

**INSTRUCTION MANUAL FOR**  
**THE NATURALISTIC ACTION TEST**

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## 1. Introduction

Naturalistic action is learned, sequential, object-oriented behavior in the service of everyday goals. Short, self-contained sequences are commonly designated tasks (e.g., making a cup of coffee); longer sequences are designated activities, and in special cases, *Activities of Daily Living* (ADL; e.g., eating, dressing). A decade of research conducted at Moss Rehabilitation Research Institute in Philadelphia has shown that subjects recovering from stroke and brain injury and those with progressive dementia are highly prone to errors of action when engaged in naturalistic action. Errors may include omissions, such as failing to close a container, or more significantly, to turn off the stove. They may also include a wide range of overt or commission errors, such as throwing away an object of value (instead of the paper it came wrapped in), perseveratively adding sugar to a cup of coffee, or taking the wrong medicine. Acquired vulnerability to errors limits a subject's ability to function independently and may dispose the subject to institutionalization (2,7).

Research indicates that subjects become vulnerable to errors of action on account of depletion of the cognitive resources needed to sustain action plans, select actions and objects at the right time and in the right order, and engage in self-monitoring and error correction (6, 11, 13). Like absent-minded memory and action slips in healthy people (10), errors in subjects are jointly determined by resource capacity and situational demands. Tests show that the frequency and nature of errors vary according to the complexity of the task and its affordance for particular errors. They also vary with set-up conditions, including the visibility of target objects and the presence of non-target distractors (12, 14, 17).

These research findings motivated the creation of the *Naturalistic Action Test* (NAT). The NAT measures how well subjects perform naturalistic action under controlled, laboratory conditions, when they are given free reign to act (within the bounds of safety) and are not penalized for physical limitations. These features of the NAT distinguish it from the functional assessments used in many rehabilitation settings. For example, the ADL items of the *Functional Independence Measure* (FIM; 5) rate subjects on the nature and degree of assistance required during real life ADL performance. Neither the set-up conditions nor the giving of assistance is standardized; and the ratings turn out to be influenced primarily by the subject's motor impairments (9).

The NAT was developed through extensive experience with a research instrument called the *Multi-level Action Test* (MLAT: 1, 4, 13, 16). We created the NAT by shortening the MLAT and greatly simplifying the scoring procedures. Unlike other clinical assessments, which require extensive training in administration and scoring (e.g., AMPS: 3), the NAT procedures are reliably mastered with approximately 8 hours of supervised experience.

The NAT was validated in a study involving 45 right-hemisphere and 30 left-hemisphere stroke subjects, 25 traumatic brain injury subjects, and 28 controls (15). Results are summarized in Section 8.

### Who are the intended users of the NAT?

- Neuropsychologists, occupational therapists, and other rehabilitation clinicians who work with adult neurological populations will find the NAT useful for:
  - measuring the severity of a subject's naturalistic action impairment and comparing it against a reference group
  - setting treatment goals and destination plans
  - educating subjects and family members about the types of problems they are likely to encounter after discharge.
- Cognitive and rehabilitation researchers may choose to use the NAT as a:
  - baseline performance measure in treatment studies
  - functional outcome measure in treatment studies
  - functional disability measure for characterizing a study population
  - baseline severity measure to equate subjects in cognitive neuropsychological research.
- Use is not restricted to any specific professional group, and no intensive training or rater-calibration credentials are required.

### For what types of subject is it recommended?

- The NAT was developed for individuals with stroke, TBI, and progressive dementia but is applicable for any condition that affects attention, working memory, goal formulation and execution, object recognition, or related cognitive functions.
- The NAT is suitable for subjects with hemiparesis, weakness, and range of motion limitations. No penalty is assigned for physical assistance necessitated by these conditions.
- It is also suitable for subjects with aphasia, as long as they can demonstrate comprehension of task instructions.

### What is it like to administer?

- The NAT is a performance-based test in which the tasks, materials, layout, and cueing procedures are all standardized. It can be set up in any room that accommodates a 4' X 6' assessment station.
- Most subjects require 30-45 minutes to complete the NAT.
- Performance is scored for steps accomplished and for a small set of overt errors.
- Scoring can be done in-room, concurrent with test administration, using the Scoring sheets. Formal training is unnecessary; all the information needed to achieve reliable scoring is present in this instruction manual.

### What are its psychometric properties?

- A validation study involving 100 patients undergoing rehabilitation for stroke or TBI showed that the NAT
  - discriminates patients from age-matched controls
  - has excellent inter-rater reliability
  - is internally consistent
  - correlates highly with concurrent performance on the FIM, which measures caregiver burden

- correlates with measures of attention.
- A follow-up study with 48 of these patients, conducted six-months post discharge, demonstrated that inpatient NAT scores were strongly and significantly associated with a widely used functional outcome measure (8). Thus, inpatient NAT scores predicted functional abilities after discharge.

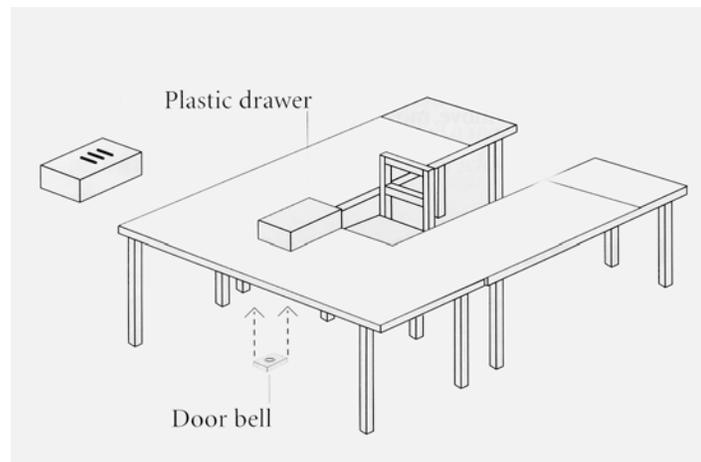
## 2. Materials

Throughout this manual US-specific materials precede UK-specific materials in descriptions, separated by a forward slash (for example, Task 1 requires the administrator to provide ‘jelly/jam’).

