Virtual Reality Lateralized Attention Test
VRLAT

Examiner's Manual

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I. Introduction to the VRLAT

A. Brief Overview of Spatial Neglect

Hemispatial neglect is a disabling disorder of arousal, perception, and action that occurs in approximately 40-50% of right hemisphere stroke patients (Bowen *et al.*, 1999; Buxbaum *et al.*, 2004) and a smaller proportion of patients with left hemisphere stroke. Patients with neglect are impaired in the detection of objects, individuals, and events on the contralesional (in this case, left) side of space. Among patients who have suffered a right cerebrovascular accident (RCVA), left-sided perceptual deficits predict particularly poor rehabilitation outcomes (Cherney & Halper, 2001). Left neglect is also a significant obstacle to independence in activities of daily living (ADL), and results in longer hospitalizations (Katz *et al.*, 1999; Paolucci *et al.*, 2001). A number of rehabilitation approaches, including rightward-displacing wedge prisms (e.g., (Farne *et al.*, 2002; Rode *et al.*, 2006; Serino *et al.*, 2007) and non-invasive electrical brain stimulation (TMS and tDCS; e.g., Brighina *et al.*, 2003; Sparing *et al.*, 2009) show promise in reducing the effects of neglect. Detection of the disorder, even when subtle, is therefore of clear clinical relevance.

Neglect is frequently diagnosed on the basis of pencil-and-paper tasks requiring the cancellation or bisection of lines or other stimuli (e.g., Rivermead Behavioral Inattention Test (Wilson *et al.*, 1987)). These tasks, however, may not be sufficiently sensitive to detect subtle deficits. For example, in a large-scale study of RCVA conducted in our laboratory (Buxbaum et al., 2004) occupational and physical therapists were asked to diagnose neglect based on patients' performance during clinical therapy. For 13 of 49 patients, neglect was detected by therapists but not by typical paper-and-pencil neglect tests, whereas only 2 patients were classified as exhibiting neglect based on paper-and-pencil tests but not identified by therapists.

One reason for this disparity is that performance in the real world places relatively strong demands on attention and arousal, which in turn exacerbates spatial biases (Robertson & Frasca, 1992). Indeed, neglect is associated with poor navigation in the real-world environment (Punt *et al.*, 2011; Turton *et al.*, 2009). This suggests that neglect may be more accurately assessed using tasks with a strong attentional component, such as real-world obstacle courses (Webster *et al.*, 1994; Webster *et al.*, 1995). Unfortunately, however, such tasks are time-consuming to construct, and require large clinical settings; they are therefore rarely performed. To the degree that the relevant attentional demands can be simulated, these difficulties may be circumvented by the use of virtual environments (Rizzo et al., 2004).

In response to the need for an easily administered, sensitive, and valid measure of neglect, we developed the Virtual Reality Lateralized Attention Test (VRLAT) (Buxbaum et al., 2008; 2012; Dawson et al., 2008).

B. Description of the VRLAT

The VRLAT (Buxbaum et al, 2012; Dawson et al., 2008; see also Buxbaum et al., 2008 for a similar precursor) requires Participants to travel along a virtual, non-branching path, either propelling themselves using a computer joystick (Participant-Driven Mode) or passively viewing the environment while an Examiner navigates the path at a constant rate (Examiner-Driven Mode). Participants are asked to identify virtual objects on either side of the path and to avoid colliding with the objects. The software signals collisions with virtual objects with auditory feedback corresponding to obstructed progress.

The VRLAT includes three Levels (Simple, Complex, and Enhanced), each with 20 target objects (10 on each side of the path) consisting of colored trees and statues of common animals (e.g., red tree, dog statue). The Simple array only contains these 20 target objects, while the Complex array contains an additional 20 common outdoor objects (e.g., bushes, fountains, benches) that serve as distractors. The Enhanced array contains all 40 of the target and distractor objects of the Complex array, with the addition of 8 auditory distractors (e.g. sounds of ambulance alarm, a dog barking) and 8 small visual moving distractors (e.g., skateboard rolling across path, paper airplane flying across path). The left to right (versus right to left) direction of movement of visual distractors is balanced. Participants are simply asked to name all of the trees and statues that they see with as precise a name as possible (e.g., "blue tree", "turtle"). Each array is administered once in the forward direction, and once in the reversed direction so that the same items appear once on the left and once on the right side.
Responses are scored "on line" at the time of administration by the Examiner (see Section VII).

Figure 1 shows a screenshot from the Enhanced Level of the VRLAT. Note that the virtual path was designed to twist and wind across the computer monitor, so that an object on the left of the path might appear in the virtual "distance" on the left and/or right side of the screen. Thus, any calculated disparities between left and right naming scores are most clearly attributable to path-relative locations.

