Note: This material was adapted from the original CANTAB administration manuals for adult subjects by Paul Fray Ltd. Control Systems. This manual includes task administration instructions only. For issues regarding setup of the CANTAB and processing task data for analysis, Paul Fray’s CANTAB manuals are essential.
I. Initial Set-up/Preparation

Overview.
The CANTAB is a battery of neuropsychological tests written for IBM-compatible computers using a high resolution touchscreen monitor. The battery consists of two software diskettes and a response key/hard lock that can be ordered from Paul Fray, Ltd. Control Systems, 4 Flint Lane, Ely Road, Waterbeach, Cambridge CB5 9QX, UK. The authors of the CANTAB are J.L. Evenden, R.G., Morris, T.W. Robbins, and B.J. Sahakian at the Department of Experimental Psychology, University of Cambridge.

Hardware Requirements.
Specific details about CANTAB’s hardware requirements are available in the accompanying manuals from Paul Fray, Ltd. It is assumed that the user has a working CANTAB system that is ready for data collection. CANTAB runs through DOS.

Preparing for Data Collection.

A. The computer should be turned on and the touchscreen calibrated before each run. The screen should be cleaned with a mild alcohol solution prior to each subject run.

To Calibrate Screen: Two steps:

(1) In the directory: c:/cantab, the user types: calib <enter key>

You will be presented with screen instructions to touch the top right and bottom left corners of the screen. If this procedure is successful, the computer will verify the calibration with an on-screen message.

(2) At the c:/cantab/ prompt, the user types: grid <enter key>

You will be presented with a grid-like map of the screen. Run one finger across the grid in any path. You should see a tracing of the path on the screen to ensure that the screen is accurately responding to your touch.

Touch the Esc key to exit calibration/grid modes.

B. The experimenter should be seated in front of the keyboard, which should be placed to the left or right of the monitor. The subject should be seated in front of the monitor. The experimenter should be positioned to easily demonstrate each task to the subject by touching the monitor.

C. The subject should be seated at a comfortable distance from the screen, with enough room to easily reach both the screen (top to bottom) and the CANTAB keypad/hard lock. We have found the use of booster seats necessary to test young children.

Accessing the CANTAB program groups:
At the c:\ prompt, type cd cantab (to get into the Cantab directory
type cantab (to start the Cantab program)

You will see a menu on the screen that lists each testing battery. CANTAB contains three subtask batteries that test functions of Working Memory, Visual Memory, and Attention. The following options are available on the computer screen:

- Working Memory/Planning (one battery)
- Parallel Practice Battery
- Parallel Battery One
- Parallel Battery Two
- Parallel Battery Three
- Parallel Battery Four

All of the parallel batteries contain different versions of the Visual Memory and Attention subtasks. There are also menu options for analyzing data and for exiting the CANTAB program.

The batteries are comprised of the following subtasks:

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Many of the CANTAB subtasks have well-studied neural correlates in adult subjects. The following diagram illustrates the primary brain areas that are activated during CANTAB subtasks:
In the collection of normative data, we ran tasks in the following order:

Working Memory/Planning Battery

Parallel Battery One: Pattern/Spatial Recognition

Parallel Battery One: ID/ED Set Shift

This six-task battery can be administered to a 4-to-8 year-old child in approximately 60-90 minutes depending on the maturity level of the child. (We have found that taking planned breaks during task administration is NOT a good idea. If a child appears to be fatigued, extremely fidgety, or asks for a break, then one is certainly offered. Otherwise, if breaks are offered at regular intervals when the child is in a motivated-to-work state, there is a decreased likelihood that s/he will return to the battery with the same degree of motivation.)

To begin with the Working Memory Battery, touch the box labeled “Working Memory/Planning”.

The first thing that you must do before starting the actual tasks is to enter subject details (e.g., a name, identification number, or some other code that you will remember). CANTAB automatically adds date and time to each file. Select the menu option labeled “Enter subject details”. Once subject details are correctly entered, touch the menu option that says

Select the option that says “Run Working Memory/Planning battery”. This ensures that all of these working memory/planning tasks will be administered. You can also select the option that says “Run Individual Test” to administer single tasks.
II. THE WORKING MEMORY/PLANNING BATTERY

Each task is described in the order in which it is administered if you are running the entire battery.

A. MOTOR SCREENING TEST

Purpose of Task: This task is the most simple of all the tasks that are administered. It is used to measure psychomotor speed and accuracy as well as to illustrate the use of the touch screen to each subject.

Say:

*Here is the computer that we will be using to play some games. I am going to show you how it is used.*

_Do you know the letters of the alphabet?_ [Wait for a response]

_How about the letter ‘X’?_ [If the subject does not know the letter ‘X’, show him/her what it looks like on the keyboard].

_For this task, you will see some large ‘X’’s on the computer screen, one at a time. Your job is to touch the ‘X’ in the center, at the place where the two lines meet. You are to touch the ‘X’ as quickly but as carefully as you can, okay?*

_I will do the first three just to show you how it works, then it will be your turn._

Press the SPACE BAR. An ‘X’ will appear at some random location on the screen. The ‘X’ will be purple. When you touch the X displayed on the screen, it will turn green, and a tune sounds.

_Say:_ *The idea is to touch the X’s when they flash on the screen, as I am doing now. (Demonstrate). You must use the tip of your finger to touch the X correctly. After you touch the X, you must then take your hand away after you hear the song so that the next X will appear, okay?*

_After three X’s, the computer will pause with the message, PLEASE WAIT._

_Say:_ *Now it is your turn. Remember to press the X’s with the tip of your finger as quickly as you can.*
NOTE: YOUNG CHILDREN OFTEN DO NOT TOUCH THE SCREEN WITH ENOUGH PRESSURE. IF THIS HAPPENS, REACH OVER TO TOUCH THE ‘X’ WITH THE CHILD SO THAT LATENCIES ARE MOST ACCURATELY RECORDED. IT MAY BE NECESSARY TO RECALIBRATE THE SCREEN IF THE CHILD HAS TROUBLE ON EACH OF THE 10 MOTOR SCREENING TRIALS.

