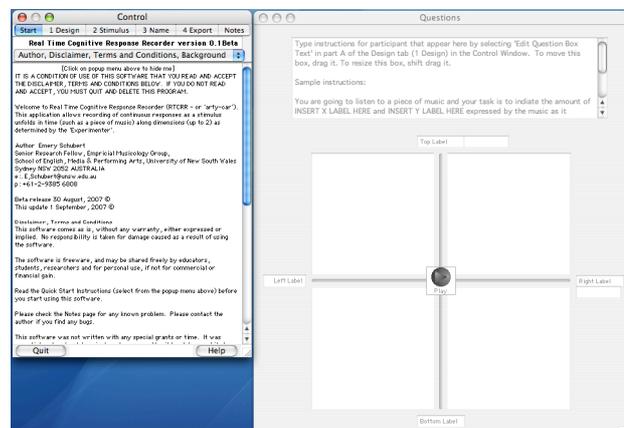
RTCRR was intended as an update of the 2DES EmotionSpace Lab 1.0 (hence 'ESL', [2, 3]), but only worked on the old style (OS 9 and earlier) Macintosh computers of the day. The current version is completely rewritten, taking into account many of the features that people have requested over the years and can now be implemented with improvements in computers and authoring software. This includes the freedom to choose the labels for the dimensions required (ESL was set to display valence as the x-axis, and arousal as the y-axis), the possibility of a sampling rate faster than 1Hz (the only sampling rate available in ESL), and various other features. RTCRR also acts as a support program for the pARF (portable Audience Response Facility [4]).

The software has taken several years to upgrade and I continue to acknowledge all the people involved in the first version of ESL, and the people who have made many helpful suggestions for the current version, in particular Gunter Kreuzt, and to the people who helped get me started and made contributions to this revision, including Alex Tarnopolsky, Geoff Stoddart, Clara Theo, Nikki Rickard, Kate Stevens, Brian Lucas and Andrea Halpern. It has been financially supported through an ARC Discovery Project DP0452290.

3. PROGRAM OPERATION

RTCRR has two main windows: The 'Control' Window and the 'Questions' Window (the one where continuous responses are collected from the participant, see Fig. 1).

Fig. 1 Control (left) and Questions (right) Windows of RTCRR. Control Window is showing the Start tab.