Figure 1. Screenshot from the Enhanced Level of the VRLAT

C. Uses of the VRLAT

The VLAT has psychometric characteristics that enable it to serve several purposes:

1. Identification of left spatial neglect: The VRLAT is highly sensitive in detecting clinically-relevant left spatial neglect. Although normative data are not provided for the assessment of right spatial neglect (e.g., in left hemisphere stroke), in principle the VRLAT can also be used for this purpose.
2. Assessment of proneness to visual and auditory distraction: the VRLAT can be used to assess whether spatial neglect worsens under distracting conditions or with a secondary task demand.
3. Assessment of treatment response: The VRLAT can be administered to obtain an initial baseline measure of performance, then repeated again after a course of therapy to evaluate change.
4. Assessment of navigation safety: The VRLAT can be used to assess the likelihood that the Participant will be able to navigate safely in the environment.
5. Assessment of natural recovery: In Participants who are not receiving rehabilitation therapy, the VRLAT can be used to monitor naturally occurring improvement or worsening.
6. As a research tool: A number of open questions are of interest for additional investigation, such as (for example) whether the VRLAT is more highly associated with extrapersonal as compared to peripersonal or personal neglect; the relationship of responses to targets on the left of the screen vs. left of the virtual path; the relationship of VRLAT scores to lesion loci; validation of a shortened version of the VRLAT composed only of the Enhanced Condition; and assessment of the VRLAT's predictive validity (the degree to which it predicts future independence and performance of activities of daily living).

D. Selection of Levels and Modes of Administration

Administration of all 3 Levels of the VRLAT may be useful when the Examiner is interested in assessing the effect of complexity and distraction on spatial attention. The Simple Level can be used to serve as a baseline measure of performance without distraction or attentional selection demands. The Complex Level places additional demands on attending to target items (trees and statues) in the presence of other items. The Enhanced Level includes these demands, as well as additional requirements to ignore moving and noisy distractors, and is the most difficult.

Administration of only the Enhanced Level may be useful when a very limited assessment time is available (see **Section IX).**

The VRLAT can either be administered in the Participant-Driven or Examiner- Driven mode, depending on the abilities of the Participant. The Participant-Driven mode tends to be slightly more sensitive to neglect than the Examiner-Driven mode due to the requirement to maintain attention while performing a secondary task (operation of the joystick). For Participants unable to manage the requirements of the Participant-Driven mode, however, the Examiner-Driven mode is also amply sensitive to neglect.

Moreover, much of the normative data are available for the Examiner-Driven mode with the Enhanced Array.

In summary:

1. Administration of multiple Levels (Simple, Complex, Enhanced) and/or both Modes (Participant-Driven, Examiner-Driven) is useful when a descriptive assessment of the effects of distraction and secondary task load are desired.
2. Administration of the Enhanced Array, Examiner-Driven version alone is useful when there are time constraints and a simple cutoff score for determining neglect is desired.

E. Examiner Competence

In a clinical setting, the VRLAT should be administered by a qualified therapist or technician with experience in neuropsychology and/or rehabilitation. Most professionals acquire some of this training in college and/or graduate-level courses devoted to assessment. Such courses may be found in departments of rehabilitation science, psychology, occupational therapy, speech therapy, and physical therapy, among others.

F. Participant Eligibility Criteria

The VRLAT is appropriate for use with adults age 18 to 100 years of age who understand elementary-level English, can name basic-level objects, and who have known or suspected brain pathology such as stroke, traumatic brain injury, or tumor. (Note: Normative data are provided for stroke and neurologically intact Participants only). Participants should also have adequate visual acuity (corrected or uncorrected) to be able to name moderately large pictures on a computer monitor and be able to hear (assisted or unassisted) a loud voice in a quiet environment. No minimum motor ability is required aside from the ability to maintain a sufficiently upright posture to view a computer monitor or laptop. The VRLAT has thus far been normed on individuals who had no history of psychosis or major substance abuse, and the norms can be used to interpret scores for all Participants with known or suspected neuropathology who meet those criteria.

G. Familiarity with the VRLAT

Before administering the test for the first time, the Examiner should complete the following steps to ensure appropriate use of the test:

1. Become familiar with the contents of this manual
2. Become familiar with the VRLAT software and use of the joystick.
3. Become familiar with the instructions and score sheet.
4. Review the sections below addressing the interpretation of VRLAT results.

II. Hardware for Administering the VRLAT

The VRLAT can be run on any PC under Windows 97 or Windows 7. It has not been tested under Windows Vista or Windows 8.

As long as the system has a DirectX 9 (or newer) compatible graphics chip or video card, it should be able to run the VRLAT. The software requires about 300 MB of drive space to install.

Unfortunately, it will not run on Apple products.

