The 3RT Test: Three reaction time tasks
for IBM PC computers

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The 3RT Test consists of a simple, a choice, and a conditional reaction time (RT) task. The three tasks involve comparable visual stimuli and require identical manual responses, but they differ in the complexity of cognitive processing required. The nonverbal stimuli convey commonly known meanings. Responses can be made either on the keyboard or on response keys connected to the computer's serial port. The computer's internal timer/counter is used for millisecond timing. The test administration program allows flexible setting of the test conditions. The data analysis program provides summary data not only for each RT task as a whole, but also for separate trial types within each task. Summary statistics include measures of variation and central value that are not affected by extreme scores. In addition to laboratory studies with normal adults, the 3RT Test is suitable for life-span developmental studies, cross-cultural comparisons, and other uses in various clinical settings.

Traditional ability tests usually score the number of increasingly difficult items passed by the subjects. In contrast, reaction time (RT) tests measure the speed of performance on relatively simple and easy tasks. Compared with the former, RT tests have several advantages that make them particularly suitable for testing neurological patients and for life-span developmental studies: (1) RT tests are less influenced by subjects' education and experience, so they provide purer indices of the subjects' current cognitive processing efficiency. (2) The RT score is a continuous measure and does not have arbitrary lower or upper limits, so it is sensitive to small differences over a wide range of performance. (3) Subjects are less exposed to failure when taking RT tests. (4) No parallel forms are needed for the repeated assessment of individual subjects.

On the other hand, RT tests also have some limitations: (1) Most RTs include both a central component of cognitive processes and a peripheral component of sensory and motor processes. The relative contributions of the two components are often difficult to assess with a single RT task. Yet it is often desirable to separate the two, especially when a subject has significant motor impairments such as those resulting from stroke or Parkinson's dis-

ease. (2) Typically, subjects need to learn and memorize some arbitrary stimulus–response associations before RT measures can be recorded. However, even simple associations can be difficult for cognitively diminished subjects, and the amount of practice that is needed before reaching a steady state can vary considerably among individuals. (3) Some investigators set RT windows to discard extremely fast anticipatory responses and extremely slow responses, which may be caused by external distractions, but good decisions on such limits can be made only after extensive pilot studies. Response windows are particularly difficult to set when large individual differences among subjects are expected, as in studies of aging and dementia. (4) Typically, the distribution of an individual's RTs over repeated trials of the same type are positively skewed. Since the commonly used index of variation, the standard deviation, is very sensitive to large extreme scores, its reliability can be quite low for RT measures. This may be one reason why many investigators pay attention only to the mean or median of each individual's RTs and ignore their variation, even though the latter may be as or more sensitive a measure of individual differences (Brewer & Smith, 1984; Jensen, 1979).

A set of three RT tasks, the 3RT Test, has been designed to minimize the aforementioned limitations. The 3RT Test consists of a simple RT task, a choice RT task, and a conditional RT task. The three tasks involve comparable visual signals and require identical manual responses, but different amounts of cognitive processing. The meanings of the nonverbal stimulus figures are almost universally known; therefore, the subjects do not need to learn and memorize new stimulus–response associations. The summary statistics of each individual's RTs include measures of both the central value and the variation that are not affected by occasional anticipatory or distracted responses. Consequently, the 3RT Test enables some separation be-

tween cognitive and sensorimotor processes; it is appropriate for subjects with either normal or diminished cognitive abilities; it is suitable for cross-cultural studies; it requires neither pretraining nor the setting of RT windows; and it provides summary statistics that are not affected by extreme scores.

THE 3RT TEST

An overview of the three (simple, choice, and conditional) tasks of the 3RT Test is presented in Figure 1. Two stimulus figures, the left- and the right-pointing arrowheads, are used in the simple and the choice RT tasks. These two figures and the trials in which they are shown will be designated, respectively, as *left* and *right*. The other four stimulus figures—the left and the right arrows each paired with either an = (*equal*) sign or an X ("wrong") sign—are used in the conditional RT task. These four figures and the trials in which they are shown will be designated, respectively, as $L(=)$, $L(X)$, $R(=)$, and $R(X)$, where L and R indicate *left* and *right*, and = and X indicate *same* and *opposite*.