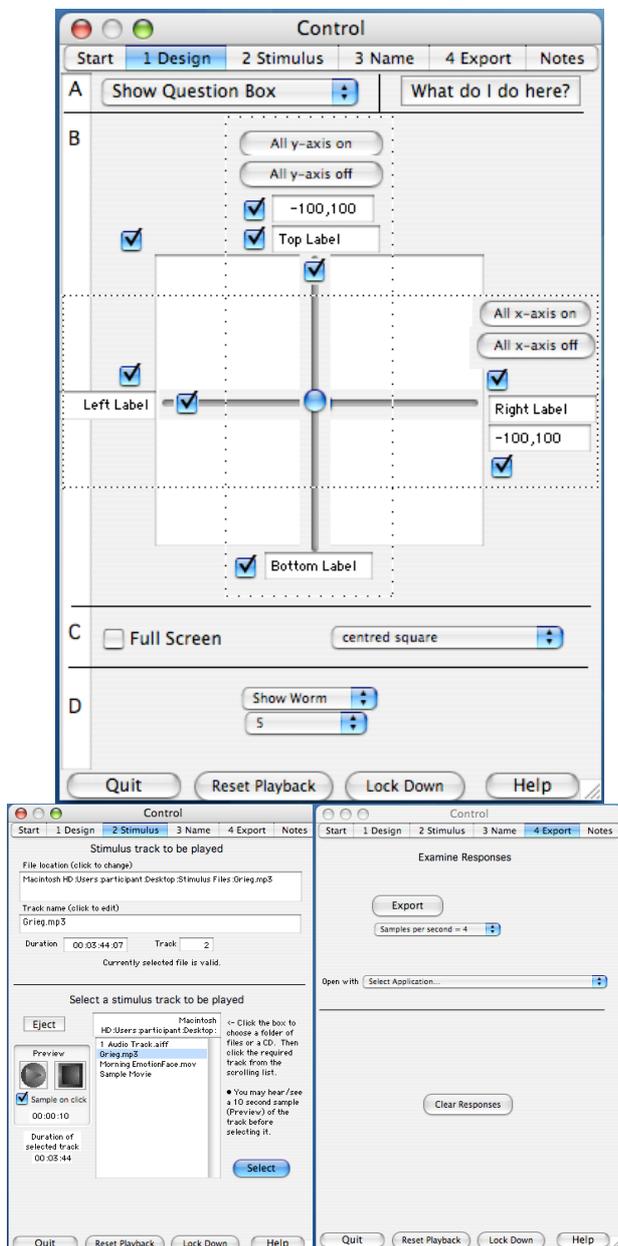


To keep the screen uncluttered, and contrary to Macintosh GUI guidelines [5], the program has no menu bar displayed at the top

of the screen. This means that the participant will have fewer distractions and temptations to explore when in the midst of a continuous response task. As a result, some important commands are activated by keystrokes, although the Control Window has several menus and buttons that provide point-and-click interactions to produce the equivalent commands. The keystroke commands are listed in the right-most 'Notes' tab of the Control Window. If closed, for example, the Control Window can be re-opened by pressing Apple-K (which toggles the window).

RTCRR is designed so that, as an experimenter, one can prepare an experiment to collect continuous data on an audio or multimedia file following the steps shown in the tabs. First (step 1, or '1 Design'), the experimenter will design the layout of the continuous response space, where she/he decides what dimensions are required, how they will be labelled, and what instructions they want to present to the participant(s) (Fig. 2, top pane).

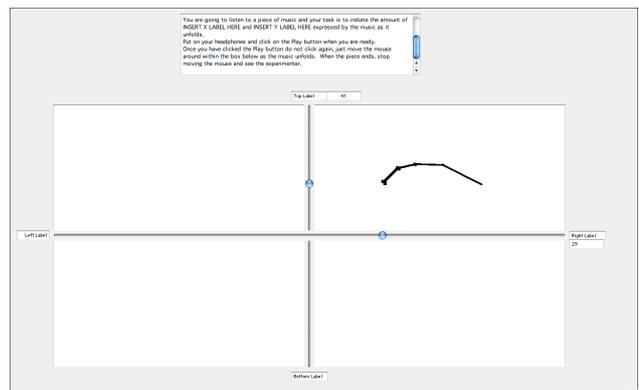
Fig. 2 Top: Design Tab of RTCRR's Control Window; Bottom Left: Stimulus Tab; Right: Export Tab.



Then (step 2 '2 Stimulus' tab, see Fig. 2, bottom left pane) the experimenter will select the multimedia file that the participant is to listen to (1 file per RTCRR copy strongly recommended, as discussed below). If using external media, such as an Audio CD, the experimenter should turn off any auto-start options so that the RTCRR application stays at the front of the screen.

In step 3, information about the participant can be entered (the experimenter can decide what—e.g., a name, a code, background information—some unique identifier is recommended). At that point the experimenter is ready to begin the experiment. This is done simply by clicking the Play button (usually) in the middle of the Questions Window (see Fig. 1 or Fig. 3). The position of this play button, as with other objects, can be adjusted by dragging it within the Questions Window. The instructions for the participant's task can be edited in part A (the top) of the Design tab. The participant can read these instructions then click the Play button in the Questions Window. The program will remain in this state until continuous recording stops (i.e. at the end of the track). After clicking Play the previously (step 2) selected sound file launches, and RTCRR starts recording the mouse movements as the stimulus file unfolds in time. An optional worm traces the mouse position around the response space (Fig. 3). It can be set to be from 1 to 10 segments long (set to 5 in Fig. 2, top pane, part D). When the piece has finished, RTCRR saves the responses in its internal format at the highest possible sampling rate. It is possible to hide the Control Window, stop objects from being moveable and block off other parts of the computer during recording by clicking the 'lock down' button in the Control Window (Fig. 2).

Fig. 3. The Questions Window showing the worm during continuous recording with 'Full screen' option selected in part C of the Design tab of the Control Window (Fig. 2, top pane), and Lock Down mode (hiding Control Window). Notice that the Play button is hidden during recording.