You will need to purchase a simple computer “joystick” type of controller. Any brand will do; these can be purchased widely on the internet and in many stores, and are generally inexpensive. The joystick need only have the ability to move freely in all directions; buttons are not required. The joystick should have a USB plug such as the one on a computer mouse. Follow the joystick package instructions for ensuring it is installed and calibrated correctly.

Figure 2. Example of a simple computer joystick

III. Downloading the VRLAT

Please contact Laurel Buxbaum (lbuxbaum@einstein.edu) for download instructions.

IV. Basic Operation

When you click on the program icon you will be presented with an opening screen similar to that shown below in Figure 3. You will be able to select any of the 4 test environments from this opening menu. The four (4) environment choices are as follow:

1 **Warmup** – This is a simple practice/warmup environment intended to help the patient familiarize themselves with navigating thru the environment using the wheelchair.
2 **Simple** – Similar path to the warmup environment except it contains a number of objects/distractions along the path.
3 **Complex** – This is a more complex version of the Simple environment containing many more distractors on the left and right side of the path.
4 **Enhanced** – Same environment at Complex except with audio and animated distractors

Figure 3. Opening menu screen.

The environment is chosen by clicking on one of the 4 buttons near the bottom of the menu screen, identified as the "Test Environments" in the figure above.

The direction of the path thru the environment can be chosen as either the standard forward path, or a “Reverse Path”. Selecting a reverse path places the Participant at the other end of the environment and the goal is to traverse the environment to the other end. A check mark in the path selection field shown above indicates that the reverse direction is selected. **Note:** The direction must be selected <u>before</u> selecting one of the 4 test environments.

Prior to invoking one of these environments, the Examiner should enter some form of patient identifier in the Text Box above the Environment selection buttons. This field will be written to an event log to aid in identifying which event logs belong to which test subjects (see below).

At the bottom of the screen is a Hint/Status Bar that provides a short information line about any of the buttons and fields in the main menu.

Note that if a joystick is not connected, moving slightly left, right, forward, or back can be accomplished with keyboard Arrow keys.

To exit the simulation environment and return to Windows you can simply click on the *Quit* button in the bottom left corner of the menu screen. **Note:** When a patient reaches the end of the path you will be returned to this menu screen and the data files closed. To invoke another test case simply enter/re-enter the test subject’s information in the Client field and launch the desired environment.

If at any time during the VRLAT you want to quit or return to the main menu, you can do so by hitting the Escape or Q (Quit) keys. This will bring up the “Mid-VRLAT Menu” shown in Figure 4. The menu can be cancelled either by hitting the Escape key again or clicking on *Resume*. Clicking on the *Main Menu* button will return you to the main menu shown in Figure 3 above. Clicking on the *Quit* menu will return you to Windows.

Invoking the mid-VRLAT menu will also pause the simulation. Data gathering will be suspended. If the simulation is resumed the application will become un-paused and data collection will continue until the end of the path is reached or the simulation is paused again or the Examiner exits.

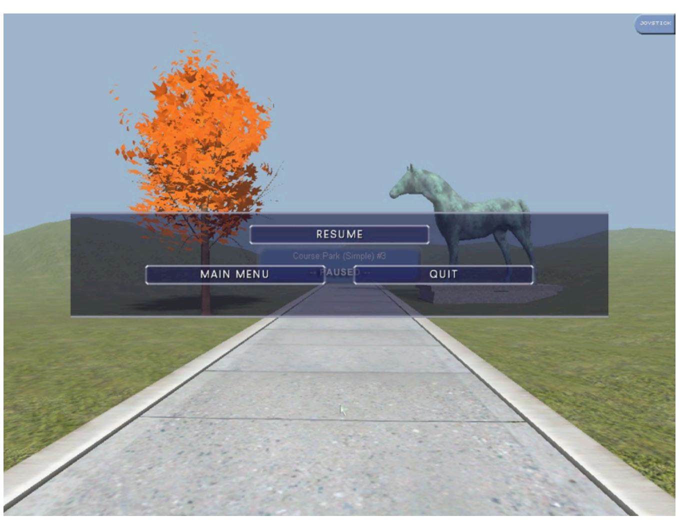

Figure 4. Mid-VRLAT menu.

VI. Test Administration

A. Practice for "Participant-Navigated" version

Allow the Participant to practice navigating by clicking on the "Practice" button. You will see the beginning of the path before you.

A "Paused" indicator may appear at the start of the task to permit any additional instructions as needed. (This indicator also identifies the course that is currently being used). Click the Escape Key and then click "Resume" to begin the task.

Instructions to be read by Examiner: Pushing the joystick forward will move you forward on the path. Try tilting the joystick slightly to the left and the right to move left or right.

Continue practice until the patient is proficient at controlling the joystick.