Make sure that the subject does not rest his/her hand on the base of the screen or on the screen itself. If the child touches the screen between trials or incorrectly in the course of a trial, the task will enter a “pause” mode until the child lifts his/her hand from the screen.

Encourage the child to place his/her hand on the table in front of the screen after each response.

Prompts to use if the subject does not do the task correctly:

**USE THE TIP OF YOUR FINGER.**

**NOW LOOK FOR THE NEXT ONE THAT FLASHERS.**

At the end of the test, the screen will read “Please wait”.

Press the **space bar** to start the next task.
B. SPATIAL SPAN TASK

Purpose of Task: This task is a measure of spatial memory span. The child must watch a sequence of events and then reproduce the sequence by memory. This task most likely involves the dorsolateral and ventrolateral frontal lobes of the brain in association with temporal and parietal association cortices.

Instructions:

*FOR THIS TEST, YOU WILL SEE A LOT OF WHITE SQUARES ON THE SCREEN.*

[Demonstrate by sweeping your hand across the screen].

*ONE BY ONE, SOME OF THE SQUARES ARE GOING TO CHANGE COLOR. YOUR JOB IS TO REMEMBER THE ORDER IN WHICH THE SQUARES CHANGE COLOR—WHICH ONE CHANGES FIRST, WHICH ONE CHANGES SECOND AND SO ON. DO YOU UNDERSTAND?*

Note: It is necessary to make sure that very young children understand the concept of “first” and “second”.

*LET'S SEE HOW IT WORKS.*

Press the SPACE BAR.

You will be given a choice of 1, 2, or 3 practice trials. We typically select 2 practice trials.

You will also be asked how many squares you want to start the initial test sequence. Select 2 again.

After your choice is made, you will be asked to specify whether you want the test to terminate when the subject’s maximum span has been reached or after a further level of difficulty (e.g., super span conditions).

The choice is made by pressing N or Y. Press N.

(Pressing Y indicates that you will measure “super span” which takes a long period of time and can be frustrating for the child. Super span administers trials until 2 difficulty levels beyond the child’s apparent maximum have been completed.)

*Practice Trials:*
At this point, the first practice trial appears.

**Practice Trial 1:** One by one, two white squares will change color. The second color change will be followed by a tone. As this first practice trial is being presented, the tester should demonstrate while at the same time saying to the subject:

```
SEE, NOW THE FIRST SQUARE IS CHANGING COLOR AND NOW THE SECOND SQUARE IS CHANGING COLOR. NOW WE HEAR A BEEP.

AFTER THE BEEP, YOU TOUCH THE ONE THAT CHANGED COLOR FIRST (DEMONSTRATE) AND THEN THE ONE THAT CHANGED COLOR SECOND (DEMONSTRATE).
```

At the end of the trial, the screen will print “FINISHED” followed by “NEW SET”.

Press the **SPACE BAR** to continue.

**Practice Trial 2:** *NOW YOU TRY. WATCH THE SCREEN CAREFULLY. YOUR JOB IS TO REMEMBER THE ORDER IN WHICH THE SQUARES CHANGE COLOR.*

When the tone sounds, say to the subject:

```
NOW TOUCH THE SQUARE THAT CHANGED COLOR FIRST AND THE SQUARE THAT CHANGED COLOR SECOND.
```

Sometimes, a child will respond so quickly from touch-to-touch that the touch screen will not keep up with the responses. If this problem occurs, say to the child:

```
MAKE SURE YOU TAKE YOUR FINGER AWAY FROM THE SCREEN BETWEEN TOUCHES. WAIT BETWEEN EACH TOUCH UNTIL YOU SEE THE BOX CHANGE COLOR.
```

**PROMPTS:**

```
KEEP LOOKING.

TAKE YOUR FINGER AWAY BETWEEN TOUCHES.
```

*Test Trials:*
Test Trial 1:  Repeat instructions as necessary. This trial will be a 2-item trial.

Trials 4-end:  If the subject passes the first 2-item trial, say

THIS TIME THERE WILL BE 3 SQUARES THAT CHANGE COLOR.

The child has 3 attempts to solve each level of difficulty correctly. If the subject makes mistakes in all 3 trials at a particular level, the program will terminate.

If the subject passes a particular level, the program continues with 4 items, 5 items, 6 items......up to 9 items.

Occasionally, a child will ask at the beginning of the task what the maximum number of color changes will be. Since memory span varies individually, say to the child:

It’s different for everyone. Let’s see.

At the end of the test, the screen will read: “PLEASE WAIT”.

Press the SPACE BAR to start the next task.
Purpose of Task: This task measures working memory, the process whereby information is held in mind over a brief delay in order to accomplish a goal. This is a self-ordered searching task. The child must search for (and find) blue tokens that are hidden inside of colored squares on the screen. The number of items to be searched increases as the task progresses from 2 items to 8 items.

Illustration of Task:
Prior to the start of the task, you will be given a choice of which level of difficulty you want to start. The easiest items involve 2-item searches; the most difficult involve 8-item searches.

The recommendation is to begin at 2 items (e.g. for cognitively impaired subjects or 3 items (for older subjects). We always begin at 2.

Practice Trials:
On the first display, you will see 2 red squares. On the right side of the screen, there will be a black column (“home base”). Refer to the red squares as boxes. Say that inside of the red boxes will be blue squares hidden inside.

Instructions assume a starting difficulty level of 2. These can be adapted with increasing difficulty levels.