In the final step (step 4 '4 Export' tab) the experimenter exports the responses into a spreadsheet compatible format for analysis of the one or more participant responses to the track. RTCRR allows the experimenter to customise the application that will open the data, for example Microsoft Excel, or SPSS (about to be selected in Fig. 2, bottom, right pane.).

To record continuous responses for other stimuli, the experimenter should copy the RTCRR program, launch it, repeat the procedure above, but using the new file, and use it to collect responses for that piece. The reason for using one RTCRR per piece is so that the exported response file contains

aligned columns of responses. The same copy of RTCRR will still record responses if the stimulus file is changed, but the response file will be more difficult to interpret and analyse. RTCRR may be copied as often as required. It is a free program and may be used freely among students, researchers and for personal use, provided it is not used for commercial or financial gain.

The bulk of the instructions in how to operate RTCRR is found in the context sensitive Help Window, which can be toggled on, to the front and hidden by pressing Apple-H repeatedly (A Help button is provided in the Control Window, too—Fig. 2). When the Help Window appears, the experimenter receives information about the button that is about to be pressed. When the Help Window appears it should be positioned so that it is not obscured by other windows, and that it does not obscure other windows. Then the experimenter can go back to the window they are working in (either the Control or Questions Window) and instantly see the help information about any of the objects on that window.

RTCRR works best if each copy is contained in its own folder. Having the copies of RTCRR in separate folders is necessary to prevent saved responses from being merged into one, large and potentially confusing file.

RTCRR saves its data to a file called ResponseFile in the same folder in which RTCRR resides. It is not advisable to tamper with this file. It allows RTCRR to be portable with the data set the experimenter is working on. So, to move RTCRR to another computer, for example, but to continue adding to the currently collected data set, the ResponseFile should be included as well. To delete the Responses, either delete the ResponseFile itself or clear the data (an option available in the Export tab only—Fig. 2 bottom, right pane). To examine the collected data, use the Export button in the Export tab. This feature allows exporting of data at various sampling rates. RTCRR stores responses at the highest possible sampling rate (up to 30Hz). Since not all computers can reach this maximum sampling rate, and because the experimenter may wish to down-sample the data (to reduce the amount of redundancy—for example—a sampling rate of 2Hz is considered sufficient in the collection of emotional response data – [6]) the Export command has a user settable sampling rate, ranging from 1Hz (for compatibility with EmotionSpace Lab, and for down sampling) through to 30Hz (the highest theoretically possible for RTCRR).

4. Specifications

The following lists the specifications and results of testing of RTCRR for the Beta version which was limited-released on September 1, 2007.

System 'Requirements'/Recommendations

- Processor Speed/Operating System: Tested on MacBook, G4 Macintosh, G5 Dual Processor, on OS10.3 and higher. Tested on non-Intel machines, though no reason why it wouldn't work on Intel based machines.
- 2GB RAM recommended, but not essential.
- 10MB free space recommended.

- Memory and disc space requirements vary with file size, size of windows and response file export sampling rate.

Other Hardware Requirements

Only a mouse, display, processor and keyboard are required. No other peripheral devices are required. This version supports 'cognitive', self-report responses (including self-report emotional responses and assessments). Physiological responses are not synchronised by or integral with the current version of RTCRR.

Continuous Response Interface

- One (vertical or horizontal) or two (vertical and horizontal) response-space axes available.
- Each axis has two labels associated with them (one for upper end of the scale and another for the lower end of the scale), and a label to indicate the current slider value in real time—the range of this scale can be set by the experimenter.
- Values for range of each dimension fully customisable, true resolution limited by pixel size. So for finer resolution use a larger response-space box (which requires more memory) and a wider response scale range.

Stimulus File Format (Audio and Multimedia)

Any audio or multimedia file supported by QuickTime™ is supported by RTCRR, which includes most audio and multimedia file formats, including standard aif, wav, mp3, quicktime movies, tracks on audio CD and so forth. Movie images, if required, are displayed in the top left corner of the Window. It is important to test this so that the images do not interfere with the other object (especially the response-space).

