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Factors Affecting Performance on the Lahi- A Complex Continuous Performance Task

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FACTORS AFFECTING PERFORMANCE ON THE LAHI – A COMPLEX
CONTINUOUS PERFORMANCE TASK

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BY
DANIEL KRETCHMAN

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ABSTRACT

This experiment examined basic properties of the Lahi, a multi-target continuous performance task with three sections, used in R. Feuerstein's Learning Propensity Assessment Battery. Signal detection theory was used to evaluate performance by undergraduate students on the measure. Results did not identify differences between the three possible multiple targets, when evaluated on their own. There were differences in performance, however, when the order of presenting the targets was changed between the different sections of the task, as well as differences over time for most of the alternate forms of the task. Implications for the clinical utility of this measure for disorders with attention related symptoms discussed.

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INTRODUCTION

Statement of the Problem

The Lahi is a continuous performance task (CPT) used in R. Feuerstein's dynamic assessment battery, the Learning Propensity Assessment Device (LPAD) (Feuerstein, Rand, Haywood, Kyrar, & Hoffman, 1995). Although many of its features are similar to other continuous performance tasks, it is more complex and places additional cognitive demands in areas such as learning, working memory, representation, and perception. There is a dearth of research on single tests from the LPAD, including the Lahi. Due to its multiple cognitive requirements, this test provides many opportunities for both broad and sensitive screening of cognitive deficits. Additionally, the complexity of the task creates a situation that is closer to real-life demands than most CPTs.

In this initial stage, exploratory research was conducted to examine differences between the three alternative forms of the task, which together comprise the Lahi. This initial evaluation of some basic properties and confounding issues may serve as a basis for future research.

Justification

For accurate completion, the Lahi appears to demand multiple cognitive functions, such as representation, sustained attention, working memory, learning, and visual imagery, to name a few. The task itself, however, as well as possible methods of application have not been empirically researched. This research serves as a scientific starting point to evaluate the measure, so as to permit future research

into the validity of theorized activities and cognitive functions that may be assessed through the test.

Like most of the instruments comprising the LPAD, the Lahi represents an attempt to reduce cultural influences on the measurement of its underlying construct. Measures that are completely culture-free are highly unlikely (and in some instances, undesirable). With our evolving awareness of the influence of culture on assessment performance, however, methods of evaluation such as the Lahi take on new importance.

The Lahi

Continuous Performance Tasks

CPTs originated in 1956 in the context of research on sustained attention and alertness (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). In general, there is an identified target, usually a letter or number, that the test taker must identify and respond to continuously within a field of stimuli. The field comprises targets and non-targets, or distractors. There are many variations on the task with changes in modality (e.g., visual or auditory), kind of stimulus (e.g., letter, number, or other symbols), rate of stimulus presentation, kind of discrimination (e.g., successive or simultaneous), method of presentation (e.g. computerized or paper), level of cognitive processing required (e.g., constant vs. changing target), length of task, and duration of stimulus, to name but a few (Reeve, 1997; Ricco, Reynolds, & Lowe, 2001).

Although CPTs originally were developed to assess what we now call sustained attention or vigilance (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Rosvold et al., 1956), and continue to be used in this context today (Harper & Ottinger, 1992; Mirsky et al., 1991; Ricco et al., 2001), various forms of CPTs are used in other research. As Ricco et al. (2001) and Davies and Tune (cited in Harper & Ottinger, 1992) note, these tasks may require more than sustained attention, and thus they are also utilized for research relating to intelligence (Swanson & Cooney, 1989) or memory (McDowell, Whyte, & D'Esposito, 1998). Specifically, we find CPTs used in research on different kinds of memory, particularly in conjunction with brain imaging techniques. These studies usually use tasks known as X-back. This kind of task requires the individual to identify whether each stimulus presented in a sequence also appeared X units previously in the string. In most cases, X will be 1, 2, or 3. For example, if $X = 2$ the individual would try to recall if the current stimulus was identical to the one presented two units earlier (McAllister et al., 1999; McDowell et al., 1998).

The effect of variations of CPTs and the specific scores derived often are related by different researchers to components of attention, cognitive efficiency, memory, and executive functioning (e.g., response inhibition, self-regulation) (Ricco et al., 2001). In other words, a 2-back task, requiring the individual to identify whether an auditory stimulus is identical to that heard two sounds ago, may not address the same functions as the Connors' CPT (Connors, 1995), which requires pressing a space bar on a keyboard for all letters except X, when the letters

are flashed on a screen for 250 ms (with varying interstimulus intervals). Ricco et al. (2001) clarify this with a list of seven components of attention or executive control. Each of these components has multiple CPT-related variables, from different tests, that are purported to measure the specific domain: (a) alertness/arousal, (b) selective or focused attention, (c) sustained attention, (d) consistency of responding, (e) response speed/information processing speed, (f) response inhibition or dyscontrol, and (g) shifting/altering attention (Ricco et al., 2001).

The Lahi belongs to a sub-group of CPTs called cancellation tasks. These are tasks that require the individual to draw a line through a symbol on paper. Motor functioning, visual scanning, and the lack of interstimulus interval (ISI) and presentation time most likely differentiate between cancellation tasks and other subsets of CPTs. It is unique in using multiple simultaneous targets, creating a test situation that may be closer to everyday function than many tests. Additionally, the sequence of testing as well as the kind of stimuli add to the factors that may affect performance.

Description of Materials and LPAD Administration Procedures

The Lahi is an adaptation of a CPT developed by Zazzo (1969, cited in Feuerstein et al., 1995). Stimuli for the Lahi are squares with a line protruding outward from one of the corners or midpoints of the sides (see Figure 1). The stimuli are set in random order in rows of 40 items.

In this task, the target consists of three (out of the possible eight) stimuli. These are located at the top of the stimulus field (see Appendix A). To simplify differentiation, the three stimuli that make up the targets are called a “model,” and different models are referenced with uppercase letters (i.e. A, B, or C).