B. All versions

Click on the Level of the VRLAT that you want to administer. You will see the beginning of the path before you.
Note: if a "Paused" indicator appears at the start of the task, hit the Escape Key and then click "Resume".

Instructions to be read by Examiner: You will see a pathway. Alongside the pathway are a number of objects. As you guide yourself (*or: as I guide you*) along the pathway, name the animal statues and colored trees with a complete name. For example, you might say 'bear statue' or 'grey tree'. If you see other objects, please do not name them. Only name statues and trees. Also, please try to move quickly through the course without stopping, and try not to bump into anything.

At each level, run the VRLAT in the forward direction, then the reversed direction.
Click the checkbox for reversed direction prior to choosing the course type.

If running the Examiner Navigated mode, operate the joystick such that forward progress appears moderately slow and steady.

C. Testing Time

The full version of the VRLAT requires approximately 15 minutes. A briefer version consisting only of the Enhanced Array (see Section IX) requires about 5 minutes.

VII. Scoring the VRLAT

The VRLAT is scored in "real time" while the Participant responds. There are two scoring systems: a Full Scoring System for which extensive normative data are available (see Section X below, and Buxbaum et al., 2012) and a Simple Scoring System that provides a cut-off for neglect (See Section IX).

Use the included score sheet to circle correctly named items and to indicate other responses. There are 10 targets on each side of the path. Each level is performed once Forward, and once Reversed. Thus, there are 20 left targets and 20 right targets per Level.

Responses are awarded 3 points if they include unique attributes (specific animal or color name; e.g., "Red Tree"; "Cat Statue"); 2 points if they contain category or color errors; 1 point for a general indication of the presence of an object but without further information (e.g., "something" "don't know what that is"); and 0 points if an object remains unidentified. Maximum possible points for each Level is thus 60 per path side. Total points are tallied for each side of the path for each VRLAT Level.

In addition, Collisions are tallied in the Participant-Driven administration conditions. A collision is defined as any instance in which the Participant bumps against an object or the side of the path in the course of administration. In addition to scoring collisions "on-line", the software tallies collisions and notes the coordinates of the event (see Appendix 1).

VIII. Interpreting VRLAT Results

A. Total Scores

Summing across Forward and Reversed administration at each Level, the VRLAT yields Total raw scores for each path side, for each Mode (Examiner versus Participant-Driven) and for each Level (Simple, Complex, Enhanced).

Based on a normative sample of controls (Buxbaum et al., 2012), left-sided scores below the following may be indicative of left neglect:

Simple, Examiner-Driven	56
Complex, Examiner-Driven	59
Enhanced, Examiner-Driven	54
Simple, Participant-Driven	56
Complex, Participant-Driven	55
Enhanced, Participant-Driven	57

B. Collisions

Collisions are very rare in Participants without neglect. Of 31 Participants *without* neglect reported by Buxbaum et al. (2012), there was only 1 instance of collision. In contrast, in 25 patients *with* neglect, there were 21 instances of collision. Thus, one collision is indicative of possible neglect, whereas 2 or more collisions are indicative of probable neglect. Of course, collisions should be interpreted in the context of overall performance.

IX. Shortened VRLAT and Simplified Scoring System

The Enhanced Array, Examiner-Driven Condition may also be used alone as a short test when time is limited.

Responses in the shortened version are awarded 1 point if they are named correctly with unique attributes (specific animal or color name), and 0 points otherwise. Maximum possible points for each Level is thus 20 per path side.

Based on a simple 20 point scoring system, scores below 18 points on the left side of the Enhanced Array would be indicative of possible neglect.

X. Psychometric Properties of the VRLAT

A. Normative Sample Performance

Table 1 provides the scores of the normative sample of 70 right hemisphere stroke patients and 10 neurologically intact controls for each Level and Mode. (See Buxbaum et al, 2012, for additional information on the normative sample).

Patients	**Left**		**Right**	
	Mean (sd)	Range	Mean (sd)	Range
Simple, Examiner	52.2 (11.4)	11-60	55.8(9.6)	10-60
Complex, Examiner	51.5 (7.2)	9-60	55.4 (8.4)	8-60
Enhanced, Examiner	50.5 (13.2)	3-60	54.1 (8.4)	13-60
Simple, Participant	53.8 (9.9)	15-60	57 (4.2)	42-60
Complex, Participant	51.7 (11.4)	15-60	55.4 (8.4)	27-60
Enhanced, Participant	50.8 (12.6)	9-60	54.9 (7.2)	26-60

Controls	**Left**		**Right**	
	Mean (sd)	Range	Mean (sd)	Range
Simple, Examiner	59.2 (1.5)	56-60	59.8 (0.4)	59-60
Complex, Examiner	59.7 (0.4)	59-60	58.2 (3.2)	50-60
Enhanced, Examiner	58.3 (1.9)	54-60	58.2 (1.8)	56-60
Simple, Participant	59.0 (1.6)	56-60	59.8 (0.4)	59-60
Complex, Participant	59.3 (1.9)	54-60	58.9 (1.6)	56-60
Enhanced, Participant	59.5 (1.2)	56-60	58.4 (2.7)	52-60

Table 2 shows the performance of Participants in the normative study of Buxbaum et al. (2012) on paper-and-pencil tests of neglect and on real-world navigation.