Response File Format

The exported file collects all responses since the last 'Clear' operation (Fig. 2 bottom-right pane) and presents them in a format that can be opened by a spreadsheet or statistics program. The exported file can be opened by a program selected by the experimenter. The data displays individual responses in blocks of (usually) three columns (Fig. 4). The first column is the time elapsed in milliseconds. The second column is the x-axis cursor position (in units defined by the range of the axis in the Design tab). The third column is the y-axis cursor position (also in units defined by the range of the axis). Subsequent blocks of three columns are responses from additional participants.

RTCRR stores response data in an internal format in a file called 'ResponseFile'. The file is written to by RTCRR whenever a continuous response recording is completed. The file on itself is of little use to the experimenter because of the esoteric formatting, but is essential for portability and exporting of data into a readable format. To run experiments on another computer using the same audio with the intention of adding more participant responses, the file named 'ResponseFile' needs to be copied, as well, and it needs to be located in the same folder as the one containing RTCRR.

User Help

Instructions for operation of the RTCRR are presented in two forms – the 'Quick Start' guide available in the first tab of the

Control Window, an the context sensitive Help Window (which can be toggled on or off by the Apple-H keystroke) and hovering the cursor over the various objects and elements of the Control Window and the Questions Window.

Fig. 4. Sample Exported Continuous Response for Three Participants.

Time (ms)	Bix	Enter	partici	yEnter	partici	Time (ms)	Bix	Enter	partici	yEnter	partici	Time (ms)	Bix	Enter	partici	yEnter	partici
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	250	10	-14	250	-3	-4	250	2	2	2	2	2	2	2	2	2	2
4	500	12	-11	500	-5	-9	500	5	3	3	3	5	5	5	5	5	5
5	750	26	23	750	-8	-15	750	20	16	16	16	7	7	7	7	7	7
6	1000	6	28	1000	-16	-47	1000	20	16	16	16	10	10	10	10	10	10
7	1250	6	28	1250	-16	-47	1250	22	18	18	18	12	12	12	12	12	12
8	1500	3	25	1500	-24	-64	1500	30	26	26	26	15	15	15	15	15	15
9	1750	-2	-2	1750	-47	-64	1750	35	34	34	34	17	17	17	17	17	17
10	2000	-2	-27	2000	-52	-57	2000	39	43	43	43	18	18	18	18	18	18
11	2250	-2	-27	2250	-54	-50	2250	39	43	43	43	19	19	19	19	19	19
12	2500	19	-49	2500	-54	-50	2500	48	44	44	44	20	20	20	20	20	20
13	2750	38	-16	2750	-54	-46	2750	49	49	49	49	21	21	21	21	21	21
14	3000	37	-7	3000	-54	-45	3000	49	43	43	43	22	22	22	22	22	22
15	3250	37	-7	3250	-54	-45	3250	52	42	42	42	23	23	23	23	23	23
16	3500	44	44	3500	-54	-45	3500	55	35	35	35	24	24	24	24	24	24
17	3750	-37	38	3750	-54	-45	3750	62	29	29	29	25	25	25	25	25	25
18	4000	-42	-17	4000	-54	-45	4000	67	40	40	40	26	26	26	26	26	26
19	4250	-42	-17	4250	-54	-45	4250	67	40	40	40	27	27	27	27	27	27
20	4500	-37	-26	4500	-43	-41	4500	52	55	55	55	28	28	28	28	28	28
21	4750	5	-37	4750	-28	-39	4750	41	55	55	55	29	29	29	29	29	29
22	5000	23	-17	5000	-10	-31	5000	34	52	52	52	30	30	30	30	30	30
23	5250	23	-17	5250	-10	-31	5250	34	52	52	52	31	31	31	31	31	31
24	5500	22	-8	5500	11	-21	5500	29	41	41	41	32	32	32	32	32	32
25	5750	18	9	5750	16	-19	5750	27	38	38	38	33	33	33	33	33	33
26	6000	-23	37	6000	62	-18	6000	27	38	38	38	34	34	34	34	34	34
27	6250	-23	37	6250	71	-13	6250	27	38	38	38	35	35	35	35	35	35
28	6500	-29	36	6500	71	-13	6500	27	38	38	38	36	36	36	36	36	36
29	6750	-48	36	6750	78	-14	6750	27	38	38	38	37	37	37	37	37	37
30	7000	-52	20	7000	78	-15	7000	27	38	38	38	38	38	38	38	38	38
31	7250	-52	20	7250	78	-15	7250	27	38	38	38	39	39	39	39	39	39
32	7500	-32	-2	7500	78	-15	7500	27	38	38	38	40	40	40	40	40	40
33	7750	20	21	7750	78	-15	7750	27	38	38	38	41	41	41	41	41	41
34	8000	25	23	8000	78	-15	8000	27	38	38	38	42	42	42	42	42	42
35	8250	62	76	8250	78	-15	8250	27	38	38	38	43	43	43	43	43	43
36	8500	62	76	8500	25	-27	8500	20	32	32	32	44	44	44	44	44	44
37	8750	58	33	8750	-35	-18	8750	7	28	28	28	45	45	45	45	45	45
38	9000	42	21	9000	-35	-18	9000	-5	31	31	31	46	46	46	46	46	46
39	9250	42	10	9250	-36	-13	9250	-5	31	31	31	47	47	47	47	47	47
40	9500	14	-31	9500	-56	22	9500	-12	46	46	46	48	48	48	48	48	48
41	9750	14	-31	9750	-53	47	9750	-18	46	46	46	49	49	49	49	49	49
42	10000	-12	-26	10000	-42	75	10000	-49	10	10	10	50	50	50	50	50	50
43	10250	-19	9	10250	-42	75	10250	-50	10	10	10	51	51	51	51	51	51
44	10500	-20	16	10500	-33	79	10500	-50	10	10	10	52	52	52	52	52	52
45	10750	-20	16	10750	-32	80	10750	-50	9	9	9	53	53	53	53	53	53
46	11000	-21	41	11000	-26	81	11000	-47	-17	-17	-17	54	54	54	54	54	54