Figure 1. Stimuli for the Lahi

The original Lahi consists of two forms. Form I consists of one model with 1 + 24 rows of stimuli. The first row is for practice and orientation to ensure that the test taker fully understands the task and to allow for correction if required. The standard administration time is 10 minutes, but this may be lengthened or shortened if required. Form II consists of three parts, each similar to the first form, but with 10 rows. Two of the three models are different and the third model is a repeat of the model in Form I. Standard administration time is 5 minutes per model, but this may be lengthened or shortened if required. The test is not designed to be self-terminating; rather, the individual should continue working until the end of a time limit. There are also several variations of administration (Feuerstein et al., 1995), dependent on the specific objectives of the tester.

The individual is told to scan the stimuli from left to right and mark a slash through each item that appears in the model (i.e., mark any item that is a target). In group administration, the test administrator announces the passing of each minute,

and the test taker marks off the point they are scanning (between two items); when the test is administered individually, the administrator marks off the time.

Objectives and Use of the Lahi

When used in the LPAD, the scores derived from the Lahi are: (a) the total number of items scanned, (b) the number of false alarms (FA) (i.e., distractors that the test-taker marked off; also referred to as errors of commission), and (c) the number of omissions (i.e., missed targets) (Feuerstein et al., 1995). In this context, the individual completes three different models and the information is used to compare performance over the different models as indications of flexibility or perseverance in representation and longer-term attention span.

Specifically, according to the experimental test manual, the goals of the Lahi are:

1. To assess levels of efficiency in learning a simple task.
2. To assess increases in levels of the rapidity/precision complex with repeated exposure and practice with task.
3. To assess crystallization of learning after practice with task.
4. To observe subjects becoming independent of stimuli with automatization of learning.
5. To create a learning curve of performance with repeated exposure and practice. (Feuerstein et al., 1995, p. 12.1)

In short, one of the overall objectives of the test is to assess how learning of a task occurs. In this case, learning includes, but is not limited to, the effects of attention, the mediation required to teach, and learning efficiency. Furthermore, use of the additional forms is used to assess the ability to shift to new task demands (Feuerstein et al., 1995). Finally, Feuerstein et al. (1995) also suggest that the Lahi is related to reading ability. This is based on the assumption that both tasks require

“the subject to develop an orientation to the process of scanning (a closely presented range of similar visual/perceptual stimuli).” (p. 12.5).

Cognitive Abilities and Elements Addressed in the Lahi

Feuerstein's Theory

Feuerstein's theory addresses cognition via multiple cognitive functions (see Appendix B for a complete list). For instance, when looking up information in a table, an individual must be able to use multiple sources of information simultaneously (i.e., rows and columns), and ignore irrelevant information (e.g., information in adjacent columns). These functions serve as the underlying components of cognitive operations that can be viewed as content-specific thought processes (e.g., synthesizing information from the table with previous knowledge).

An individual's poor performance on a task, such as the Lahi, may be due to a deficient cognitive function, rather than to difficulty at the operational level (Feuerstein, Rand, Hoffman, & Miller, 1980). For example is the difficulty due to problems related to reduced need for precision and accuracy in data gathering; or difficulties in identification of the specific cues? Consequently, Feuerstein's theory contends that in most cases, the efficient way to correct cognitive problems would be by addressing the underlying function(s) not the specific operation.

Although Feuerstein describes 18 functions, each individual has her or his own profile of functioning: some with no deficiencies, others with one or two, and some with multiple problems. Deficient functions may appear in a particular phase (i.e., input, elaboration, or output), or they may be observed in two or three phases.

Identification of the problematic functions and phase are essential in remediating difficulties. The LPAD, as a battery of tests, uses multiple measures for isolating the deficient cognitive function(s). Therefore, the results from the Lahi are not considered deterministic on their own, but should be integrated with other test results.

Traditional Theoretical Perspectives

Alternatives to Feuerstein's theory exist in different theories and theoretical interpretations of cognitive functions and phenomena.

Attention. Mirsky, Anthony, Duncan, Ahearn, and Kellam (1991) presented a model of attention that identifies four distinct functions: Focus-Execute, Sustain, Encode, and Shift. Of the four, sustained attention, sometimes termed vigilance, was measured using CPTs. Interestingly, they reviewed data on Neale et al.'s Span of Apprehension Test (1969) (as cited in Mirsky et al., 1991) which is considered a measure of vigilance or resistance to distraction; based on this review, there was insufficient evidence to state that vigilance, or sustaining attention, and resistance to distraction were identical elements of attention.

Due to its complexity the Lahi addresses all four elements. Sustained attention is required to work over time; focus is needed to select the target from within the field of stimuli; the ability to shift attention is necessary to efficiently change from one model to the next, as well as address the different alternative targets within each model, simultaneously; and encoding is required in the learning or internalizing of each model.

Working memory. Baddeley and Hitch's (Smith & Jonides, 1997) model of working memory focuses on three main components: (a) central executive, which is involved in integrating and directing resources, (b) articulatory loop, responsible for language related aspects, and (c) a visio-spatial sketchpad, which focuses on spatial aspects of information, with each of the last two consisting of storage and processing components (Payne & Wenger, 1998).

Smith and Jonides (1997) presented evidence for an additional part relating to object storages, as opposed to a verbally based or spatially based type of memory.

Proactive interference. The term proactive interference relates to memory difficulties in remembering items due to previously learned items (Payne & Wenger, 1998). This is not a singular explanation for reduction in ability when changing models but a possible alternative.

Chunking. In effect, this is a grouping or recoding of information to allow greater intake or utilization (Miller, 1956). A simple example would be trying to remember letters (e.g., *b, c, e, e, h, i, i, l, n, n, o, r, s, t, u, u*) as opposed to a sentence (e.g., "The unicorn is blue").

Signal Detection Theory

CPTs analyze performance in various ways. Variations begin with the simple assessment of the number of items scanned, false alarms (FA), omissions. Other evaluations may be dependent on the specific task and hypothesized cognitive components, such as the length of time from stimulus presentation until

response. Many clinical tests employ signal-detection theory (SDT) approaches, which are believed to reflect the individual’s sensitivity to identifying targets and tendency to respond (Ricco et al., 2001). This theory appears to be particularly relevant to the hypothesized attention-related components of CPTs.