### General requirements

1. U-shaped table (or similar arrangement). The NAT was developed using a 4’x6’ U-shaped table which allowed subjects to reach all necessary items. The dimensions of the table are as follows: the work surface is 18” deep; the subject sits in a 36” wide opening with table surface on three sides. It is available for purchase from Smith + Nephew Rehabilitation Division (P.O. Box 1005, Germantown, WI 53022-8205, USA; 800-558-8633).

It is permissible to create a work area that surrounds the subject on three sides using three tables in a similar configuration (see below).



2. Stopwatch or other timing device, for timing cues.
3. Attachable drawer (for Task 3): should be attached to table top, just to the right of midline, using Velcro tape.
4. Remote doorbell (for Task 3): bell should be placed on the undersurface of the table, just to the right of midline and within the subject’s reach. Ringer can be placed anywhere in room.
5. Blindfold to shield subject’s eyes during setup (optional).

In addition to the aforementioned general requirements, the items listed in the three Tasks below must be provided by the NAT user.

Specific requirements

**Task 1**

*Instruction:* Make toast with butter and jelly/jam, and instant coffee with cream/milk and sugar.

*Array:*

All and only the target objects needed for task:

1. toaster
2. two knives
3. one spoon
4. stick/block of butter in butter dish
5. sugar bowl with sugar
6. creamer/milk jug with cream/milk or non-dairy creamer
7. paper towel in center of work table
8. mug filled with warm water
9. bag of bread containing at least six slices, loosely sealed with twist tie
10. jar of instant coffee with screw top lid (lid loosened)
11. jar of jelly/jam with screw top lid (lid loosened).

**Task 2**

*Instruction:* Wrap a gift as a present.

*Array:*

Target objects plus distractors: (Note: distractors are marked with \*.)

1. cardboard box with flaps and attached lid.
2. doll (the gift)—sized to fit snugly in box.
3. scissors
4. pruning scissors/garden secateurs\*
5. cellophane tape/sellotape
6. electric/insulating tape\*
7. paper bag\*
8. stapler\*
9. bag of self sticking bows
10. long roll of wrapping paper
11. tissue paper (one or two sheets) lying open inside the box and arranged to cover open flaps.

**Task 3**

*Note re: bologna/cheese slices*

In this Task, a “sandwich” consists of a protein and spread: either bologna and mustard, or cheese and butter or margarine (whichever is convenient for the NAT user).

*Instruction:* Prepare and pack a child's lunchbox (with sandwich, drink and snack/biscuits), and pack a child's school bag (with ring binder notebook and stocked pencil case). Ring bell attached to the underside of table top after completing each task.

*Array:*

1. lunchbox
2. thermos bottle (thermos lid and thermos cup are placed in the drawer)
3. unwrapped tray of sandwich cookies/biscuits
4. stack of bologna or cheese slices, containing at least six slices
5. jar of mustard with screw top lid or butter in butter tub
6. bottle of juice with screw top (can refill with any colored liquid)
7. bag of bread containing at least six slices, loosely sealed with twist tie
8. zip up pencil case
9. one pen and three pencils for pencil case
10. protractor for pencil case
11. eraser for pencil case
12. pencil sharpener for pencil case
13. ruler for pencil case
14. pack of four or more colored markers/marker pens
15. ring binder with hole punched paper, number of holes must equal number of rings (paper placed loosely inside binder, not on rings)
16. aluminium foil roll
17. knapsack/school bag

*Drawer contents:*

(Items marked # may be replaced with other small, manipulable objects, if necessary)

(Note: distractors are marked with \*)

18. envelope # \*
19. spoon \*
20. two knives
21. fork \*
22. miscellaneous coupons # \*
23. spatula \*
24. retractable tape measure # \*
25. thread spool/cotton reel # \*
26. screwdriver # \*
27. toothbrush # \*
28. ice tongs # \*
29. thermos lid
30. thermos cup

*Underneath the facing table:*

31. remote (push-button) doorbell

### 3. General instructions

#### **Administration time**

Most subjects complete all three Tasks of the NAT in approximately 45 minutes. The maximum time allotted to complete each Task is 30 minutes. (See *Cueing procedures*, Section 5.)

#### **Layout of materials**

The placement of objects for each Task is shown on pages 21-23. Note how each object is oriented.

#### **Positioning and interacting with the subject**

The subject should not see the examiner prepare the table – they may be placed behind a screen, turned around or taken out of the room during set-up for the next Task. It is advisable to use a blindfold when leading the subject into the prepared testing area to prevent them from seeing a side of the table they might not naturally attend to (e.g., on account of hemispatial neglect).

At the onset of testing the subject should be seated with chair or wheelchair centered in the array, and within easy reach of all objects on testing table. Do not permit the subject to move their chair during the test.

Keep conversation with subject to a minimum; avoid eye contact while the subject is working.

#### **Giving assistance to subjects**

The NAT is a test of cognitive performance. Physical assistance is given when needed (e.g., in the case of hemiparesis) but should not be a cause of unnecessary conversation. The fact that physical assistance is available should not be stated at the outset, since this may encourage unnecessary requests for help. However, in response to a question or need for reassurance, subjects may be told: *“I will help you if you can’t do something, but I need you to start it on your own.”* It is important that the subject indicates their intentions clearly (e.g., by reaching for objects, attempting to open containers) before physical assistance is given.