Table 2. Neglect and Attention Battery Performance

	Neglect Patient Mean (SD)	Non-neglect Patient Mean (SD)	Control Mean (SD)
Number of Subjects	35	35	10
Bell Cancellation Left (%)	62.8 (27.2)	88.5 (14.0)	97.1 (4.2)
Bell Cancellation Right (%)	72.8 (15.1)	87.9 (16.8)	98.8 (2.5)
Letter Cancellation Left (%)	66.0 (29.9)	96.3 (10.5)	99.0 (2.1)
Letter Cancellation Right (%)	74.1 (22.1)	93.4 (11.4)	99.0 (2.1)
Fluff Test Left (%)	76.9 (23.7)	94.8 (11.9)	NA
Fluff Test Right (%)	93.6 (12.6)	93.6 (17.5)	NA
Line Bisection (deviation, mm).	0.57 (15.2)	-1.7 (4.8)	-1.7 (3.9)
Laser Line Bisection (deviation, mm)	20.3 (33.15)	17.0 (39.9)	3.6 (1.7)
Left Visual Deficits (number, % of pts.)	25 (71%)	15 (43%)	NA
Moss Real World Navigation, Left (collisions)	0.7 (2.2)	0.1 (0.3)	NA
Moss Real World Navigation, Right (collisions)	0.3 (0.59)	0.3 (1.1)	NA

Table 3 shows Spearman's Correlations between the VRLAT Enhanced Examiner-Driven Left-Sided Score and Tests of Neglect and Attention in the Normative Patient Group from Buxbaum et al. (2012).

	Spearman's Rho
Bell Cancel Left	**0.43**
Bell Cancel Right	0.21
Letter Cancel Left	**0.59**
Letter Cancel Right	**0.49**
Line Bisection	-0.39
Laser Line Bisection	-0.27
Fluff Test Left	**0.41**
Fluff Test Right	0.09

Note: Bolded values are significant at $p < .007$ (corrected p value).

B. Test Reliability

Internal consistency reliability- The 3 Array levels of the VRLAT are highly internally consistent (Cronbach's α = .97). This provides acceptable confidence that the three Array levels are measuring a single unidimensional construct (hemispatial neglect).

"Split half" reliability- Given that subjects in Buxbaum et al. (2012) received scores for their performances both "coming" and "going" in each VRLAT condition, we assessed whether it was permissible to collapse across these two performances in each condition. Cronbach's α was robust (range .85 - .93), indicating that the two directions may be viewed as equivalent.

C. Test Validity

Concurrent criterion validity- The VRLAT's Enhanced Array, Examiner-Driven, Left-sided scores correlated significantly with standard measures of neglect, including the Bell and Letter cancellation tasks. Importantly, the VRLAT's correlation with collisions in real world navigation was also robust, and was stronger than the correlation of the navigation test with other clinical tests. Finally, collisions with left-sided virtual objects in the Enhanced Array Patient Driven conditions, unlike paper-and-pencil tests, were also significant predictors of left-sided collisions on real-world navigation.

Discriminant validity (specificity)- The VRLAT is not influenced by non-lateralized attentional deficits (as assessed by right-sided target detection). Moreover, the VRLAT is equally likely to categorize patients with and without visual deficits as having neglect, whereas the paper and pencil tests are significantly more likely to diagnose neglect in patients with field deficits. This suggests that the VRLAT may be a somewhat more specific test of neglect than the paper-and-pencil tests. Given the difficulty of distinguishing neglect and hemianopia (Kooistra & Heilman, 1989; Vallar et al, 1991), future research is necessary to further assess this possibility.

Content and Face validity- The VRLAT requires Participants to navigate while attending to objects in a simulated environment. It consequently provides a virtual replication of many of the task demands that cause difficulty for patients with hemispatial neglect. The fact that the VRLAT tasks bear a transparent relationship to the types of tasks patients need to perform (face validity) makes it a valuable tool in educating patients and families. In addition, the VRLAT can assist clinicians in developing an appropriate discharge plan.

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Appendix 1: Data Files

There are 2 data files collected for each test run. These are the navigation files (.nav) and the event files (.csv). Both of these files are stored in a separate "Data" directory. The navigation files are binary files used to track movement thru the environments.