There are several theories of signal detection (e.g., high-threshold, low-threshold, choice theory) applicable to different kinds of designs (yes-no, forced choice). In the present study, classical SDT was applied, with the Lahi viewed as a yes-no design. The basis for this lies in the nature of the task: the participant views a stimulus in the field, makes a comparison to the model, and then makes a dichotomous decision whether the stimulus and model match.

Classical SDT assumes one of four possibilities: a signal is present and detected (hit), present but not detected (miss), absent and detected (false alarm), or absent and not detected (correct rejection) (see Table 1).

Table 1
Signal and response possibilities in classical SDT

		EXPECTED (stimulus)	
		Signal	No Signal
OBSERVED (response)	Signal Detected	Hit	False Alarm
	No Signal Detected	Miss	Correct Rejection

According to this theory, one needs to discriminate a stimulus, or signal, from a non-stimulus, or noise (Payne & Wenger, 1998). SDT uses two measures to assess performance: (a) d' , called the sensitivity index, which is a measure of the discrepancy between the hit and false alarm rates (Macmillan & Creelman, 1991), and (b) c , response bias, which measures an individual's tendency to inhibit a response regardless of whether the stimulus is a signal or distractor (Hochhaus, 1972). The advantage to these measures is that, although discrimination is measured with d' , we also have c as an indicator of response regardless of signal presence or absence (Payne & Wenger, 1998). In other words, c provides us with information on whether the individual is conservative or liberal in deciding if a stimulus is a signal, or not. For example, those who are more conservative will likely have more FA and fewer omissions, because they will attempt to avoid missing signals. Additionally, SDT works under the assumption that the sensitivity per item is fixed for a particular individual, therefore d' should not change when factors other than sensitivity are altered (e.g., response bias) (Macmillan & Creelman, 1991).

What Needs to be Defined About the Lahi

There are a number of ways to administer the Lahi (Feuerstein et al., 1995). Moreover like most tests in the LPAD battery, Lahi scores are not norm-referenced. In other words, the individual's results are not compared to a standardization sample's performance on the measure. On one hand, this is consistent with Feuerstein's approach of conducting an ipsative comparison as opposed to a

normative comparison. On the other hand, there is a certain amount of subjectivity in comparing these results to performance on other subtests within the battery when evaluating an individual's cognitive functions.

There is an observed performance curve for the three model application: after the first model there is an overall drop in performance during the second model and a relative rise in the third. Although this is a general observation, it has not been empirically examined. Identification of multiple model performance could aid in defining research questions and new analysis.

Summary and Hypotheses

Kuhn (1970) states that paradigmatic debates are not solely about resolving past empirical evidence, but that a paradigm should serve as a guide toward future research. The research in this thesis can be viewed through the lens of other cognitive theories, such as those presented, or through Feuerstein's theory on cognitive functions. For example, it may be that the results will be more applicable to Baddeley's model of working memory or Feuerstein's assumptions – that outcome would serve as a basis for further exploration of representational ability, attention span, working memory, or Feuerstein's cognitive functions.

This research explores basic characteristics of the Lahi. Properties examined include the effect of using different targets, the order in which the targets are administered, and the effect of time on performance. As there is no known previous research on the Lahi, hypotheses were developed based on anecdotal and clinical experience, as well as research on tests that appear to share a commonality

with the Lahi (i.e., CPTs). Two factors are hypothesized to affect performance between groups: (a) Model C appears to be easier to learn than the other two models, and (b) a distinct learning curve occurs over the course of the administration. It is also hypothesized that there is a degradation of performance over the duration of the measure.

METHOD

Participants

This research sample of 60 participants, was recruited primarily from undergraduate psychology classes at the University of Rhode Island. Participation in the experiment fulfilled a class requirement, contributed to extra credit, or in one case, was done at the student's initiative.

The age range of the participants was from 18.2 to 43.2 years. Demographic information of the participants whose data were analyzed is presented in Table 2.

Exclusionary criteria

Prior to data collection, it was determined that data from participants with major head trauma would be excluded, as well as data from participants whose data were determined to be outliers. One case was replaced due to poor performance, as determined by visual comparison. This participant skipped a complete line of targets on one sheet and scanned only 19 items during a full minute on another sheet. Although it could be argued that the individual did not identify targets in the unmarked row, this is highly unlikely, and, compounded with the low scanning

Table 2

Participant Self-reported Demographics

Ethnicity		Gender		Age		Reported Head Injury	
Asian-American:	3	Female:	40	Mean:	20.4	Yes:	2
Black / African-American:	2	Male:	18	SD:	4.5	Missing:	1
Latino/a	1	No response:	2	Missing:	6		
White / Caucasian:	52			Min.:	18.2		
Other:	1			Max.:	43.2		
No response:	1						
Total:	60						

rate, it is possible that the individual had some impairment or disorder which affected performance, or simply did not put effort into the task.

Although 60 participants were used in the analyses, the test was administered to a larger number of people. Initially, participants were assigned to groups based on a random-numbers table. This procedure, however, resulted in unequal numbers of participants per group. Thus, in order to ensure a sufficient number of participants for each group, more data than necessary were collected. A large portion of the extra tests was eliminated due to performance-related problems, such as participants not marking all the minutes on the sheet, per instructions.

From the remaining tests, the data used were taken in order from the stack of tests. Participants were randomly assigned to groups, which was considered sufficient to prevent any systematic bias in data selection.

Because this research was conducted to evaluate the measure, not to establish normative performance, eliminating participants' data based on low performance or for other reasons was considered essential. This would not be acceptable practice for creating normative standards.

Materials

The general structure of the Lahi is a group of three items that constitute the target, and a field made of rows of the target items intertwined with distractors (i.e., non-target items). The three items that combine to make a target are called a "model" (see Appendix C).

The original Lahi consists of two forms, approximately 11" x 17" each. The first form has a single model (three target items), and 24 rows of targets and distractors. In Feuerstein's adaptation, the second form was divided into three sections (Feuerstein et. al, 1995). Each is similar to the first form, but shorter and with different models and fields. The first model on the second form is identical to the model in the first form. This was not required for this project; therefore it was not reproduced (i.e., the second form contained two models).