When a subject clearly indicates their intention to perform an action (either correct or incorrect), assistance may be given, according to the following restrictions:

1. Give help from the subject’s strong (ipsilesional) side (standing to the side and slightly behind the subject)
2. Avoid eye contact and conversation
3. For range of motion problems, move an object closer only upon the subject’s request or gesture; if you cannot tell which object to move, move the closest object toward the subject

#### 4. Instructions to subjects

Instructions are given before each Task (see below). Note that the subject is asked to repeat back the instructions before beginning. If during the instruction period the subject indicates they have not recalled the instructions or misunderstood them, the examiner must repeat the instructions from the beginning. If the subject states the task without mentioning its specifications (e.g. “I am going to make coffee.”), the examiner should state that the subject is correct and repeat the specifications of the task (e.g. “That’s right, coffee with cream/milk and sugar.”) Have the subject repeat the instructions, including the specifications.

If the subject has expressive aphasia or is otherwise unable to verbalize the instructions, the examiner should seek confirmation that the instructions have been understood (e.g., using the subject's gestures, writing and pointing responses, and answers to yes/no questions). Be aware that a subject's failure to understand the instructions may invalidate the results.

While explaining the Task, the examiner should briefly display the corresponding pictures (pages 24-28). For Tasks 1 and 3, show both pictures in immediate succession to underscore that each Task has two parts.

##### **Instructions for Task 1: Toast and Coffee**

*“I would like you to do two things (holding up two fingers): make a single slice of toast (pointing to picture of the completed task) and make instant coffee (pointing to picture of the completed task). Everything you need for these two tasks is out here (gesturing around the table). You are to make a single slice of toast with butter and jelly/jam and make a cup of instant coffee with cream/milk and sugar. Please repeat what you are going to do.”*

(Subject repeats instructions or otherwise indicates comprehension.)

*“O.K., please begin.”*

##### **Instructions for Task 2: Present**

*“I would like you to wrap a present (pointing to picture of the completed task). Use just what you need from what’s out here (gesturing around table). Remember, you are to wrap the gift as a present. Please repeat what you are going to do.”*

(Subject repeats instructions or otherwise indicates comprehension.)

*“O.K., please begin.”*

##### **Instructions for Task 3: Lunchbox and Schoolbag**

*“I would like you to do two things (holding up two fingers): pack a lunchbox (pointing to picture of the completed task) and pack a schoolbag (pointing to picture of the completed task). All the items are out here (gesturing around table) or in here (opening and closing the drawer). You are to pack a child’s lunchbox with a sandwich, a drink and a snack/biscuits; and pack a child’s schoolbag with supplies for school. Please repeat what you are going to do.”*

(Subject repeats instructions or otherwise indicates comprehension.)

*“There is one important rule that you must follow: Ring the bell under the table after finishing each task (demonstrates reaching under table and ringing bell). So, after you finish packing the lunchbox, ring the bell and after you finish packing the schoolbag, ring the bell again. Please repeat this rule so that I can be sure you understand it.”*

(Subject repeats the instructions or otherwise indicates comprehension.)

*“O.K. Before you begin I want to remind you that you must pack a lunchbox with a sandwich, a drink and a snack/biscuits, and pack a schoolbag with supplies for school. Don’t forget that you must ring the bell under the table after finishing each task. Please begin now.”*

## 5. Cueing procedures

This section spells out the circumstances under which examiners are permitted to verbally interact with the subject during the NAT, and the content of these verbalizations, which we call “cues.”

### Initiation cue

If the subject does not begin working immediately after the instructions have been delivered, cue with: *“Go ahead and get started.”* Repeat this initiation cue if necessary.

### Generic cues

In contrast to timed-based cues (see below), generic cues are non-informative and may be given at any time and as often as necessary. Generic cues are given in response to the subject’s request for information or to have the instructions repeated. They are given also as answers to other questions and comments, including expressions of perplexity, frustration or discouragement.

Generic cues are as follows:

- for Tasks 1 and 2: *“Everything you need is out here. Just do the best you can.”*
- for Task 3: *“Everything you need is out here or in the drawer. Just do the best you can.”*
- alternatively, if appropriate: *“I can’t tell you how to do it. Just do the best you can.”*

### Time-based cues

As explained below, the number of time-based cues that can be administered is limited. When

the limit is exceeded, the current Task should be discontinued.

Time-based cues are given after *one minute* periods of:

- **Unproductive behavior** — examples of which are grooming or toying with objects, or
- **Non-progressing behavior** — in which the subject is stuck on one aspect of the task.

Note that active scanning of the array is not considered unproductive or non-progressing, and thus should not trigger a cue.

The content of time-based cues is as follows:

- (after 1 minute of unproductive behavior) “*Remember that you are supposed to be...*” (Examiner repeats instructions for the Task, including display of the picture(s).)<sup>1</sup>
- (after 1 minute of non-progressing behavior) “*Why don’t you try something else?*”

If, after the first time-based cue, the subject does not resume task-relevant behavior, allow another minute to elapse, then repeat the cue. If on-task behavior is still not resumed, allow a third minute to elapse, then terminate the Task (without giving a third cue).

If the subject resumes task-relevant behavior after a cue, but subsequently engages in unproductive or non-progressing behavior lasting one minute, begin the cue sequence again with cue #1. Discontinue the Task if a total of 5 minutes of unproductive/non-progressing behavior is timed.

**Summary: When to discontinue a Task:**

- If there have been three *consecutive* minutes of unproductive/non-progressing behavior, discontinue the Task before giving the third cue; or
- If there has been a *total* of five minutes of unproductive/non-progressing behavior during performance of the Task, discontinue the Task before giving the fifth cue.
- Otherwise, allow the subject to continue working until they indicate that they are finished. If the subject has stopped working and appears to be finished, but portions of the Task remain incomplete, allow one minute to elapse before asking, “*Are you finished?*” This does not count as a cue, whether or not the subject resumes working.