Practice Trial 1:

**THE FIRST THING I WANT YOU TO NOTICE IS THIS BLACK COLUMN (POINT TO THE RIGHT SIDE OF THE SCREEN.) WE THINK OF THIS AS A LITTLE HOME OR A HOME BASE.**

**WHAT BELONGS IN THE HOME BASE ARE SOME BLUE SQUARES. THE BLUE SQUARES ARE HIDDEN INSIDE OF THESE BOXES (POINT TO RED BOXES ON THE SCREEN). YOUR JOB IS TO FIND THE BLUE SQUARES AND PUT THEM AWAY IN THEIR HOME.**

**TO FIND A BLUE SQUARE, YOU NEED TO TOUCH ONE OF THE RED BOXES LIKE THIS (DEMONSTRATE). (THE FIRST SQUARE THAT YOU TOUCH WILL ALWAYS HAVE A BLUE SQUARE INSIDE OF IT). YOU CAN SEE THAT THE BOX HAS A BLUE SQUARE INSIDE OF IT.**

**NOW WE PUT IT AWAY BY TOUCHING OVER HERE.** (TOUCH THE BLACK COLUMN TO DEMONSTRATE THAT THE BLUE SQUARE WILL BE MOVED THERE).

Say:

**THERE IS STILL ANOTHER BLUE SQUARE TO FIND. BUT, HERE IS THE RULE FOR THIS TASK: THE RULE IS THAT THE COMPUTER WILL NEVER HIDE THE BLUE SQUARE IN THE SAME PLACE MORE THAN ONCE. SO, SINCE WE HAVE JUST FOUND A SQUARE HERE (POINT TO THE BOX YOU JUST TOUCHED), I NEED TO TOUCH THE OTHER BOX (DEMONSTRATE) TO FIND THE OTHER SQUARE. THEN I PUT IT IN THE COLUMN WITH THE FIRST ONE.**

**NOW I AM FINISHED BECAUSE I HAVE FILLED THIS COLUMN WITH BLUE SQUARES.**

The computer will print “completed” and play a short song. Then the words “NEW SET” will appear.

**SAY: NOW IT IS YOUR TURN.**

Press the **SPACE BAR**.
Practice Trial 2:

Two yellow boxes will appear on-screen.

Say:  

TOUCH ONE OF THE BOXES TO SEE IF THERE IS A BLUE SQUARE INSIDE.

Note: By design, the first box that the child touches on this trial will NOT have a blue square inside. Often this trial will be confusing to the child (and to many adults).

Say:

YOU SEE, THERE IS NOT A BLUE SQUARE IN THAT BOX YET.

(Implying that there will eventually be one located there).

It is a good idea at this point to re-state this element the task rule:

EACH BOX WILL HAVE A BLUE SQUARE IN IT AT SOME POINT.

After the subject responds by touching the other box, say:

NOW YOU HAVE FOUND ONE BLUE SQUARE. LOOK FOR THE OTHER ONE. REMEMBER THAT IT WILL NOT BE IN SAME BOX WHERE YOU JUST FOUND ONE.

If the subject makes a mistake, say: REMEMBER THAT THE SECOND BLUE SQUARE WILL NOT BE IN THE SAME BOX AS THE FIRST ONE.

Test Trials: .

The first four test trials will consist of 2-item searches.

Repeat the essential instructions used in the practice trials if needed. Most of the time the child is able to solve the first few test problems without difficulty.

PROMPTS: REMEMBER TO LOOK FOR THE BLUE SQUARE IN A DIFFERENT BOX FROM WHERE THE OTHER ONE WAS.

OR

GOOD TRY. TRY AGAIN.

The number of boxes will now be gradually increased. Following the four 2-item searches, there will be four trials with 3 items, four trials with 4 items, four trials with 6 items, and four trials with 8 items.

At each trial, say: NOW THERE ARE “N” BOXES AND ‘N’ BLUE SQUARES TO FIND.
With young children, it helps to ask them at the start of each level if they remember the rule.

After the first blue square has been found on a trial, say:

 YOU HAVE ‘N-I’ MORE TO FIND. REMEMBER, THEY WILL BE IN DIFFERENT BOXES FROM THE FIRST ONE.

Avoid reminding the subject of this instruction from now on. Use the following prompts if needed:

 REMEMBER TO PUT IN ON THE RIGHT.

 LOOK FOR ANOTHER ONE.

We successfully administer every trial of this task to all children between the ages of 5 and 8. Four year-olds often start to randomly search at the 6-item level. Apparently random searches are NOT in themselves an acceptable reason to abort the task. In order to get a measure of strategy use, all of the 6 and 8-item trials must be administered. If random searching is accompanied by extreme frustration, anger, fidgetiness or threats to discontinue, it is permissable to abort the task (by pressing the ESC key) after the last 6-item trial.
D. TOWER OF LONDON.

*Purpose of Task:* The Tower of London (not to be confused with the Tower of Hanoi) is a measure of planning and inhibitory control. On each trial, the child must solve a problem in a minimum number of steps. As the number of problem-solving steps increases, the planning requirements of the task increase.

*Illustration of Task:*
Practice Problems:

The task begins with several 1-step problems. For the purposes of task administration, these can be considered practice trials, because they are not scored.

The first problem is to be demonstrated by the tester. Afterwards, the subject must make all moves him/herself.