As a simplifying convention, the different target models are referred to here as A, B, and C, according to the order of appearance in Feuerstein's original adaptation. Test administration consisted of three parts: the first part administered

was the sheet with a single large field; the second part was the top section of the second sheet; the third part was the bottom half of the second sheet.

To better control experimental conditions, a total of nine forms were created. These included three large forms with identical fields, differing only in the targets (i.e., Model A, B, or C), and six additional forms containing all possible pairwise combinations of the three models (e.g., C and B, A and B, B and A, etc). The top and bottom fields on the second form were held constant. Appendix A presents forms for all variations of the first form (Figures A1-A3) and two of the six variations of the second form (Figures A4-A5). The forms in Appendix A are reduced from the original 11"x17" to 8.5"x11" for inclusion in this thesis.

Copyright

The original test, titled "Test Des Deux Barrages" was developed by Zazzo (1964, cited in Feuerstein et al., 1995). Permission for photocopying and manipulation for research purposes was obtained from the publisher, Delachaux et Niestlè (see Appendix D).

Procedures and Administration

Due to the size of the test sheet, administrations were conducted in rooms with large tables. The test was administered to groups of five to fifteen individuals. Before beginning the test, the participants received a general explanation of the procedure, and an informed consent form (see Appendix E) structured according to the University of Rhode Island (URI) Institutional Review Board (IRB) guidelines. The form was reviewed and signed by those choosing to take part in the research.

Participants who chose to remain, completed a demographic information form (Appendix F).

Directions for the task (see Appendix G) were adapted from the LPAD experimental manual (Feuerstein et al., 1995) and from LPAD course lectures (Feuerstein, Rafi, LPAD lecture, January 12, 1998). Although the initial instructions were standard for all groups, the test administrator repeated or rephrased as necessary, and answered any related questions.

The participants were instructed to scan the field of targets and distractors continuously, row by row, during the allotted time, and each time a target was identified to mark it off by drawing a line through it.

Time for administration was eight minutes for the first sheet, the large form with a single model, and 5 minutes for each part of the second sheet. (Due to the expected possibility of a large number of participants completing the second and third sections in less than the allocated time, only four minutes were used in the analysis.) During this time, the administrator announced “minute” at the end of each minute, and the test takers were to mark off the space they were scanning at that time, by putting a line after the item they were scanning.

During the administration, there was a brief break between parts of the tests to allow for collection and distribution of materials. Break times varied somewhat between administrations, due to variable numbers of participants; however, breaks were always less than three minutes.

Each participant was tested on one of the following six possibilities (conditions):

1. Model A, then B, then C (10 participants).
2. Model A, then C, then B (10 participants).
3. Model B then A, then C (10 participants).
4. Model B then C, then A (10 participants).
5. Model C then A, then B (10 participants).
6. Model C then B, then A (10 participants).

Scoring

Scoring was done by assigning a number 1-9 (excluding 5) to each of the eight possible figures. The number assigned was determined by the location of the protrusion in relation to the number 5 on a computer keyboard's keypad (e.g., lower left protrusion = 1, middle left side = 4). This allowed the data to be encoded numerically onto a MS Excel™ spreadsheet. Additionally, the cumulative number of items scanned per minute was entered on the spreadsheet. This method differs from the originally planned scoring method, which used a template. Although this method required greater resources, it ensured the correctness of the information, a critical element considering the effects created by small changes when calculating signal detection measures.

Each data point was analyzed to determine whether it was a hit, miss, false alarm, or correct rejection. This information then was used to calculate the signal

detection measures, and the number of items scanned. These processes were automated using MS Excel™ to minimize the possibility of errors.

Calculating d'

In classical SDT, d' is calculated through the following process (Macmillan & Creelman, 1991): (a) calculation of the proportion of hits (H) = number of hits / number of signals detected; (b) calculation of the proportion of false alarms (FA) = false alarms / number of undetected items; (c) conversion of each of the previous two indexes into the inverse of the normal cumulative distribution function (z); (d) thus, $d' = z_{(H)} - z_{(FA)}$

Calculating c

Response bias is the tendency to favor one response over the other (Macmillan & Creelman, 1991). Although d' remains unchanged in regard to factors outside the stimuli, the response bias remains constant in relation to sensitivity changes. As with d' , there are several kinds of response bias, dependent on the kind of detection theory as well as application (e.g., attention, memory). Based on Snodgrass and Corwin's (1988) research, c is the most suitable for use with the Lahi: $c = 0.5 * (z_{(H)} - z_{(FA)})$. Because the inverse of the cumulative distribution z scores was used, it was necessary to avoid values of 0 or 1 for the number of hits or false alarms, which would transform to negative and positive infinity, respectively. To prevent these kinds of difficulties, Snodgrass and Corwin (1988) suggested setting initial values of 0.5 for each cell, and this suggestion was followed in the present investigation.

Every sheet was scored twice, without visual access to the other scoring. This minimized any human error in the data input. Following the final calculation of all measures, one to two minutes were scored by hand for each part of the test. This ensured that there were no systematic errors in data entry or in calculating the measures.

Design

Three measures were analyzed as dependent variables: (a) number of items scanned, (b) d' – sensitivity index, (c) c - response bias. These last two measures are from SDT. Between group independent variables were: (a) the order of test presentation (Order) (6 levels), and (b) which model was presented (Model) (3 levels). The within subject independent variable was time (Minute) (4 levels).

Participants were randomly assigned to one of the six groups and each completed all three sections (see Figures 2a and 2b). Each group began with one of the three models, therefore, each model appeared twice as the first in the order of administration. Data from the first section were collapsed for each model and used for the first analysis. The second analysis used all three components of the test.