For dual processor G5 a minimum sampling rate of 10Hz could be obtained, possibly 15Hz. The above data are a rough guide only. Users are encouraged to experiment to determine highest sampling rate by recording fast mouse movements to a short stimulus file, exporting at the highest sampling rate (30Hz) then examining the smallest amount of time in the file at which a sampled value changed. Inverting this time period corresponds to the approximate maximum sampling rate RTCRR can handle with the given feedback options and computer processor.

The worm is the most useful feedback tool for two dimensions, but most costly. Smaller number of segments will reduce this cost slightly. With one axis displayed, the worm is not necessary for providing feedback, because the slider does this anyway.

5. CONCLUDING COMMENTS

Future version of the program will include more features considered useful for the research community. A similar program that is also free and available for other platforms is EMuJoy (Nagel, 2007).

RTCRR is freeware, and may be shared freely by educators, students, researchers and for personal use, but not for commercial or financial gain. At the time of printing, a Beta version was available from the UNSW Empirical Musicology web site empa.arts.unsw.edu.au/em (under Facilities/Software) or directly from empa.arts.unsw.edu.au/em/downloads/rtcr.dat. The program is being launched to coincide with the inaugural International Conference on Music Communication Science, December 5-7, 2007, where this paper is being presented.

6. REFERENCES

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Recording and Synchronising

During continuous response recording, time stamps are based on time code received from Quicktime in frames per second for the file being played. During continuous response recording, responses are recorded at the highest rate possible, and can then be down-sampled as required, via the Export tab (Fig. 2 bottom, right pane).

Sampling Rate and Feedback Options Tests

During continuous response, feedback can be in the form of the current position label, moving sliders (for each dimension) and a worm, whose length (memory) can be adjusted from 1 to 10 segments (each segment representing up to the last 10 mouse positions recorded – see Fig. 3 for an example). Each of these options can be customised via the Design tab. The more of these options selected, the more work RTCRR has to do, and, in addition to computer processor limitations, the more it may impinge on maximum sampling rate.

For less powerful machines than a Macintosh G5 dual processor

- With worm on, 2Hz sampling rate can be reasonably expected.
- With all options off (though the participant gets very little feedback) about 7Hz can be expected. All options off is not recommended.
- With all options on but worm off, about 4Hz can be reasonably expected.