Say:

**THIS GAME CAN BE A LITTLE TRICKY TO UNDERSTAND. I AM GOING TO SHOW YOU HOW IT WORKS, SO PAY CLOSE ATTENTION. REMEMBER NOT TO TOUCH THE SCREEN UNTIL AFTER I HAVE EXPLAINED ALL OF THE RULES.**

Press the **SPACE BAR** to bring up the first trial on the screen. Say:

**FIRST, I WANT YOU TO NOTICE THAT THE SCREEN IS DIVIDED INTO TWO PARTS, A TOP HALF AND A BOTTOM HALF. THE TOP HALF OF THE SCREEN (POINT) IS GOING TO BELONG TO THE COMPUTER. YOU WON'T EVER HAVE TO TOUCH ANYTHING UP THERE.**

**THE BOTTOM HALF OF THE SCREEN (POINT) IS GOING TO BE YOUR WORK SPACE.**

**LOOK AT THE TOP HALF OF THE SCREEN. WE THINK OF THESE AS COLORED BALLS STACKED UP IN HOLES. HERE (POINT TO THE FIRST COLUMN) THERE ARE THREE HOLES. THERE IS A RED BALL ON TOP OF A GREEN ONE. HERE (POINT TO THE SECOND COLUMN) THERE ARE TWO HOLES BUT NO BALLS INSIDE, AND HERE (POINT TO THE LAST COLUMN) THERE IS ONE HOLE WITH A BLUE BALL IN IT.**

(It is useful here to make sure that young children know how to recognize the colors blue, green, and red).

**NOW LOOK AT THE BOTTOM OF THE SCREEN. YOU ALSO HAVE SOME ROWS OF BALLS HERE. BUT YOU CAN SEE THAT YOUR BALLS ON THE BOTTOM ARE IN DIFFERENT PLACES THAN THE BALLS ON THE TOP.**

**YOUR JOB IS TO PUT YOUR BALLS IN THE SAME PLACES AS THE ONES ON THE TOP. YOU WANT THIS ROW (POINT TO BOTTOM LEFT) TO LOOK LIKE THIS ROW (POINT TO TOP LEFT). YOU WANT THIS ROW (POINT TO BOTTOM MIDDLE) TO LOOK LIKE THIS ROW (POINT TO TOP MIDDLE) AND YOU WANT THIS ROW (POINT TO BOTTOM RIGHT) TO LOOK LIKE THIS ROW (POINT TO TOP RIGHT).**

Note: Very young children (ages 4 & 5) often do not understand conceptually what they are supposed to do until after 3-4 trials have been explained.
NOW THE WAY TO MAKE YOUR PART OF THE SCREEN LOOK LIKE THE TOP IS BY MOVING YOUR BALLS AROUND. TO MOVE A BALL, YOU TOUCH IT LIKE THIS (TOUCH THE BLUE BALL).

YOU CAN SEE THAT THE BALL IS FLASHING. THAT MEANS THAT IT IS READY TO MOVE.

NOW YOU HAVE 2 CHOICES. YOU CAN EITHER TOUCH THE PLACE WHERE YOU WANT TO MOVE THE BALL, OR IF YOU CHANGE YOUR MIND ABOUT MOVING A BALL, YOU CAN TOUCH THE BALL AGAIN LIKE THIS (DEMONSTRATE) SO THAT IT STOPS FLASHING. WHEN A BALL STOPS FLASHING, IT IS NOT READY TO BE MOVED.

To assess the child’s understanding of the task, say:

WITHOUT DOING ANYTHING YET, CAN YOU TELL ME WHICH BALL YOU WOULD WANT TO MOVE?

A) If the child responds correctly, say:

YES. THAT’S CORRECT, BUT BEFORE WE DO THIS PROBLEM, THERE ARE TWO RULES THAT YOU NEED TO REMEMBER.

FIRST, THE BALLS CAN ONLY BE MOVED THROUGH THE TOP OF THE HOLES. THEY ARE PLACED ON TOP OF EACH OTHER. YOU CANNOT MOVE A BALL THAT IS UNDERNEATH ANOTHER ONE LIKE THIS GREEN ONE (DEMONSTRATE THAT TOUCHING IT WILL NOT CAUSE IT TO FLASH). TO MOVE THE GREEN ONE, YOU HAVE TO FIRST GET THE ONE ON TOP OF IT OUT OF THE WAY.

SECOND, YOU CANNOT MOVE A BALL INTO EMPTY SPACE LIKE THIS RED ONE. (POINT TO RED ONE AND SHOW THAT IT CANNOT BE MOVED INTO THE EMPTY SPACE ABOVE IT.) IT HAS TO SIT ON TOP OF ANOTHER BALL OR BE PLACED ON THE BOTTOM OF THE BLACK HOLE.

Note: These rules can also be easily illustrated with a 3-dimensional version of the task.

B) If the child does not know the first correct move, say:

I WANT TO MOVE THIS BALL (THE BLUE ONE), SO I TOUCH IT. YOU CAN SEE THAT ON THE TOP, THE BLUE BALL IS UP HERE (POINT TO TOP RIGHT), SO I WANT MY BLUE BALL TO BE HERE (POINT TO BOTTOM LEFT). TO MOVE IT, I TOUCH THE SPOT WHERE I WANT IT TO GO, LIKE THIS. (DEMONSTRATE).

Say VERY quickly:

NOW, YOU CAN SEE THAT THE BALLS ON THE BOTTOM OF THE SCREEN ARE IN THE SAME SPOTS AS THE BALLS ON THE TOP OF THE SCREEN.

(Then tell the child the two rules mentioned above).
After successfully completing a trial, the computer will give the message “FINISHED” followed by “NEW PATTERN”. Press the SPACE BAR to start the next problem.

Say:

NOW YOU TRY THIS ONE. THIS TIME YOU WILL NEED TO MOVE ONE OF YOUR BALLS TO MAKE IT LOOK LIKE THE TOP.

LOOK AT THE TOP PATTERN. LOOK AT THE BOTTOM PATTERN. THINK ABOUT WHICH BALL YOU WILL HAVE TO MOVE TO MAKE THE BOTTOM PATTERN LOOK LIKE THE TOP PATTERN. DON’T START UNTIL YOU THINK YOU KNOW WHICH MOVE TO MAKE.