Regardless of why the Task was discontinued, score everything up to the point of discontinuation.

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<sup>1</sup> This is the only circumstance under which the instructions are repeated. As noted previously, a request to have the instructions repeated is met with a generic cue. We reasoned that subjects differed in the ability or willingness to request help, so that repeating instructions on demand would advantage some subjects over others. To avoid this, we used unproductive behavior, instead of verbalized requests, as a trigger for instruction repetition.

## 6. Scoring procedures

There are three separate Scoring sheets (.pdf files) available, which you downloaded with this manual: NAT Score sheet (3 pages), Comprehensive Error Score sheet (4 pages), and Lateralized Attention Score sheet (1 page).

Subjects are scored for Accomplishment (i.e. steps performed). In addition, selected errors are recorded and combined with the Accomplishment score into a single NAT score ranging from 0-6 for each Task (higher scores signify better performance; maximum score for the test = 18). Scoring sheets (separate .pdf files) specify for each Task (a) which steps to score for accomplishment, (b) which behaviors to score as errors, and (c) how to calculate the NAT score. Familiarize yourself with the Scoring sheets prior to testing a subject in order to understand the definitions and descriptions of the Tasks and errors.

Errors are scored “on-line”, as the subject performs the Task. In contrast, the Accomplishment score is not tallied until the end of the Task. This can occasionally result in scoring duplication. For example, in Task 2 (Present task), the sequence error ‘*closes box flap without gift inside*’ is scored as soon as it happens. If the error is never corrected, the subject will also lose accomplishment credit that would normally be given for putting something into the box. On the other hand, if at some point the subject corrects the error by opening the box and placing the gift inside, they are awarded accomplishment credit for putting something into the box. The sequence error stands, however.

As stated, only certain behaviors are scored as errors. The scoring is not concerned with: prolonged struggles to manipulate and use items; mis-reaching that falls short of taking the wrong object; the quality of wrapping food and/or presents; or verbalizations by the subject regarding their actions. However, you may want to note these behaviors, as well as instances of other deviant actions, for clinical and family education purposes.

### **Accomplishment score**

Accomplishment steps are identified on the top section of the Scoring sheet for each Task. There are six accomplishment steps for Task 1 (three for toast; three for coffee), four for Task 2 (present), and ten for Task 3 (six for lunchbox; two for schoolbag; two for bell ringing). At the termination of each Task, the examiner checks/ticks off the steps accomplished, then sums the number of checks/ticks. This sum, expressed as a percentage, is the Accomplishment score.

### **Error score**

Each and every instance of a scoreable error should be recorded, even if subsequently corrected/repaired.

The following is a description of scoreable errors:

**Task 1 errors:**

*Toasts (or puts in toaster) more than one slice of bread:*

The instructions state that *one* slice of toast should be made.

It is an error if the subject puts two slices of bread in the toaster, even if the error is corrected before the toaster is turned on. Whether the multiple toasting is done at the same time or successively is not relevant.

*Substitutes sugar for jelly and or sugar for butter:*

Count each such substitution as a separate error.

*Repeats condiment use after intervening action:*

This is considered a perseveration. If, for example, the subject adds sugar to coffee, then butters the toast, then adds more sugar to the coffee, the second sugaring act constitutes a perseveration error.

*Omits implement for scooping, spreading, or stirring:*

Code this error if the subject uses anything other than spoon or knife to manage coffee, sugar, cream/milk, jelly/jam or butter (e.g., stirs coffee with his/her finger, pours sugar from sugar bowl).

*Violates the toast sequence:*

- applies condiment to bread before toasting
- applies jelly/jam before butter
- operates toaster before inserting bread

The correct toasting sequence is:

- bread in toaster, toaster on, toast bread, apply butter, apply jelly/jam
- Any of the above violations of this ordering constitutes an error.

**Task 2 errors:**

*Violates the giftbox sequence:*

- closes flaps before inserting gift
- closes lid before inserting flaps

The correct giftbox sequence is:

- put gift into box, close both flaps, close lid.
- code an error if the subject closes the box flaps before inserting the gift, regardless of whether the gift is subsequently inserted (this will be reflected in the Accomplishment score)
- code an error also if the subject closes the box lid with the box flaps still outside

Sometimes, a subject closes the box before inserting the gift in order to test the fit of wrapping paper. If this is a plausible interpretation of the behavior, and if the gift is inserted thereafter,

there should be no impact on either Accomplishment or Error score.

*Uses distractor object(s):*

- electric/insulating tape for cellophane tape/sellotape
- pruning scissors/secateurs for scissors
- paper bag as wrap
- stapler for cellophane tape/sellotape

Code these error instances if and only if the distractor object is used in place of the target. Other uses of the distractor object (e.g. pruning scissors/secateurs or stapler as the gift) are not coded as errors. Nor is simply picking up and putting down the distractor coded as an error.

*Affixes bow without removing backing (no tape used):*

Code this error only when the subject places the bow without sticking it on. It is not an error if a subject uses cellophane tape/sellotape to affix the bow to the box.

Note: Do not code errors for the quality of gift wrapping. Any reasonable attempt to cover the gift is acceptable.

### **Task 3 errors:**

*Omits use of knife when applying mustard/butter:*

Code this error if the subject uses instead their finger to apply mustard/butter to the bread, or substitutes the spoon or fork (from the drawer).