The event files contain event information concerning impacts with the surrounding walls or objects along the path. This file contains "comma separated fields" (csv) and is suitable for import to Excel or other data manipulation packages.

A short sample of a typical .CSV file is given below.

File: ..\..\Data\Events_20050328131525.csv
Version 1
Environ: Park (Simple) V4
Path Direction: Forward

No USB1 Devices Detected

Client: Subject ABCD

Time	X	Y	Z	Yaw	Pitch	Roll	eType	Tag
6.009	2059.8	4822.7	334	-129	0	0	2	L_TreeOrange
10.857	2430.7	4667.2	337.9	-44.8	0	0	2	R_Horse1
14.059	2431.9	4747.1	345.5	-324.2	0	0	2	R_Wall
19.349	2302.6	4685	334	-82.9	0	0	2	R_Horse1
27.331	1758.2	3581.5	338.2	-133.9	0	0	2	L_Pig1
38.845	2122.6	2998.1	355.3	-46.6	0	0	2	R_TreeWhite
42.396	2012.8	2697.4	339	-107.8	0	0	2	R_Turtle1
46.427	1595.8	2594.9	334	-167	0	0	2	L_Camel1
49.604	1661.8	2312.1	334	-105.4	0	0	2	R_TreeGreen
55.866	865.5	2068.9	338.9	-150.5	0	0	2	L_Cat1
60.141	897.9	1818	334	-90.4	0	0	2	R_TreeBlack

Table A1. Typical Event CSV file.

Basic information includes the test subject name (entered from main menu), the environment used, path direction (forward/reverse) selected, and the data files name. Each subsequent event is recorded in the tabular form shown above.
Information includes:

• Time – time in seconds from when the simulation was started
• X,Y,Z – location in the environment where an impact occurred
• Yaw, Pitch, Roll – position and orientation of the subject in the virtual environment.
• eType – event type (all impact events are type 2)
• Tag – This is the object that was hit. Each object has a single letter prefix (L or R) that is used to indicate what side of the path the object was on. The rest of the tag indicates what the object was.

For example: -The first event occurred at 6.009 seconds into the simulation where the Participant struck the Orange Tree on their left. -The 2^{nd} event occurred at 10.857 seconds where the Horse on the right was struck.

Appendix 2. Manipulation of Data in .nav and .csv files

Simple data analysis of single or multiple csv files can be performed by using the Excel *"Data-Sort"* function and sorting the data based on the Tag field. This will separate all the Left and Right occurrences which can then be tallied.

Simple X-Y charts of collisions points along the path can also be plotted in Excel by selecting all the X & Y coordinates and performing an X-Y plot.

You can get more information by combining your ".nav" and ".csv" file in Excel to do some preliminary analysis and visualization. Before you can make use of the binary Nav file you must convert it to a CSV file that Excel or other analysis program can understand. This is done through the *"Convert Nav File"* utility included in the distribution. The utility can be invoked from the Windows Start→Programs menu under the Neglect folder. This is a no frills conversion utility that allows you to select a single Nav file and convert it to its CSV equivalent. The interface is as shown below:

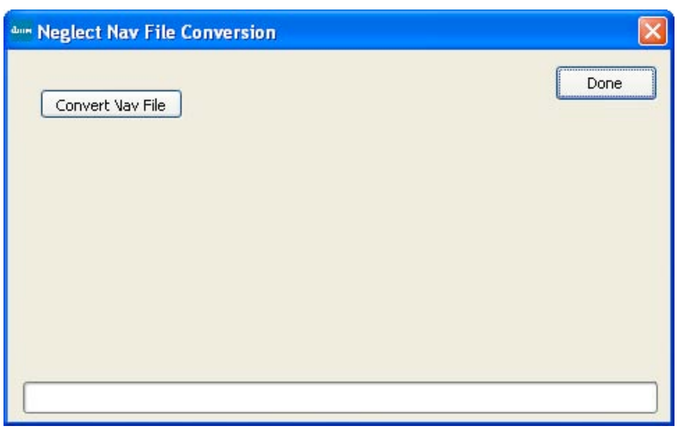


Figure A1. Convert NAV File Utility

When you select the Convert Nav File button you will be presented with a standard Window's file selection dialog showing only the Nav files in the Data directory. Select the file (single only at this time) and hit the Open button. The progress bar at the bottom will indicate the conversion progress and you will be presented with a status message at the end of the operation. In the sample in Figure 8 we have converted the *Chair_20070413211939.nav* file. This results in the generation of the CSV file *Chair_20070413211939_nav.csv* shown on the right. This CSV (text) version of the file can then be imported directly into Excel, a text editor, or another analysis package.