TOUCH THE BALL THAT YOU WANT TO MOVE...NOW TOUCH THE PLACE WHERE YOU WANT TO MOVE IT.

It is possible that a subject will make a mistake at this level, in which case they can make further moves to reach the correct solution. These moves are limited to a fixed number at each problem difficulty level. The computer will print “TOO MANY” if this number is exceeded.

There are 2 more one-move problems.

PROMPTS: TOUCH THE ONE YOU WANT TO MOVE.

TOUCH WHERE YOU WANT IT TO GO.

TOUCH IT AGAIN IF YOU CHANGE YOUR MIND.

IMPORTANT: Remember that response time is being recorded. Don’t use prompts unless you are absolutely sure that the subject does not know what to do.

SPECIAL INSTRUCTION: Problem 4.

The subject is required to move the ball from the left to the right-hand column. If the subject fails to do this, say:

YOU CAN MOVE THE BALL ON THE LEFT (POINT) DIRECTLY TO THIS PLACE ON THE RIGHT (POINT). IT IS OKAY TO JUMP OVER THE MIDDLE HOLE.

Next, there are 2-move problems.

Say:

FOR THIS NEXT ONE, YOU WILL HAVE TO MOVE TWO BALLS. DON’T START UNTIL YOU THINK YOU KNOW WHICH BALLS TO MOVE. TRY TO GET IT RIGHT THE FIRST
TIME.

If incorrect, encourage the subject to keep trying until too many moves have been made or the problem is solved.

If the subject makes inappropriate responses, say:

\[\text{YOU CANNOT MOVE A BALL THAT HAS ANOTHER ONE ON TOP OF IT.}\]

OR

\[\text{YOU CANNOT MOVE A BALL TO A PLACE WITHIN AN EMPTY SPACE BECAUSE IT WOULD DROP TO THE BOTTOM}\]

Be quick to give these instructions and to catch errors to ensure that the subject does not get confused and think that the computer’s lack of response is due to some other problem.

Crucial: Before each problem, tell the subject the number of moves that are expected.

If a child does not understand the task by the time the first 2-move problem is presented, abort the task by pressing the ESC button.

After the first block of Tower of London problems, the computer will say “PLEASE WAIT”.
You are now ready to start the first block of the “Tower of London Motor Control Task.”
TOWER OF LONDON MOTOR CONTROL TEST

Instructions:

NOW WE ARE GOING TO DO SOMETHING DIFFERENT. THIS TIME THE SCREEN IS GOING TO LOOK THE SAME, WITH A TOP HALF AND A BOTTOM HALF. INSTEAD OF COPYING THE TOP OF THE SCREEN, YOU ARE GOING TO PLAY “FOLLOW THE LEADER”. THE COMPUTER IS GOING TO BE THE LEADER.

THE COMPUTER WILL MOVE ONE OF ITS BALLS ON THE TOP. WHEN IT DOES, YOU MOVE YOUR BALL ON THE BOTTOM IN THE SAME WAY, OKAY?

ON THE FIRST ONE, THE COMPUTER WILL MOVE ITS RED BALL VERY QUICKLY. YOU MAKE THE SAME MOVE WITH YOUR RED BALL, OKAY?

If the subject does not understand, say:  LET’S SEE HOW IT WORKS.

(Usually a demonstration makes the instructions clear.)

Press the SPACE BAR.

The display will appear as in the “TOWER OF LONDON” test. One of the balls will quickly move to a new position.

Say:

MOVE THE BALLS AS QUICKLY AS YOU CAN. MAKE THE SAME MOVE THAT THE COMPUTER DOES. GO AHEAD.

If the subject makes a mistake, s/he will have to correct his/her error before the next move by the computer. The aim is to get the subject to copy the upper pattern of moves, not to treat it as a series of one-move planning problems.

PROMPTS:  COPY WHAT THE COMPUTER DOES.

MOVE THE BALL.

HERE IS THE NEXT ONE.

YOU CAN’T MOVE THAT ONE.

YOU CAN’T PUT IT THERE.

At the end of the yoked motor control patterns, the computer will say “Please wait”.
You then say:

**NOW WE ARE GOING BACK TO WHAT WE WERE DOING BEFORE, WHEN YOU SOLVED THE PROBLEMS.**

**TOWER OF LONDON, BLOCK II.**

Instructions:

**YOU WILL HAVE TO THINK AGAIN TO MAKE THE BOTTOM LOOK LIKE THE TOP.**

**FOR THIS FIRST ONE, YOU WILL NEED TO MAKE TWO MOVES.**

The first two problems require two moves. *These are practice problems* to get the subject back into the problem-solving set. Then there are two test problems with four moves and four with five moves. Use the prompts listed above. *It has been our experience that children often find the 4-move problems in this set to be more difficult than the 5-move problems.*

Note: Occasionally, a child will appear to “lock up” in the middle of a 4 or 5-move problem, and the silence can be uncomfortable. Wait a couple of minutes. If the child has not moved, say

Are you stuck or are you still working on this one?

If the child is stuck, DO NOT do the problem for him/her. Encourage continued effort.

Prompts: Keep trying.

*You may want to just make a move to see what happens*

*This problem seems hard for you. We can only go on to the next one by making more moves to finish this one.*

*(USE THESE LATTER TWO PROMPTS ONLY IF ABSOLUTELY DESPERATE)*

Each problem must be completed or the number of possible moves exceeded before you can advance to the next trial.

**TOWER OF LONDON MOTOR CONTROL TASK, BLOCK II**

Use the same instructions and prompts as before.
At the end of the “Tower of London” task, you will have completed the “Working Memory/Planning” battery. You will be at the large menu screen that lists the individual working memory/planning tasks.

**TO EXIT THE WORKING MEMORY BATTERY:** Press “exit program” ONLY ONCE to return to the point where you can choose which battery to use. You will view a menu with the CANTAB task batteries listed.