*Foil wrap too small (gap greater than 1"/25mm):*

When the subject uses foil to wrap the sandwich or the cookies/biscuits, note whether the piece ripped from the foil roll covers the object adequately. If the gap in coverage is more than 1"/25mm, code an error.

*Violates the juice-thermos sequence:*

- attempts to pour juice without opening juice bottle
- places lid or cup on an empty thermos without juice in it
- places cup on thermos without lid
- packs thermos into lunchbox without cup or without both cup and lid
- packs thermos into lunchbox without filling with juice (no lids on)

The correct sequence is:

- open juice bottle, pour juice into thermos, place lid on thermos, place cup on thermos
- Any of the cited violations of this ordering constitutes an error, and it is possible to make multiple errors. Sometimes a subject will test the fit of the thermos lid and/or cup before that step is called for. If this appears to be the case, and the hand does not leave the lid or cup, do not code a sequence error. If the hand does leave the lid or cup, do code the error.

*Packs object into wrong container:*

- puts lunchbox objects into schoolbag

- puts schoolbag objects into lunchbox
- puts lunchbox/schoolbag objects into drawer
- puts drawer distractor-objects into lunchbox/schoolbag

When the subject moves small objects (e.g. pencils, erasers), one handful equals one instance of the error. Note how many times the subject places an object or “handful” in the incorrect location and record each one as an error. Packing the *filled* lunchbox into the schoolbag is not an error; packing an *empty* lunchbox is an error. It is required only that the binder is packed in the schoolbag; the final disposition of the paper is not relevant (unless no paper is packed inside the schoolbag).

*Bell ringing requirement:*

Failure to ring the bell after completing the first part of the Task (lunchbox) results in loss of accomplishment points. This failure is recorded as soon as the subject completes the first part of the Task (lunchbox) and engages any object from the second part of the Task (schoolbag). Whether or not the subject remembers to ring the bell later is irrelevant. If the subject simply scans the table before ringing the bell, without touching second-task objects, do not penalize the score. Failure to ring the bell after completing the second part of the Task (schoolbag) also results in a loss of accomplishment points.

**7. Interpretation of the NAT score**

**Discrimination among patient and control groups**

Tables 1 and 2 provide demographic and clinical information on a sample of 45 RCVA, 30 LCVA, 25 TBI, and 28 controls to whom we administered the NAT (15). The mean total NAT score for patients was 10.9 (SD 5.5) and for controls, 17.3 (SD 1.2) ( $U = 355, p < .001$ ).

The lowest score for controls was 14, with 71 percent scoring a perfect 18. Patients’ scores were distributed across the whole score range (0-18). Two-thirds of the patients scored outside the control range.

Mean NAT scores for TBI, RCVA, and LCVA were, respectively, 12.6 (SD 5.8), 10.3 (SD 4.9), and 10.3 (SD 6.0).

Table 1.

Demographic data

GROUP	AGE		EDUCATION (YEARS)		GENDER
	Mean	Range	Mean	Range	Males, Females
<b>Patient</b>					
LCVA (N=30)	62.3	34-80	12.5	3-20	11, 19
RCVA (N=45)	60.5	37-80	11.7	6-20	23, 22
TBI (N=25)	35.7	18-66	12.3	5-20	23, 2
<b>Control</b>					
CVA controls (N=20)	62.1	44-80	13.5	9-19	8, 12
TBI controls (N=8)	37.3	18-69	12.8	12-16	5, 3

Table 2.  
Clinical data

Group	Days Post Onset		Glasgow Coma Scale *		Total FIM Score (max. 126)		Motor/Cognitive Symptoms (% of group)			
	Mean	Range	Mean	Range	Mean	Range	Hemi-paresis	Aphasia	Receptive Aphasia	Hemispatial Neglect
LCVA (N=30)	56.9	9-202	Not Applicable		93.4	60-118	73%	70%	13%	17%
RCVA (N=45)	43.0	6-138	Not applicable		95.3	66-121	82%	7%	2%	38%
TBI (N=25)	72.4	15-241	9.0	3-15	101.3	43-121	4%	40%	40%	16%

\* Assessed at time of initial injury; records available for 19 TBI patients.

### Percentile equivalents of raw scores

Table 3 shows the distribution of NAT scores obtained in the validation study, broken down by diagnosis and age. In that study, a score of six in a young TBI patient corresponded to the eighth percentile. The same score in an older TBI patient corresponded to the thirty-third percentile. For younger CVA patients, a score of 12 corresponded approximately to the fiftieth percentile (14 percent + 42 percent of those patients scoring at or below 12), whereas in the older CVA group a score of 6 corresponded approximately to the fiftieth percentile (49 percent scoring at or below 6).

Examiners may find this a useful guide for interpreting the scores of their CVA and TBI subjects. However, caution is warranted due to small numbers in the cells of the table.

Table 3.

The distribution of NAT scores by diagnosis and age grouping.

Percentages are calculated on the number of patients in each age grouping. Higher scores signify better performance.

	TBI pts (n=25)			
	≤35 years of age		>35	
Total NAT Score	No.	Percentage	No.	Percentage
0-6	1	8%	4	33%
7-12	2	15%	2	17%
13-18	10	77%	6	50%
	CVA pts (n=75)			
	≤60 years of age		>60	
Total NAT Score	No.	Percentage	No.	Percentage
0-6	5	14%	19	49%
7-12	15	42%	11	28%
13-18	16	44%	9	23%

## Errors

Patients committed on average 4.3 overt errors (SD 3.6), and controls committed one-tenth that (Mn. 0.43, SD .75). No control made more than three errors, whereas half of the patients did.