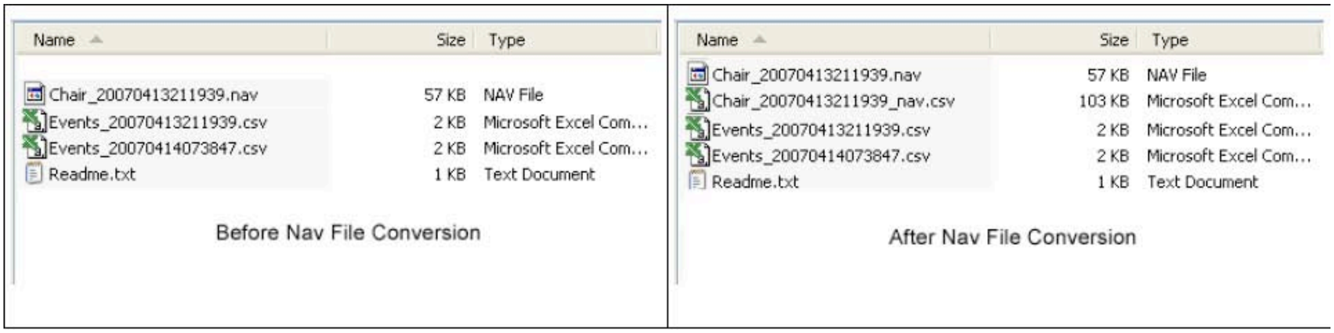
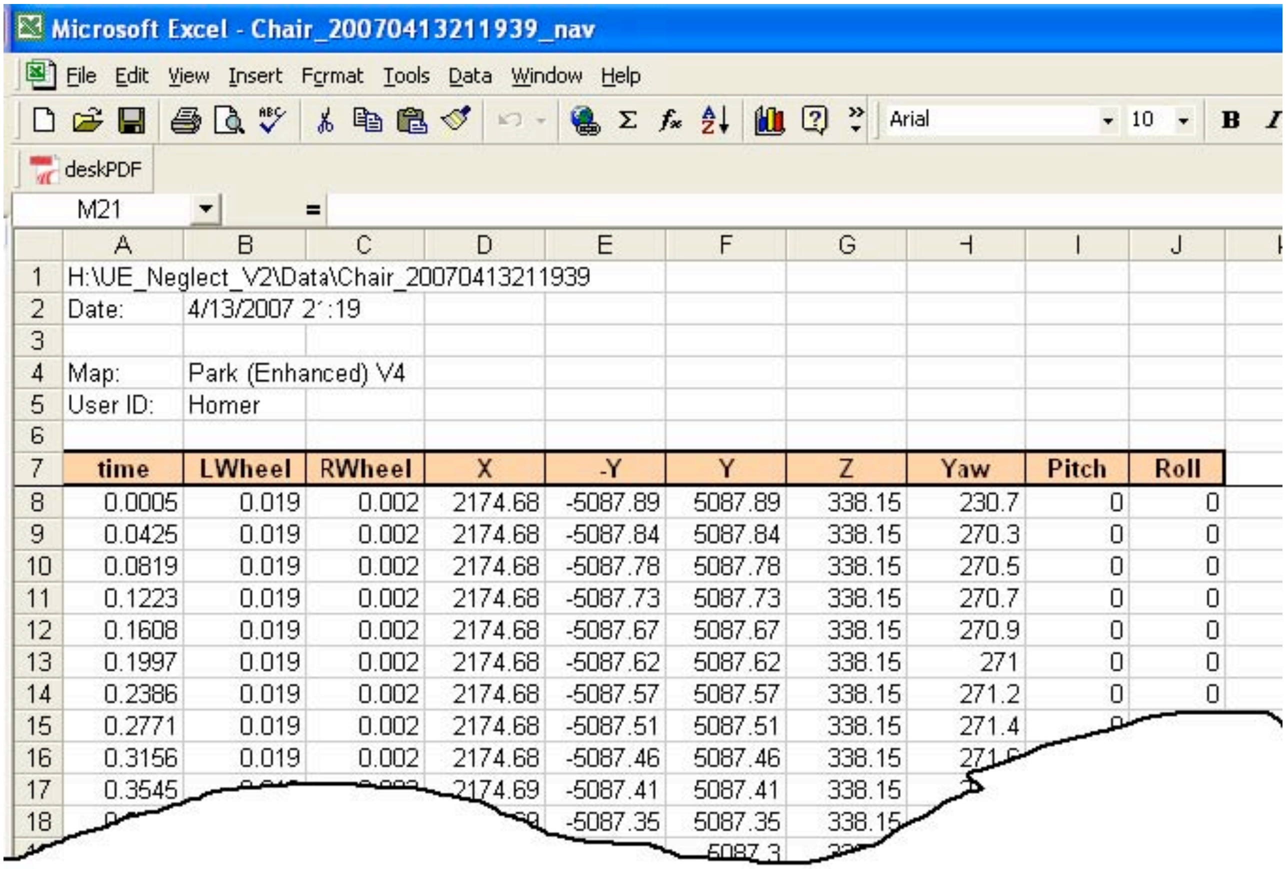