The remaining two tasks are administered through the “Parallel Battery 1”.

Select “Parallel Battery 1”.

All of your subject identification information will be saved and carried over to the remaining tasks.

**Parallel Battery I: Visual Memory and Attention Tasks**

We administer one task from the Visual Attention: the Intradimensional/Extradimension Set Shift task.

Once you have selected Parallel battery I, select the option “Run Individual Task”. You will then be presented with a list of all of the tasks in this battery.

Select “ID/ED Set Shift”.

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II. INTRADIMENSIONAL/EXTRADIMENSIONAL SET SHIFT
**Purpose of Task:** This task is a measure of discrimination learning and abstract reasoning. It was designed to disentangle the processes involved in a common neuropsychological task, the Wisconsin Card Sorting Task. ID/ED Shift contains nine stages which must be passed in order. The child makes responses and, based on feedback as to whether s/he is correct, must use these responses to formulate new ones. Several task rules must be learned and then discarded when they are no longer reinforced.

**Instructions:**

When you hit the **SPACE BAR** to start this task, you will be presented with a **bright GREEN screen**.

The program is waiting for you to **type in two parameters** before it advances to start the task.

The first parameter concerns whether you start the task with the dimension of “line” or “shape” as relevant. **Press “L”** (for line) or “S” (for shape) to begin with either lines or shapes as the initial dimension. We always start this task with L.

The computer responds with “Thank you”. This procedure ensures that no clue is given to the subject about what they are going to do.

The second parameter concerns whether the first major set shift will be intradimensional or extradimensional.

Press either “I” (intradimensional) or “E” (extradimensional) for ID or ED as the initial shift.

**Important:** ALWAYS start with “I”.

The screen will go black. There will be a very brief pause, then four large boxes will appear. Two of the boxes will be empty; two of the boxes will contain lined patterns.

Say:

**NOW YOU CAN SEE TWO PATTERNS ON THE SCREEN (POINT). ONE OF THESE PATTERNS IS CORRECT AND THE OTHER ONE IS INCORRECT. BUT WE DON’T KNOW WHICH ONE IS WHICH. YOUR JOB IS TO FIGURE OUT WHICH ONE IS CORRECT BY TOUCHING ONE OR THE OTHER. IF YOU TOUCH THE CORRECT PATTERN, THE SCREEN WILL FLASH GREEN. IF YOU TOUCH THE INCORRECT PATTERN, THE SCREEN WILL FLASH RED. YOU WANT TO GET AS MANY GREENS AS YOU CAN.**

(The children are generally very responsive to this instruction.)

**AS YOU WORK, THERE IS A RULE THAT YOU WILL LEARN TO HELP YOU KNOW WHICH PATTERN WILL GIVE YOU GREEN, OKAY?**

Wait for an affirmative nod or response that indicates understanding of the instructions thus far.

**BUT THE COMPUTER IS GOING TO KEEP TRACK OF HOW WELL YOU ARE DOING. WHEN IT THINKS THAT YOU KNOW THE RULE PRETTY WELL, THE COMPUTER IS GOING TO CHANGE IT. HOWEVER, YOU STILL WANT TO GET AS MANY GREENS AS YOU CAN.**

**AT THE BEGINNING, THERE IS NOTHING ON THE SCREEN TO TELL YOU WHICH OF THE**
TWO PATTERNS IS CORRECT. YOUR FIRST CHOICE WILL BE A GUESS. THE COMPUTER WILL THEN TELL YOU IF YOU ARE CORRECT OR NOT.

LET’S GIVE IT A TRY.

If the child hesitates, prompt with: JUST GUESS THIS FIRST TIME. OR CHOOSE NOW.

Note: The child must select a box on the screen with a pattern in it. If the child selects one of the empty boxes, review the task instructions.

Keep going until the task is completed. The stages proceed in the following order:

- Simple Discrimination
- Simple Reversal
- Compound Discrimination I
- Compound Discrimination II
- Compound Reversal
- Intradimensional Shift
- Intradimensional Reversal
- Extradimensional Shift
- Extradimensional Reversal

After six correct choices in a row, criterion is reached for a particular level, and the task proceeds to the next stage. After a series of 50 trials in which criterion is not reached the task aborts itself without going to the next stage.

At the end of this task, you will once again be in the “task” menu for Parallel Battery I. The next task to administer is within the “Visual Memory” category:

Select “Pattern/Spatial Recognition” from the task menu.
I. PATTERN RECOGNITION

Purpose of Task: This task measures recognition memory for both patterned and spatial stimuli. The task begins with two blocks of pattern recognition trials. The subject first views a series \( n=12 \) of geometric designs that are presented one after the other. After a brief pause, the subject views a pair of patterns--one familiar and one novel. The task is to touch the pattern that is familiar—to match to sample. This task has an extensive empirical foundation and appears to involve an early-maturing medial temporal lobe (hippocampal) recognition memory system.

Instructions:

Say **ON THIS TASK, YOU ARE GOING TO SEE SOME PATTERNS ONE AT A TIME IN THE MIDDLE OF THE SCREEN. YOUR JOB IS TO JUST SIT BACK AND WATCH THEM AS CAREFULLY AS YOU CAN. YOU WILL SEE MANY DIFFERENT PATTERNS.**

AFTER YOU SEE ALL OF THE PATTERNS, THERE WILL BE A SHORT PAUSE. THEN THE COMPUTER WILL SHOW YOU TWO PATTERNS. ONE OF THESE TWO WILL BE A PATTERN THAT YOU HAVE SEEN BEFORE AND ONE WILL BE SOMETHING DIFFERENT. YOUR JOB WILL BE TO TOUCH THE ONE YOU HAVE SEEN BEFORE, OKAY?

REMEMBER, FIRST YOU JUST SIT BACK AND LOOK AT THE PATTERNS AS THEY APPEAR.