GROUP CONDITION

ONE-WAY MANOVA 3x1

Figure 2a. Methodology schematic for 3x1 MANOVA

Figure 2b. Methodology schematic for 6x3x(4) MANOVA

RESULTS

The following are results for the two main statistical analyses conducted. A one-way MANOVA examined the dependent variables for the total time, eight minutes, on the first part of the administration. The purpose of this analysis was to compare overall performance differences between participants. This eliminated the variables of performance over time, and order in which the tasks were presented. Identifying whether differences existed or not was needed for interpretation of the second analysis.

The next procedure, a three-way MANOVA, examined differences in performance over the course of a full administration of the task (i.e., all three sections). As in the previous analysis, differences per model were examined; however performance over time and the effect of the order in which the specific model was presented were also evaluated.

One-way MANOVA

Data for the one-way MANOVA were obtained from the first section of the task (see Figure 2a). This resulted in a sample size of 60 (20 per group). The independent variable was Model (i.e., Model A, Model B, or Model C). Dependent variables, d' , c , and the number of items scanned, were evaluated for the total time, 8 minutes, to identify differences in performance across models.

Assumptions

Many statistical procedures require that the data for the variables meet certain assumptions. Violation of these assumptions may lead to results that are

inaccurate (e.g., under estimating the variance). Pallant (2001) applies Tabachnick and Fidell's (1996) procedures for evaluating data to the SPSS computer program.

To ensure adequate power and to prevent singularity from occurring when checking homogeneity of variance-covariance matrices, Tabachnick and Fidell (1996) suggest having at least as many participants per cell as dependent variables (three in this analysis), which in this case would require a total of at least nine participants.

Tabachnick and Fidell (1996) state that MANOVAs are robust to violations of this assumption, if not the result of outliers, particularly when the sample size in each cell is at least 20, as in this analysis. Additionally, they note that with at least 20 data points per cell, as in this analysis, the data should be robust to violations of multivariate normality.

The presence of outliers was assessed using Mahalanobis distances, which determine the distance of each case from the centroid of the remaining cases. The most extreme Mahalanobis distance was then compared to a critical χ^2 value using the number of dependent variables as the degrees of freedom (df), and an α level of 0.001 (Tabachnick & Fidell, 1996). In this analysis, the largest Mahalanobis distance was 11.432, which is less than the critical value of $\chi_{(3)}^2 = 16.27$.

Univariate normality was assessed using Kolmogorov-Smirnov statistics. All results were non-significant, indicating normality for the data. Box plots showed a small number of potential outliers. These were not eliminated for three reasons: (a) there was no consistency among the cases, (b) none of the outliers were

classified as extreme by SPSS, and (c) the 5% trimmed mean and the actual mean did not show a large difference.

The relationship between each pair of dependent variables was assessed visually through scatter plots. The majority of the data appeared linear, though in some instances (e.g., $d' \times c$ on the third model, C), one to two points deviated.

Because the homogeneity of regression assumption is primarily meaningful for Roy Bargmann stepdown analysis, it was not evaluated for this analysis (Pallant, 2001).

Multicollinearity and singularity occur when variables are highly correlated, .9 and higher according to Tabachnick and Fidell (1996). Correlations between each pair of dependent variables were checked to minimize the possibility of redundancy. All correlations were below .9.

With equal cell sizes, MANOVA is generally considered robust to violations of homogeneity of variance-covariance matrices. Box's M test was used for evaluation. For this analysis $p = 0.778 > 0.001$, therefore, requirements for this assumption were met.

According to Levene's test of equality of error variances, d' and the number of items scanned do not show problems. For c , however, $F(2, 57) = 3.31, p < 0.05$. Tabachnick and Fidell (1996) clearly state that significant $F > 3$, there is a possibility of inflated type I error (particularly with unequal sample sizes). Their recommendation is to use a more stringent α level, 0.025 or 0.01, for follow-up univariate procedures.

Outcome

Wilks' Lambda was used to evaluate the effects of the independent variable. This criterion examines the pooled ratio of error variance/(error variance + effect variance). Although there are other possibilities for evaluating results of MANOVAs, Wilks' Lambda is preferred for this analysis. It is more powerful than Pillai's criterion (Tabachnick & Fidell, 1996); Hotelling's trace only takes into account the pooled ratio of effect variance to error variance, and Roy's greatest characteristic root (gcr) uses only the first dimension for combining dependent variables, rather than pool them as do the other criteria.

The one-way MANOVA (3 levels) was conducted to examine if there were differences in performance on a multi-target cancellation task with three possible multiple targets. Three dependent variables were used: d' – sensitivity, c – response bias, and the total number of items scanned. All measures were totals for the entire 8 minutes. There were no significant statistical differences identified between the three different groups of targets, $\Lambda = 0.875$, $F(6,100) = 1.270$, $p > 0.05$. Based on these results, it is not possible to conclude that there were statistically significant differences between the different targets presented on this task.

Three-way MANOVA

A 6x3x(4) MANOVA was conducted to examine differences of the effects of order of administration, model type, and time, as well as any interactions among

these, on performance, as measured by the dependent variables (i.e., d' , c , and number of items scanned).

Assumptions

To ensure adequate power and to prevent singularity, a sample of 10 individuals per cell was used, for a total of 60 participants.

MANOVAs, like other multivariate and univariate inferential procedures, require that the data meet certain conditions or assumptions. Tabachnick and Fidell (1996) state that MANOVAs are robust to violations of assumptions, if not the result of outliers. Despite this, it is important to evaluate if the data meet assumptions, and if not, are any violations within acceptable limits, or will the results lead to a higher probability of a type I error. To determine this, assessments of univariate and multivariate outliers, linearity, normality, multilinearity, singularity, homogeneity of variance-covariance matrices, and equality of variance were conducted.

Similar to the previous analysis, the presence of outliers was assessed using Mahalanobis distances. For this analysis, the largest Mahalanobis distance was 11.432, which is smaller than the critical value of $\chi_{(3)}^2 = 16.27$.

Univariate outliers were assessed by visually examining box plots, and by comparing the actual mean with the 5% trimmed mean. SPSS identified a small number of outliers in box plots; however, in all instances, comparison of the mean with the trimmed mean showed little difference. Normality was examined using Kolmogorov-Smirnov's statistic. Results of this test showed that a small number of

cells deviated from normality, particularly in the first two groupings (Orders 1 and 2). Because outliers were not extreme in these cases, MANOVA procedures should be robust to these violations.