Figure A2. Data Directory Before/After Conversion

NAV Data file Contents

If you have Excel installed and you double-click on the newly created Nav file you will see something similar to Figure A3:



	A	B	C	D	E	F	G	H	I	J
1	H:\UE_Neglect_V2\Data\Chair_20070413211939									
2	Date:	4/13/2007 2':19								
3										
4	Map:	Park (Enhanced) V4								
5	User ID:	Homer								
6										
7	time	LWheel	RWheel	X	-Y	Y	Z	Yaw	Pitch	Roll
8	0.0005	0.019	0.002	2174.68	-5087.89	5087.89	338.15	230.7	0	0
9	0.0425	0.019	0.002	2174.68	-5087.84	5087.84	338.15	270.3	0	0
10	0.0819	0.019	0.002	2174.68	-5087.78	5087.78	338.15	270.5	0	0
11	0.1223	0.019	0.002	2174.68	-5087.73	5087.73	338.15	270.7	0	0
12	0.1608	0.019	0.002	2174.68	-5087.67	5087.67	338.15	270.9	0	0
13	0.1997	0.019	0.002	2174.68	-5087.62	5087.62	338.15	271	0	0
14	0.2386	0.019	0.002	2174.68	-5087.57	5087.57	338.15	271.2	0	0
15	0.2771	0.019	0.002	2174.68	-5087.51	5087.51	338.15	271.4		
16	0.3156	0.019	0.002	2174.68	-5087.46	5087.46	338.15			
17	0.3545			2174.69	-5087.41	5087.41	338.15			
18					-5087.35	5087.35				

Figure A3. Typical Navigation CSV contents

time (Time Stamp) - Column A Each line of sampled data has its own time stamp. The units are in seconds from the start of the simulation. Typically this is accurate to 3 decimal places or approximately 1mS.

LWheel/RWheel – Columns B-C – Not applicable to this version of the VRLAT

Joystick Position - Columns D-G The subject's position and orientation at any point in time (**time stamp Col A**) during the simulation is given by the values in fields D through G of the converted data file.

Location X, Y, Z (Units – Inches) The VRLAT's 3D engine uses a Left Hand Coordinate System (Figure X) as opposed to the typical Right Handed Coordinate System many may be accustomed to. A typical orientation of the axis in this system is shown below. The figure to the right represents a top down view of the axes. Positive X is to the right, but positive Y is down as opposed the the standard coordinate system. The Z axis in this case is ***out of the page*** as indicated by the black circle on axis shown in the diagram on the right in Figure A4.

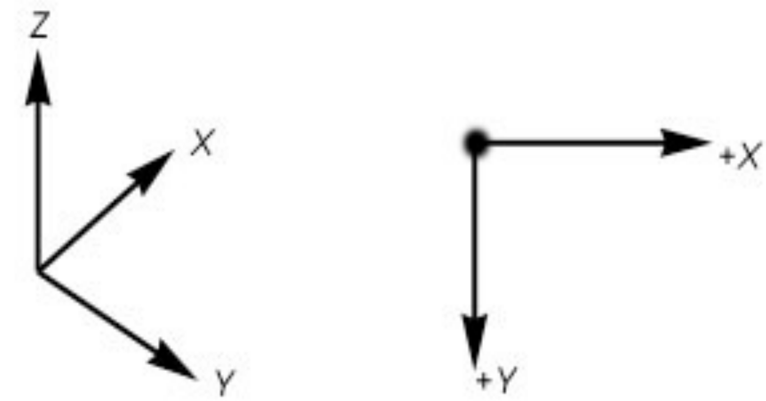


Figure A4. Yaw angle measurement

In our case the subjects's location on a 2-dimensional map is given predominately by the X and Y coordinates as shown above in the “top down” view. The Z value is a measure of the subject's elevation above an arbitrary zero reference. As the subject moves through various areas of the environment this value will change as the vehicles goes up/down various hills and dips in the terrain.

The XYZ coordinates of the chair are the coordinates of its Centroid at the time the vehicle position was sampled. This combined with the Pitch, Yaw, Roll in subsequent columns specify the vehicles location and orientation in 3D space.

Note: It is also possible to plot steering behavior, objects contacted along the path, and location of the various audio and animated stimuli using Excel. Additional directions for performing the multi-step operations necessary to derive data plots may be obtained by contacting the test authors.