(IMPORTANT: DO NOT USE THE WORD “OBJECT” TO DESCRIBE THE PATTERN, SINCE IT MAY ENCOURAGE THE USE OF VERBAL MEDIATION.)

Press the **SPACE BAR** to start the task.

Part I. STUDY PHASE

The patterns will appear. Make sure the subject is attending to them. If not, use a prompt (i.e., **KEEP LOOKING** or **WATCH THE SCREEN**).

Part II. TEST PHASE.

After a brief pause, two patterns appear on the screen. Say:

**NOW THERE ARE TWO PATTERNS ON THE SCREEN. ONE OF THEM IS ONE THAT YOU JUST SAW. POINT TO THE ONE THAT LOOKS LIKE ONE YOU HAVE JUST SEEN.**
If necessary, for the next choice, say: \textbf{POINT TO THE ONE YOU SAW BEFORE.}

If necessary for the rest of the test, say: \textbf{WHICH ONE DID YOU SEE BEFORE? POINT.}

Note: The subject gets feedback after each choice. A correct choice is indicated by a green check mark. An incorrect choice is indicated by a red “X”. After the first choice is made, tell the subject either:

\begin{quote}
\textit{“The check mark means that you got it right”}
\end{quote}

or

\begin{quote}
\textit{“That was not correct”}.
\end{quote}

At the end of the first block of trials, the screen will say \textbf{PLEASE WAIT}.

Say: \textit{NOW WE ARE GOING TO DO THE SAME THING AGAIN BUT WITH NEW PATTERNS. LOOK CAREFULLY AND TRY TO REMEMBER THE PATTERNS YOU SEE.}

The second block of trials proceeds as above. After it is complete, the screen will say \textbf{PLEASE WAIT}.

When you press the space bar, the “Spatial Recognition Task” begins.

\textbf{SPATIAL RECOGNITION.}

\textit{Purpose of Task:} This task is similar to the pattern recognition task except that the subject must remember spatial locations rather than patterned stimuli. Almost universally, spatial recognition is viewed as more difficult than pattern recognition.

\textbf{Part I: Study Phase}

Before Pressing the space bar, say:

\begin{quote}
\textit{NOW WE ARE GOING TO DO SOMETHING DIFFERENT. THIS TIME, INSTEAD OF SEEING PATTERNS, YOU ARE GOING TO SEE SOME EMPTY BOXES AT DIFFERENT PLACES ON THE SCREEN. YOUR JOB IS TO REMEMBER THE PLACES WHERE YOU ARE SEEING THE BOXES.}
\end{quote}

\textbf{Prompts:} \textit{TRY TO REMEMBER WHERE THEY APPEAR.}
Make sure that the subject is looking at the screen. Use the prompt: *KEEP LOOKING* if s/he is not.

Five boxes will be presented, one after the other.

**Part II. TEST PHASE.**

After a short pause, two boxes will be presented on the screen.

Say:  

*NOW THERE ARE TWO BOXES. POINT TO THE ONE THAT IS IN ONE OF THE SAME PLACES YOU SAW BEFORE.*

**PROMPTS:**

*POINT TO THE ONE THAT WAS IN ONE OF THE SAME PLACES AS BEFORE.*

*WHICH ONE? POINT.*

Again, a green check mark indicates a correct choice. A red “X” indicates an incorrect choice. *Children seem to perform relatively poorly on this task. Be prepared to encourage continued performance after many failures.*

At the end of the first block, the screen will say “PLEASE WAIT”.

**Blocks 2-4:** Four sets of stimuli are presented overall, for a total of 20 trials.

At the start of each block, say:

*NOW I WOULD LIKE YOU TO DO THE TEST AGAIN WITH SOME MORE BOXES. LOOK AT THEM CAREFULLY AND TRY TO REMEMBER WHERE THEY WERE.*

Continue until the four tests are completed. In between each one, the computer will read “PLEASE WAIT”.

It is helpful to tell the subject before the fourth block: *THIS NEXT SET IS THE LAST ONE.*

**II. INTRADIMENSIONAL/EXTRADIMENSIONAL SET SHIFT**

When you hit the space bar to start this task, you will be presented with a bright GREEN screen.

The program is waiting for you to type in two parameters before it advances to start the task.
The first parameter concerns whether you start the task with the dimension of “line” or “shape” as relevant. Press “L” (for line) or “S” (for shape) to begin with either lines or shapes as the initial dimension. We always start this task with L.

The computer responds with: “Thank you”.

This procedure ensures that no clue is given to the subject about what they are going to do.

The second parameter concerns whether the first major set shift will be intradimensional or extradimensional.

Press either “I” (intradimensional) or “E” (extradimensional) for ID or ED as the initial shift.

Important: ALWAYS start with “I”.

The screen will go black. There will be a very brief pause before two patterns appear on the screen.

Say:

NOW YOU CAN SEE TWO PATTERNS ON THE SCREEN (POINT). ONE OF THESE PATTERNS IS CORRECT AND THE OTHER ONE IS INCORRECT. BUT WE DON’T KNOW WHICH ONE IS WHICH. YOUR JOB IS TO FIGURE OUT WHICH ONE IS CORRECT BY TOUCHING ONE OR THE OTHER. IF YOU TOUCH THE CORRECT PATTERNS, THE SCREEN WILL FLASH GREEN. IF YOU TOUCH THE INCORRECT PATTERNS, THE SCREEN WILL FLASH RED. YOU WANT TO GET AS MANY GREENS AS YOU CAN.

(The children are generally very responsive to this instruction.)

NOW, HERE IS THE THING: THERE IS A RULE THAT YOU WILL LEARN TO HELP YOU KNOW WHICH PATTERN WILL GIVE YOU GREEN, OKAY?