The relationship between each pair of dependent variables was assessed visually through scatter plots. The majority of the data appeared linear, though in some instances (e.g., $d' \times c$ on the third model, C), one to two points deviated.

Again, because the homogeneity of regression assumption is primarily meaningful for Roy Bargmann stepdown analysis, it was not evaluated for this analysis (Pallant, 2001).

Multicollinearity and singularity occur when variables are highly correlated, .9 and higher according to Tabachnick and Fidell (1996). Correlations between each pair of dependent variables were checked to minimize the possibility of redundancy. As stated previously d' and c correlated. Although some correlations were relatively high, .8, most were low to moderate, .2 - .6. Some higher correlations were consistently found for the number of items scanned, however only a few of these exceeded .9.

With equal cell sizes, MANOVA is generally considered robust to violations of homogeneity of variance-covariance matrices. Although the computer procedure was unable to conduct Box's M test, Tabachnick and Fidell (1996) state that this test is "notoriously sensitive" (pp. 382) and can be disregarded if there are equal sample sizes.

Levene's test of equality of error variances indicated no violation of the homogeneity of variance assumption.

Outcome

A 6x3x(4) MANOVA was conducted to examine if there were differences in performance on a multi-target cancellation task with three possible multiple targets. The independent variables were: (a) Model (3 levels, between-subjects), (b) Order (6, between-subjects), and (c) Minute (4, within-subjects). Dependent variables were: d' – sensitivity, c – response bias, and scanned - the number of items scanned per minute. Total N was 60 participants. An α level of 0.05 was used for all statistical procedures.

Main Effects and Interactions

Results of the MANOVA show significant differences for the main effect of Model, $\Lambda = 0.826$, $F(6, 320) = 5.344$, $p < 0.0001$, partial $\eta^2 = 0.091$, observed power 0.996; the main effect of Minute, $\Lambda = 0.828$, $F(9, 154) = 3.681$, $p < 0.0001$, partial $\eta^2 = 0.172$, observed power 0.987; the interaction between the main effects of Minute x Order, $\Lambda = 0.641$, $F(45, 691.98) = 1.605$, $p < 0.008$, partial $\eta^2 = 0.085$, observed power 0.997; and the interaction Minute x Order x Model, $\Lambda = 0.400$, $F(90, 1054) = 1.697$, $p < 0.0001$, partial $\eta^2 = 0.097$, observed power 1.000.

Follow-up Tests

In evaluating results from univariate and multivariate statistics, the highest order interaction usually serves as the main criterion for evaluation, superceding any lower order interactions or main effects. Little is known about the

psychometric properties of the Lahi, and therefore this research was defined a priori as exploratory. Scientifically, this determination is important in defining the overall objective of obtaining maximum information on the test. Therefore, significant lower order interactions and main effects were also evaluated as part of the analysis.

Model. For the main effect of Model, univariate tests showed significant differences for c , $F(2, 162) = 4.319$, $p < 0.015$, partial $\eta^2 = 0.051$, observed power 0.744, and the number of items scanned, $F(2, 162) = 13.203$, $p < 0.0001$, partial $\eta^2 = 0.140$, observed power 0.997. Although d' did not show significance, it should be noted that power was low, 0.085.

Post-hoc tests for between-subject main effects were conducted using the Scheffé test, which is considered relatively conservative (Keppler, 1991), and therefore more appropriate for controlling the family-wise error that may result from numerous multiple comparisons.

Post-hoc analyses, show that the response bias, c , of Model B ($M = 0.3644$, $SD = 0.2337$) was lower than c for Model C ($M = 0.4569$, $SD = 0.2429$), $p < 0.015$. The number of items scanned showed that Model C ($M = 81.5083$, $SD = 15.0614$) was significantly higher than both models A ($M = 74.425$, $SD = 14.4206$), $p < 0.008$ and B ($M = 69.9167$, $SD = 16.2538$), $p < 0.0001$.

Minute. Mauchly's Test of Sphericity showed violation of the assumption of sphericity for the number of items scanned. Therefore, for the within-subjects analysis of variance (ANOVA), the Huynh-Feldt correction was used to assess significance for this independent variable.

Results for this analysis showed a difference in the number of items scanned, $F(3, 486) = 8.755, p < 0.0001$, partial $\eta^2 = 0.051$, observed power 0.995.

Pairwise comparisons were conducted for within-subjects (and interaction) effects using the Bonferroni correction to control for multiple comparisons. These showed a significantly smaller number of items scanned in the first minute ($M = 73.2222, SD = 18.0203$) than in the third ($M = 77.3056, SD = 14.3990$), $p < 0.001$, and fourth ($M = 76.5167, SD = 14.3268$), $p < 0.001$ minutes. Similarly, during the second minute ($M = 73.9556, SD = 16.6155$) less items were scanned than in the third, $p < 0.013$, and fourth, $p < 0.010$, minutes.

Minute x Order. Univariate analysis of the interaction Minute x Order showed significant differences for c, $F(15, 486) = 2.088, p < 0.009$, partial $\eta^2 = 0.061$, observed power 0.969, and d' $F(15, 486) = 1.754, p < 0.038$ partial $\eta^2 = 0.051$, observed power 0.928.

Analysis of simple effects of Order showed differences during the second minute for both c, $F(5, 162) = 2.862, p < 0.017$, partial $\eta^2 = 0.81$, observed power 0.833, and d', $F(5, 162) = 2.374, p < 0.041$, partial $\eta^2 = 0.068$, observed power 0.747.

Pairwise comparisons showed that during the second minute, c was greater for Order 2 ($M = 0.2844$, $SD = 0.2156$) than for Order 1 ($M = 0.4837$, $SD = 0.2139$), and d' was larger for Order 1 ($M = 3.8872$, $SD = 0.5265$) than for Order 2 ($M = 3.3206$, $SD = 0.7445$). Figures 3a and 3b present graphic representations of significant results.