Four errors occurred with disproportionate frequency among the poor performers. The error of mis-sequencing the steps in toasting or condiment use was made by 34 percent of low-scoring (0-6) patients and 17 percent of moderate (7-12) scoring patients at least once, whereas the incidence among high scoring (13-18) patients and controls was 2 percent and 4 percent, respectively. Other discriminating errors were: affixes bow without removing backing; omits implement in applying mustard; and packs lunchbox item in schoolbag, or vice versa. The presence of these errors may be useful as an additional index of severity.

## Task scores and brief administration of the NAT

The Tasks of the NAT were ordered to reflect gradation in difficulty. Mean (and SD) scores for patients were 4.55 (2.04), 3.35 (2.42), and 2.95 (2.23) on Tasks 1, 2, and 3 respectively. Controls were near ceiling on all Tasks (Means 5.57-5.86).

The majority (64 percent) of dementia patients studied in Giovannetti *et al.* (2002) who earned a low score on Task 1 also earned low scores on Tasks 2 and 3; and every patient (18/18) who scored low on both Tasks 1 and 2 also scored low on Task 3. In the validation-study sample of CVA and TBI patients, Task scores between one and four were defined as “low”, and scores of five or six were defined as “high”. We found that 88.5 percent of the patients who scored low on Task 1 also scored low on Tasks 2 and 3; and 97 percent of the patients who scored low on both Tasks 1 and 2 scored low on Task 3.

Application of a rule that discontinues patients who score low on the first two Tasks and assumes a low score on Task 3 would have correctly classified 49/50 (98 percent) of patients in the combined samples from these two studies. When time is limited, or subjects uncooperative, low scores on Tasks 1 and 2 may be considered sufficient evidence of the presence of naturalistic action impairment.

## 8. Reliability and validity of the NAT

As stated earlier, the NAT was standardized on 45 RCVA, 30 LCVA and 25 TBI inpatients in a rehabilitation setting. Two groups of non-neurological control subjects were also tested; one was age-matched to the CVA patients (n=20), the other to the TBI patients (n=8). Demographics and clinical information are presented in ref. 15.

### *Scoring reliability*

To assess inter-rater reliability, in-room (“on-line”) coding of 20 patients by a relatively inexperienced clinician was compared to a second, experienced coder’s scoring from videotape. The inter-rater reliability study yielded high agreement on both Accomplishment and Error scores. Across the three Tasks of the NAT, median weighted kappa for Accomplishment score was 0.98 (range 0.95-1.0). Percent agreement was calculated as the number of subjects for whom both raters agreed on the presence or absence of an error. The median agreement was 98 percent (range 70-100 percent). The median percent agreement on the number of times a particular error occurred was 95 percent (range 70-100 percent). These high kappas and agreement estimates demonstrate that accomplishment and error coding is reliable across scorers, even when scoring is done on-line.

### *Internal consistency*

The internal consistency of the NAT, as measured by Cronbach’s coefficient alpha, was 0.79 for the entire sample and 0.75 for the patient sample. These scores provide acceptable confidence that the three NAT Tasks are measuring a single unidimensional construct (i.e. naturalistic action).

### *Concurrent criterion validity*

The NAT measures impaired functionality in terms of task accomplishment and errors. We validated it against the FIM (5), the criterion for disability measurement, which is based on clinician ratings of caregiver assistance. The NAT yielded robust correlations (around 0.5) with both the physical and cognitive subscales of FIM.

### *Construct validity*

On the theory that naturalistic action impairment arises in the same way as spontaneous action and memory slips, i.e., from insufficient resources being allocated to the task at hand, in Schwartz et al. (15) we validated the NAT against a battery of attention tests and found strong and consistent correlations with a measure of processing speed/arousal ( $r = -0.68$ ) and with a measure of visuospatial attention ( $r = 0.61$ ). These effects suggest that diminished arousal/resource capacity, as well as visuospatial impairments, are factors that contribute to error vulnerability (see also 1, 4, 13, 16). The NAT also correlated significantly ( $p < 0.001$ ) with measures of working memory. For one such measure, the item correlation was strongest for NAT Task 3, which entails searching for a target object in a drawer and remembering to signal after completion of the lunchbox and again after completion of the schoolbag. This suggests that the

full NAT, and particularly Task 3, taps the capacity to store and manipulate information in working memory.

### *Predictive validity*

The NAT's predictive validity was assessed against the *Instrumental Activities of Daily Living* (IADL) scale, a widely used measure of independence in home and community (8). A significant association was found between discharge NAT (NAT1) and follow-up IADL in bivariate analysis ( $r = 0.58$ ) and in multiple regression analyses. The multiple regression analyses showed that NAT1's success in predicting IADL was independent of its correlation with FIM, age, or the various attention measures. NAT1 outperformed the FIM cognitive subscale in the prediction of IADL score. It also outperformed each of the attention tests. This is presumably because the NAT is sensitive to multiple attention capacities, just as IADL performance is likely to be. Finally, the correlation between a second NAT (NAT2), administered at the same time as the IADL measure, was also strong ( $r = 0.64$ ), as was the correlation of NAT2 and NAT1 (0.66).

## **9. Auxiliary (optional) scoring systems**

### **Comprehensive Error Score (CES)**

The CES codes errors in a manner that more closely approximates what was done in the MLAT studies (for discussion and interpretation, see ref. 1, 4, 13, 16). It recognizes ten types of error, under which nearly 200 individual errors can be scored.

Giovannetti (unpublished) computed CES scores for a subset of the CVA and TBI patients ( $n=46$ ) who participated in the NAT validation study (15). Approximately twice as many errors were recorded with the CES scoring system as with the NAT. Nevertheless, CES and NAT scores were highly correlated (Spearman  $\rho = -0.83$ ) and there was good agreement (83 percent) on the classification of patients as impaired/unimpaired under the two scoring systems.<sup>2</sup>

The CES scoring of the NAT may be useful to researchers and clinicians who want to know more about the specific error tendencies of their subjects.