Each stimulus figure measures approximately 3×3 cm. For each trial, a single stimulus figure appears at the center of the monitor screen, and the subject presses one of two keys in response. A correct response terminates the stimulus and starts a variable intertrial interval (ITI), during which the screen is blank. An incorrect response does not affect the visual display, which provides a cue for the subject to make the alternative response. The response of a trial is considered wrong if the subject has first responded with the incorrect hand.

RT TASK	STIMULUS	RESPONSE
SIMPLE	– LEFT	LEFT
	– RIGHT	RIGHT
CHOICE		LEFT
		RIGHT
CONDITIONAL	= X	LEFT
	X	RIGHT

Figure 1. The stimulus figures and the corresponding responses of the 3RT Test.

The Simple RT Task

The simple RT task consists of two segments. The simple–left segment has 16 left trials. The simple–right segment has 16 right trials. Before the start of each segment, the subject is told which stimulus figure will be shown and is asked to use the left index finger to press the Z key on the keyboard for the left trials, or to use the right index finger to press the ?/ key for the right trials. If a Microsoft-compatible mouse is attached to the computer, the subject is asked to press the keys on the mouse instead.

The Choice RT Task

The choice RT task consists of 16 left and 16 right trials presented in pseudorandom order, with four left and four right trials in each block of eight trials. The subject is told that the direction of the arrow will be unpredictable and is asked to respond with the hand indicated by the arrow.

The Conditional RT Task

The conditional RT task consists of eight each of the $L(=)$, $L(X)$, $R(=)$, and $R(X)$ trials presented in pseudorandom order, with two trials of each kind included in each block of eight trials. The subject is told to respond with the same hand indicated by the arrow when it is paired with the = sign, and to respond with the opposite hand when the arrow is paired with the X sign. This task is called *conditional* because the response is conditional upon the = or the X sign.

THE TEST ADMINISTRATION PROGRAM

The test administration program starts with a series of prompts on the monitor screen for the investigator to enter the subject's ID, gender, age, and years of education, plus the date and starting time of the test session, as well as the session number for the particular subject.

Next the investigator is asked to set the minimal and maximal values of the ITIs within the range of 0.1–9.9 sec. The ITIs are randomly generated in a rectangular distribution within the chosen limits.

Next a screen is shown for the selection of the following test conditions: (1) The highest level of the RT task to be administered. The three RT tasks are always presented in the order of simple, choice, and conditional, but the investigator can choose to administer only the first one or two instead of all three tasks. (2) The stimulus figures to be used. As an alternative to the arrowhead figures already described and shown in Figure 1, arrows with stems that look like the outline of one-way traffic signs can be used. (In this case, the left arrow will appear on the left half of the screen, the right arrow on the right half, and the = or the X sign will appear at the center). If only the simple RT task is to be administered, a nondirectional + sign, with each bar measuring 2.5×0.5 cm, can also be selected as the stimulus figure. (3) Whether the simple RT task will start with the left or the right segment.

After the setting of the test conditions, the RT tasks are presented in sequence. Each task begins with an instruction screen that shows the stimulus figure(s) and the expected response(s). A press of the space bar terminates the instruction screen and starts an ITI before the first trial.

During a run of trials, the investigator can interrupt the program by pressing the Q key. After interruption, three options are offered: (1) To resume testing (e.g., after the subject has stopped coughing). (2) To cancel the current RT task (e.g., when a subject has made many errors on the conditional RT task). If the investigator has programmed to administer all three RT tasks but later decides to cancel the task at the choice RT level, the conditional RT task will also be canceled automatically. (3) To cancel the whole session (e.g., when conditions are discovered that would make all RT measures during the current session invalid).

At the end of the presentation of the RT task(s), the investigator can choose whether or not to repeat the administered (and not canceled) task(s) once more. The left–right order of the simple RT task is automatically reversed in the repeat presentation. In data analysis, performance during the first presentation of the RT tasks is designated the *first half*, and that during the second presentation the *second half*.

Finally, the investigator is asked to enter the end time for the test session, whether or not to save the data, and, if so, to which drive. The data file for each session is identified by the subject's ID and session number.

THE DATA ANALYSIS PROGRAM

The data analysis program summarizes the data from each test session and directs the printing of a summary record. The record starts with the subject's characteristics (ID, gender, age, years of education) and test conditions (session number, date of testing, starting time and duration of test session, range of the ITIs, whether the simple RT task began with the left or right segment, and type of visual signals used).