Model x Minute x Order. For the interaction of Model x Minute x Order, with Order then Minute held constant, univariate tests showed that the number of items scanned was significant, $F(30, 486) = 2.747$, $p < 0.0001$, partial $\eta^2 = 0.145$, observed power 1.00.

Simple effects for Model are presented in Table 3.

Figure 3a. Graphic presentation of marginal means for *c* for the Minute x Order interaction. Significant differences are circled. No other significant findings for other orders or minutes were identified.

Figure 3b. Graphic presentation of marginal means for *d'* for the Minute x Order interaction. Significant differences are circled. No other significant findings for other orders or minutes were identified.

In several of the non-significant values, power was relatively low. The most noteworthy of these is the first minute in Order 4 in which the observed power was 0.177.

Pairwise comparisons conducted identified differences on the number of items scanned. For clarity, these are organized in Table 4. Figure 4 graphically presents the pairwise comparisons.

Table 3

Simple Effects for Model (Number of Items Scanned)

Order	Minute	$F(2, 162)^a$	$p <$	Partial η^2	Observed Power
1	1	5.241*	0.006	0.061	0.827
	2	0.915	0.403	0.011	0.206
	3	2.452	0.089	0.029	0.488
	4	0.793	0.454	0.010	0.184
2	1	3.104*	0.048	0.037	0.591
	2	1.996	0.139	0.024	0.408
	3	0.296	0.744	0.004	0.096
	4	3.338*	0.038	0.040	0.625
3	1	3.098*	0.048	0.037	0.590
	2	1.327	0.268	0.016	0.284
	3	1.483	0.230	0.018	0.313
	4	0.116	0.890	0.001	0.068
4	1	0.759	0.470	0.009	0.177
	2	0.959	0.385	0.012	0.214
	3	0.331	0.718	0.004	0.102
	4	1.418	0.245	0.017	0.301
5	1	7.245*	0.001	0.082	0.932
	2	2.050	0.132	0.025	0.418
	3	4.607*	0.011	0.054	0.773
	4	1.581	0.209	0.019	0.332
6	1	20.517*	0.0001	0.202	1.000
	2	7.561*	0.001	0.085	0.942
	3	5.833*	0.004	0.067	0.867
	4	6.245*	0.002	0.072	0.890

^a* $p < 0.05$

Table 4

Pairwise Comparisons of Number of Items Scanned Per Minute

Order	Min	Model (I) ^a			Model (J)			<i>p</i> <
		Model	<i>M</i>	<i>SD</i>	Model	<i>M</i>	<i>SD</i>	
1	1	A	83.2	13.2	B	61.2	12.7	0.005
2	4	C	88.8	14.8	B	73.3	12.4	0.037
5	1	C	84.6	9.3	B	58.7	10.7	0.001
	3	A	83.2	11.8	B	68.2	11.1	0.047
		C	85.3	11.2				0.018
6	1	C	91.8	13.6	A	59.9	12.1	0.001
					B	49.9	14.3	0.001
	2	C	86.7	13.3	A	63.2	17.1	0.003
					B	62.4	15.3	0.002
	3	C	86.4	11.0	A	68.8	10.6	0.014
					B	67.7	17.6	0.008
	4	C	84.0	12.8	B	62.7	16.6	0.002

^aNote. Model (I) has larger mean.

Figure 4. Graphic presentation of Table 3 – Pairwise comparisons for Minute x Order x Model interaction

Supplementary Exploratory Analysis

Normally, univariate follow-up tests for non-significant MANOVA main effects are not conducted. Because this project was defined as exploratory, however, it was decided a priori to conduct univariate analyses for non-significant main effects.

Follow-up univariate analyses for the main effect of Order were not significant, but follow-up ANOVA for the interaction Order x Model, did show significance. Results showed the number of items scanned was significant, $F(10, 162) = 2.164, p < 0.022$, partial $\eta^2 = 0.118$, observed power 0.899. Analysis of simple effects of Order showed a statistically reliable difference in the number of items scanned for Model B, $F(5, 163) = 2.586, p < 0.028$. Pairwise comparisons showed that more items were scanned on Model B in Order 3 ($M = 77.85, SD = 18.15$) than in Order 6 ($M = 60.67, SD = 14.69$).

Results for the simple effects of Model show a significant difference on c during the first minute, $F(2, 162) = 11.090, p < 0.001$, partial $\eta^2 = 0.120$, observed power 0.991. The number of items scanned showed significant differences for each minute. Results for these are presented in Table 5. Power for non-significant effects was relatively low, 0.093 – 0.443.

Pairwise comparisons show the response bias for Model C to be greater than in models A and B. The number of items scanned was greater for C in the first, second, and fourth minutes, than for models A and B. Additionally, there

were more items scanned in Model C on the third minute, than for Model B.

Means and standard deviations are presented in Table 6.

Table 5

Univariate Results for Number of Items Scanned in the Interaction Minute x Model

Minute	$F(2, 162)$	$p <$	Partial η^2	Observed Power
1	11.063	0.0001	0.120	0.991
2	10.113	0.0001	0.111	0.985
3	7.003	0.001	0.080	0.923
4	10.415	0.0001	0.114	0.987

Table 6

Means and Standard Deviations for Model x Minute Interaction

Measure	Mi n	Model (I) ^a			Model (J)			$p <$
			M	SD		M	SD	
c	1	C	0.527	0.231	A	0.416	0.201	0.0180
					B	0.341	0.212	0.0001
Number of Items Scanned (#)	1	C	79.867	15.537	A	73.050	16.252	0.0470
					B	66.750	19.803	0.0001
	2	C	81.050	15.678	A	72.583	15.031	0.0120
					B	68.233	16.716	0.0001
	3	C	82.350	14.892	B	73.067	13.689	0.0010
	4	C	82.767	14.306	A	75.167	12.922	0.0080
					B	71.617	13.605	0.0001

^aNote. Model (I) has larger mean.

DISCUSSION

This research was designed to explore basic characteristics of the Lahi.