CES coding must be done from a videotaped record of the subject's performance. The CES Scoring sheet contains an exhaustive listing of scoreable errors for each Task. (This is true for all but Action Addition and Quality errors, which can not be exhaustively enumerated.) Scorers should use the column to the right of the error description to check off an occurrence of that error (or more than one occurrence, if appropriate). Page 1 of the CES Scoring sheet provides an aid in tabulating the number of errors per error type across the entire test. It also lists and defines the ten error types of the CES.

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<sup>2</sup> For each scoring system, a cut-off of  $>2$  standard deviations from the respective control mean was used to classify patients as impaired or non-impaired. CES omission errors were compared to lost accomplishment score points according to the NAT.

As will be obvious from the enumeration of error instances on the Scoring sheets, the number of scoreable errors varies across error types. For example, there are sixteen possible gesture errors enumerated on the Scoring sheets (seven, four, and five for Tasks 1, 2 and 3, respectively), compared with thirty-five possible Step Omissions. The CES score thus affords more “opportunities” for Step Omissions than Gesture errors. This should be taken into account when interpreting the error patterns of individual subjects or variations in error patterns across Tasks of the NAT (since the number of opportunities (i.e. scoreable errors) varies across Tasks). For these purposes, it is recommended that users calculate a *standardized error rate*, using the following procedure (see ref. 16):

To calculate standardized error rate:

1. Tabulate the number of errors (of a given type) committed on a given Task or on the test as a whole
2. Divide by the number of errors of that type that the Scoring sheet enumerates
3. Multiple by 100 (to eliminate decimals)

Users interested in calculating standardized error rates for Action Additions, which are not exhaustively enumerated on the Scoring sheet, can use instead the number of objects in the array as their estimate of the number of opportunities (i.e. the divisor in step two). A listing of these is given in Section 2 of this manual.

### **Lateralized Attention Score (LAS)**

The NAT is useful in detecting lateralized (left or right) spatial attentional biases in naturalistic action in stroke and other subjects with unilateral lesions. Such biases can be quantified by means of the Lateralized Attention Score (LAS). LAS coding must be completed by reference to a video recording of the subject’s performance.

There are three steps to calculation of the LAS:

1. Using the LAS Scoring sheet, count the number of objects used (or at least touched) at least once, maintaining separate tallies for objects located on the right and left.
2. Calculate the proportion of objects used/touched on each side of the table (grand total of objects used/touched divided by possible objects). The denominator of the formula is the total number of objects on each side of the table, as these are positioned at the start of the three Tasks (18 on the left and 16 on the right). For example, if a subject were to touch nine of the 18 objects on the left and four of the 16 objects on the right, their left proportion would be 0.5 and their right proportion 0.25.
3. Subtract the contralesional from the ipsilesional proportion to derive the LAS (i.e. LAS = ipsilesional proportion - contralesional proportion). For a RCVA, the right of the array is ipsilesional and the left of the array is contralesional, and *vice versa* for a LCVA. If a subject with a LCVA had a left proportion of 0.5 and right proportion of 0.25, their LAS would be (0.5-

0.25) = 0.25. This indicates that this hypothetical subject used and/or touched 25 percent more ipsilesional than contralesional objects.

In our sample of RCVA and LCVA subjects, the LAS was significantly different from zero, and in the positive direction, for both CVA groups (RCVA: Mn 0.13, SD 0.195,  $t$  (df=44) = 4.5,  $p < 0.0001$ ; LCVA: Mn. 0.09, SD. 23.1;  $t$  (29) = 2.2;  $p < 0.05$ ). This indicates that on average, RCVA subjects used 13 percent more ipsilesional objects and LCVA subjects 9 percent.

The LAS also correlated significantly with an ipsilesional minus contralesional score from a computerized task requiring responses to lateralized targets (RCVA:  $r = -0.36$ ,  $p < 0.05$ ; LCVA:  $r = -0.50$ ,  $p < 0.01$ ), and in LCVA, with an ipsilesional minus contralesional measure from Star Cancellation, a subtest of the Behavioral Inattention Test (18) ( $r = 0.63$ ,  $p < 0.001$ ).