BUT THE COMPUTER IS GOING TO KEEP TRACK OF HOW WELL YOU ARE DOING. WHEN IT THINKS THAT YOU KNOW THE RULE PRETTY WELL, THE COMPUTER IS GOING TO CHANGE IT TO A NEW RULE.

YOU STILL WANT TO GET AS MANY GREENS AS YOU CAN.

AT THE BEGINNING, THERE IS NOTHING ON THE SCREEN TO TELL YOU WHICH OF THE TWO PATTERNS IS CORRECT. YOUR FIRST CHOICE WILL BE A GUESS. THE COMPUTER WILL THEN TELL YOU IF YOU ARE CORRECT OR NOT.

LET’S GIVE IT A TRY.

If the child hesitates, prompt with: JUST GUESS THIS FIRST TIME. OR CHOOSE NOW.

Keep going until the task is completed. The stages proceed in the following order:

Simple Discrimination
Simple Reversal
Compound Discrimination I
After six correct choices in a row, criterion is reached for a particular level, and the task proceeds to the next stage. After a series of 50 trials in which criterion is not reached the task aborts itself without going to the next stage.
**PAIRED ASSOCIATE LEARNING**

**Purpose of Task:** This task measures associative learning for stimulus-location pairings. The child is first presented with a number of pairings to learn. Pairings range in number from 1 to 8. After viewing the pairs in a given trial (or set), the child must then match a given pattern with a specific location. In traditional neuropsychological tasks, paired associates learning is “nonspecific” in terms of functional localization. That is, it is a task that involves many areas of the brain and is impaired in many forms of brain damage. The pairings to be remembered in this version (patterned stimuli with spatial locations) suggest that it may draw heavily upon functions of the temporal and parietal lobes in conjunction with multiple prefrontal networks.

**Instructions:**

**SPACE BAR**

The test begins with one-pattern sets. There is one practice demonstration followed by two test trials.

**One Item to Learn:**

Tell the child that s/he must watch the screen.

*YOU WILL SEE SOME WHITE BOXES ON THE SCREEN. ONE AT A TIME, THE BOXES WILL OPEN UP TO SHOW YOU SOMETHING INSIDE. EACH BOX WILL EITHER BE EMPTY OR IT WILL HAVE A PATTERN IN IT. IF THERE IS A PATTERN IN A BOX, YOU MUST REMEMBER WHERE IT IS, OKAY?*

Wait for an indication of understanding.

*ON THIS FIRST SET, YOU WILL NEED TO REMEMBER ONE PATTERN.*

The child will view the first trial. Six boxes will open up, revealing a pattern inside of one of them. After all boxes have been opened, the target pattern will appear in the center of the screen. Say:

*NOW YOU MUST TOUCH THE SQUARE WHERE THAT PATTERN BELONGED.*

If the child responds correctly, there will be a second similar trial with one item to learn. If the child responds incorrectly, the same trial will be repeated.

**The child has ten attempts to solve each trial (or set) correctly.**

At the end of the third correct set with one pattern, the computer will read “**All correct. Two new patterns.**”

**Two Items to Learn:**

Same instructions as above, but say

*THIS TIME THERE WILL BE TWO BOXES WITH PATTERNS INSIDE. YOU HAVE TO REMEMBER WHICH PATTERN GOES INTO WHICH BOX.*

There are two trials at this level.
Three Items to Learn: Repeat instructions. Say that there will be three patterns to remember.

This time there will be three boxes with patterns inside. You have to remember which pattern goes into which box.

Prompts: Just press the box if you think the pattern goes there.

Look to see if you got it correct.

That's where it really goes.

Six Items to Learn:

Space bar.

This time all six boxes will have patterns inside, and you have to remember which pattern goes in which box.

You may not get them all correct the first time, and that is okay. You can have more tries until you do. Just do the best you can.

Make sure that the subject is looking at each box. When all of the boxes have been opened, a pattern appears in the middle of the screen.

Now point to the box where that pattern appeared.

If the subject is correct after all six patterns have been presented, the screen will prompt with “All correct”.

After a moment, the computer will move on to the next trial. The tester may wish to say, “Fine. You are doing well.”

If the subject makes an error, say:

Everyone makes mistakes sometimes. We are going to try this one again. Look carefully. The boxes will open up again to show you where the patterns belong.

Space bar

Eight Items to Learn:
Instructions are generally the same as before. Say:

Set 1:

**THIS TIME, TWO MORE BOXES ARE GOING TO BE ADDED TO THE SCREEN. THERE WILL BE EIGHT PATTERNS TO REMEMBER. REMEMBER TO WATCH CAREFULLY AND DO THE BEST YOU CAN.**

For eight patterns—**one set at this level**—the computer will read “**ALL CORRECT**” at the end.

Set 2.

**SELECTIVE REMINDING:** The second 8-pattern set has a selective reminding procedure. At this stage, it is possible to terminate the session by pressing ESC if the condition is not required.

**WE ARE NOW GOING TO TRY ANOTHER ONE. THIS TIME THERE WILL BE 8 PATTERNS. BUT THIS TIME, IF YOU DO NOT GET ALL OF THEM CORRECT THE FIRST TIME, YOU WILL ONLY BE SHOWN THE ONES THAT YOU GOT WRONG AFTERWARDS. WE STILL WANT YOU TO REMEMBER WHERE THE PATTERNS GO IN ONE TRY, IF POSSIBLE. THE ONES THAT YOU GET RIGHT, YOU WILL HAVE TO CONTINUE TO REMEMBER WITHOUT BEING REMINDED.**

If the child seems to be confused, repeat these instructions once more then say: **YOU WILL UNDERSTAND BETTER WHEN WE START THIS PART OF THE TEST.**

Before feedback presentation, say:

**NOW YOU WILL ONLY BE SHOWN THE PATTERNS YOU GOT WRONG.**