For each RT task, data are summarized (1) separately for the left and right trials, (2) separately for the first and second halves of the trials, and (3) for all trials combined. For the conditional RT task, summaries are also provided for responses to each of the four stimulus figures and separately for the *same* and the *opposite* trials. The summary data include the respective number of correct and incorrect responses, plus the mean, standard deviation, first quartile (Q1), third quartile (Q3), median, and quartile deviation (Q) of the RTs of the correct responses. The

Table 1
A Sample Summary Record of the 3RT Test

XYZ F 52 y/o 20 yrs
Sesno. 5 5-31-90 12:08 PM 6 min.   ITI 0.5 - 1.5 sec. LF >

Simple RT (ms)

	Correct/Wrong		Mean	Sigma	Q1	Q3	Median	Q
Left	32/	0	219	46	185	226	211	21
Right	32/	0	229	61	194	237	211	22
1st Half	32/	0	225	48	195	262	214	34
2nd Half	32/	0	223	60	191	214	206	12
Total	64/	0	224	54	192	233	211	21

Choice RT (ms)

	Correct/Wrong		Mean	Sigma	Q1	Q3	Median	Q
Left	32/	0	361	72	327	366	344	20
Right	32/	0	528	1173	278	328	306	25
1st Half	32/	0	357	122	289	352	327	32
2nd Half	32/	0	532	1168	305	343	328	19
Total	64/	0	444	828	299	352	328	27

Conditional RT (ms)

	Correct/Wrong		Mean	Sigma	Q1	Q3	Median	Q
L(S)	16/	0	536	94	475	594	532	60
L(O)	14/	2	543	144	435	584	534	75
R(S)	15/	1	528	216	428	524	480	48
R(O)	15/	1	526	117	452	527	479	38
Left	30/	2	539	118	475	594	532	60
Right	30/	2	527	170	434	528	480	47
Same	31/	1	532	162	431	540	508	55
Oppos	29/	3	535	128	435	584	502	75
1st Half	29/	3	540	174	431	584	513	77
2nd Half	31/	1	527	114	471	537	507	33
Total	60/	4	533	145	435	574	508	70

quartile deviation is one half of the distance between the first and the third quartile (McNemar, 1969, p. 19).

A sample summary record is shown in Table 1. In addition to the summarized data, the data analysis program will also list the RTs of individual trials if this is requested.

PRELIMINARY FINDINGS

The 3RT Test was first programmed for the Apple II computers, at which time it displayed outlined instead of filled arrowheads as the directional signals. Under the old system, with ITIs of 0.5-1.5 sec, the 3RT Test has been administered to over 200 normals whose ages ranged from 7 to 92 years. Although some children under age 10 and some older adults did not perform better than .80 correct on the conditional RT task, all subjects did so on the choice RT task. Only performance on the conditional RT task showed moderate associations (Pearson's rs around .40) with education. The correlations between education and performance on the simple or the choice RT task were low (Pearson's rs below .20) and statistically nonsignificant at the .05 level.

The simple RT task has been included in a battery of neuropsychological tests and administered to 118 dementia patients and 86 community controls. The quartile deviation of the RTs, followed by the median, differentiated dementia patients from community controls better than did all the other tests, including memory tests and conventional screening tests for dementia (Teng, Chui, & Saperia, 1990).

SYSTEM REQUIREMENTS

The 3RT Test is written in Turbo Pascal 5.5 for the IBM PC family of computers, including compatible laptop models. It requires a 286 CPU; an EGA, VGA, or Hercules graphics card; and at least 500×230 pixels resolution. Millisecond timing is achieved by incorporating a program that makes use of the computer's internal timer/counter (Crosbie, 1989).

PROGRAM AVAILABILITY

A 5.25-in. diskette containing the following files is available for distribution from the author: (1) two source files, one for test administration and one for data analysis; (2) executable programs; (3) a manual for using the programs in ASCII format. Requests should be accompanied by a return-address label and a cashier's check or money order for $15 U.S., payable to L.A.R.E.I. (Los Amigos Research and Education Institute) to cover materials, mailing, and administrative costs.

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