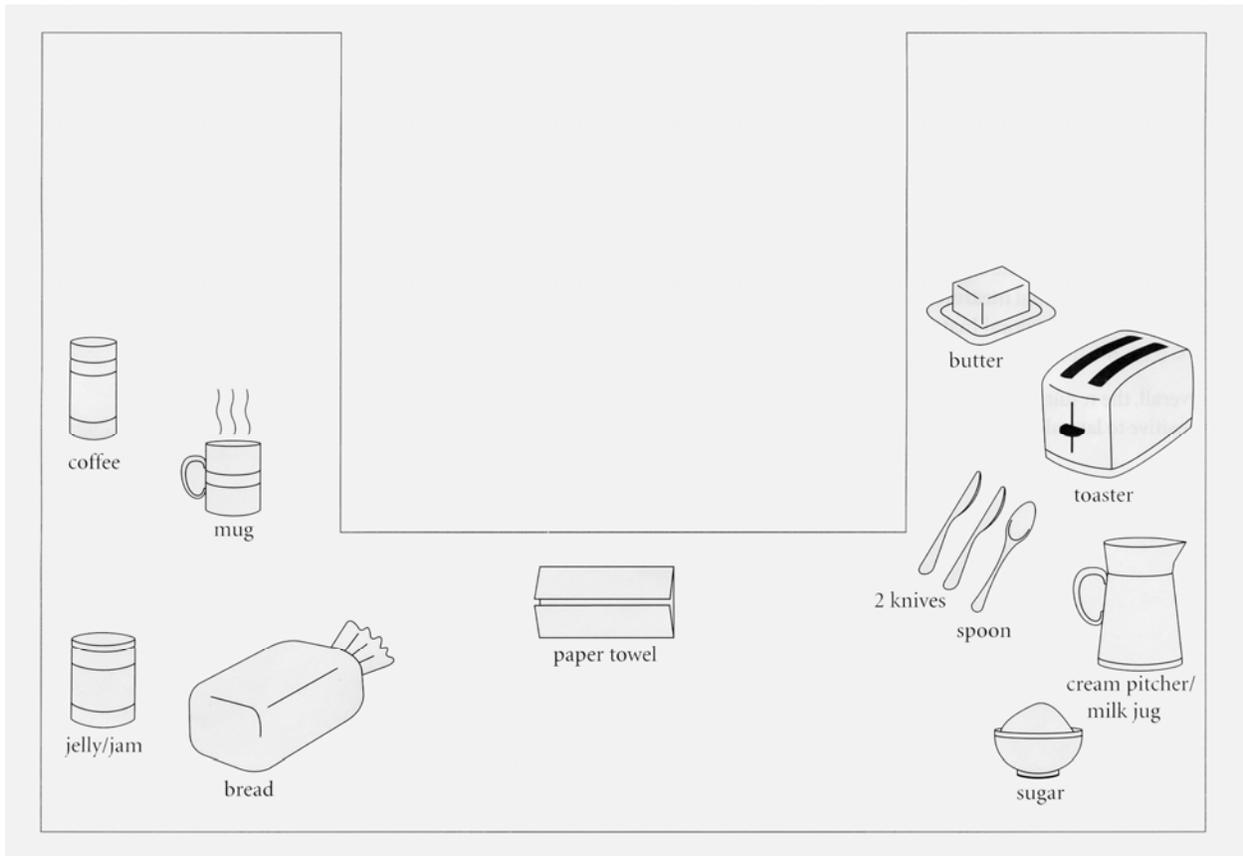
Overall, the results support the conclusion that the LAS is sensitive to lateralized attentional bias in both CVA groups.

## 10. References

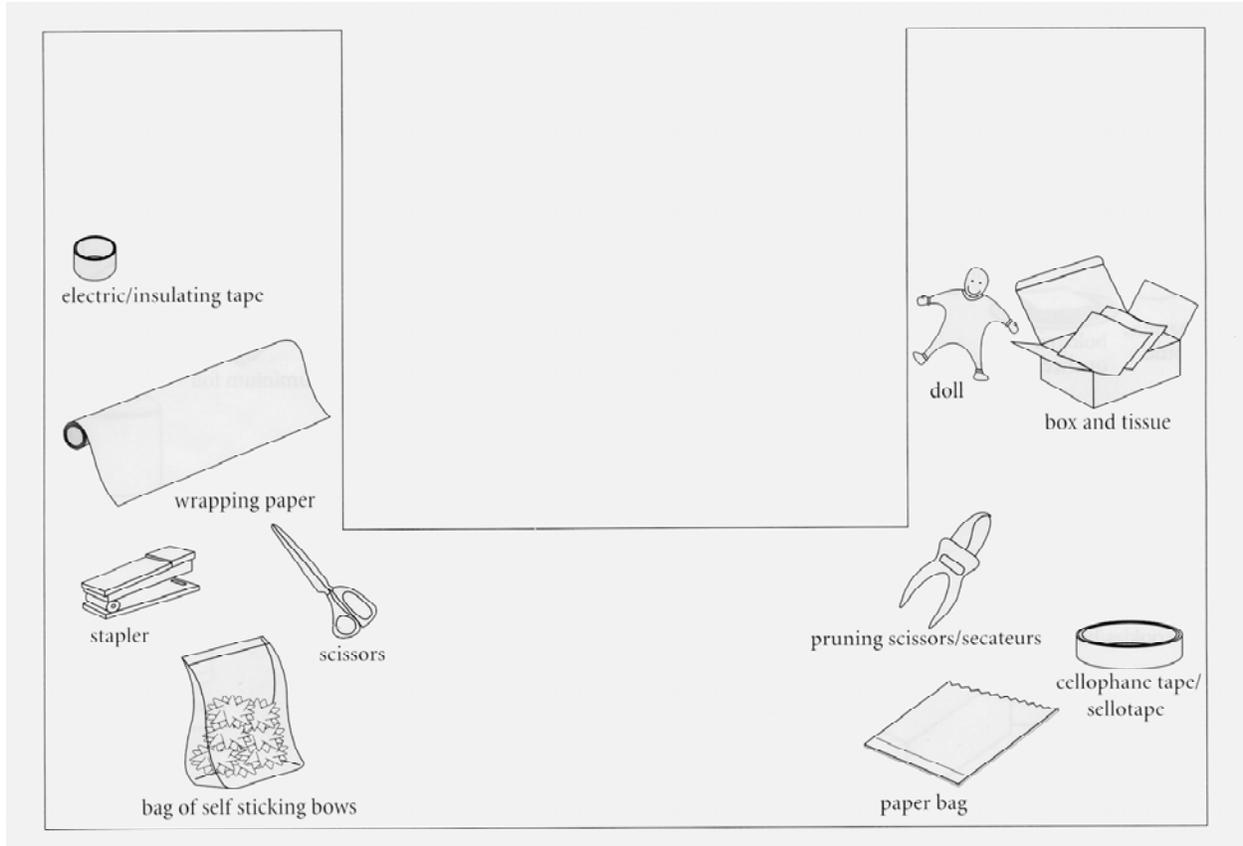
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**Table layout for Task 1 (Toast and Coffee)**



**Table layout for Task 2 (Present)**



**Table layout for Task 3 (Lunchbox and Schoolbag)**