Properties examined include the effect of using different targets, the order in which the targets are administered, and the effect of time on performance. As there is no known previous research on the Lahi, hypotheses were developed based on anecdotal and clinical experience, as well as research on tests that appeared to share

a commonality with the Lahi (i.e., CPTs). Two factors were hypothesized to affect performance: Model C appears to be easier to learn than the other two models, and a learning that occurs over the course of the administration. It was also hypothesized that there would be a degradation of performance over the duration of the measure.

There were many results from this research, some significant and others non-significant. Although research often seeks to identify reliable differences, the identification of a lack of difference may also be useful. In several instances, a significant difference occurred in a relatively random manner, with no other related significant differences or theoretical support. Considering the number of results, one or two of these may be type I errors and, in other cases, there is not a parsimonious explanation for the single, rare, occurrence. Therefore, not every significant difference will be addressed here.

Most of the significant results occurred on the number of items scanned, with some on c , and only a few on d' . It was hypothesized, and in some instances shown, that participants would perform differently depending on the specific model used as targets (i.e., Model C would be easier to learn), for the most part, however, this was not shown for SDT measures (i.e., c and d'). Therefore, one conclusion may be that, considering the ease of scoring the number of items and its significance, the other measures are not relevant. It is plausible, however, that with other populations (e.g., those clinically depressed, Attention Deficit Hyperactivity Disorder), measures of sensitivity or response bias may differentiate between

groups. Based on this, identification of groups with different sensitivity levels may serve to differentiate between clinical and non-clinical populations.

The one-way MANOVA, over the entire 8 minute period, did not identify differences between the three models. This leads to at least three possibilities: (a) the models are equivalent, (b) any effects that occur are muted over this time period, making it necessary to look at smaller time increments, or (c) confounding variables prevented identifying true differences. The third possibility may always occur, but sound experimental design, particularly randomization procedures minimize this possibility. If the first alternative is correct, no further significance would have been identified in the 6x3x(4) MANOVA. Because significant differences were found in the second analysis, it is likely that there are differences that disappear over time either because they are lost within the larger variance of the combined time periods, or counteracting effects (e.g., in Model C performance is higher at first, then much lower leading to totals that are relatively equal). Parsimony, as well as lack of theoretical and logical support for the second of these possibilities, make it likely that smaller time increments are needed; however, the second possibility was only ruled out through examination of the 6x3x(4) MANOVA. Overall, this result is relevant in examining if the hypothesized learning curve occurs over the course of the full administration. In other words, comparisons of 4-minute (i.e., the time measured for each subtest on the second form) or single-minute periods are required in order to evaluate potential

differences associated with either (a) model effects or (b) inference of presence of a learning curve over the full test administration.

If it is true that there are only true differences in the first minute or two, this may be related to the ease of learning or memorizing the model. Although there may be no differences in later minutes, this time is important in terms of requiring sustained attention over an extended time period. Another relevant result here is the differences identified in the second analysis. The main effect of Minute showed an increase for both the third and fourth minutes in the number of items scanned compared to both the first and second minutes. This is somewhat inconsistent with the hypothesis of performance degradation over time; however, a per-minute analysis of the first eight minutes is necessary to identify whether this increase remains constant, or if there are further variations through the eighth minute. Additionally, as explained previously, for the second analysis although the independent variable of Model was conservatively classified as a between-group variable, it comprises some within-group characteristics. Therefore, significant effects of degradation over the three tasks may not have been identified.

In the interaction Minute x Model x Order in the second analysis, there were identified differences that were not clearly consistent. The lack of significant differences in Orders 3 and 4 is noteworthy, because both began with Model B. As stated in the results, however, power was low for Order 4. Although there is not conclusive evidence that Model B always takes longer to scan, there are enough findings to support hypothesizing this in future research. As explained in the

methodology section, the Model component of the $6 \times 3 \times (4)$ MANOVA is partially within and partially between. This analysis was chosen to underestimate the variance, and therefore lessen the possibility of a type I error. This too may have contributed to the lack of conclusive findings.

The results for Order 6, showing differences for all minutes, are difficult to interpret by themselves. We need to incorporate that the first and third minutes on Order 5 showed differences ($C > B$ and $A \approx C > B$, respectively) and remember that Model C was the first presented on Orders 5 and 6. If these are true and correct results, then the order of presentation created a consistent effect, perhaps analogous to administering test items in an increasing degree of difficulty.

Univariate results for the Minute $\times$ Model interaction show differences for each minute, with the number of items scanned in Model C always higher than in B, and almost always higher than Model A. Although this disregards Order effects, it partially explains the perception of a learning curve that is said to occur when administration is done according to the first order (Feuerstein et al., 1995).

Although there may be a learning curve, this research has not been able to disconfirm effects of order of presentation. Were the test standardized, it could be argued that when this specific order (Model A, then B, then C) is kept, there is an expected reliable difference on performance. In turn, this could be interpreted as a learning curve, and an individual's comparative performance could be analyzed.

We need to be aware, however, that altering the order of presentation inserts another variable.

Evidence related to other theories or theoretical concepts (e.g., chunking, proactive interference) are not clear or conclusive. Because there are interaction effects that relate to order, performance cannot be attributed specifically to one or two components.

Limitations

In order to evaluate the results, the topic of confounding variables needs to be addressed. These are divided into two groups (which are not mutually exclusive). The first group includes variables that previously have been researched and were found to have some effect on similar kinds of tasks. The second group relates specifically to the administrations during this research.

Because there is scant research on the Lahi itself, it seems reasonable to generalize research from other CPTs. Ricco et al. (2001) summarize much of the research in this area. Potential influences on performance include: lighting, time of day, age, external noise, room temperature, examiner presence/absence, instruction emphasis (i.e., speed, accuracy, or both), manner of presentation of instructions, presence/absence of feedback or reinforcement, and medication/substance use.

Several of these variables were to have been controlled in this study by using a single room. This would have minimized temperature, external noise, and lighting fluctuations. In reality, two cases for Order 4 were taken from an administration in a different room. Lighting was not controlled due to administration times. One time was in the early afternoon, and the other in the

evening, leading to a difference in lighting as well as possibly having an effect in its own right. Age was controlled by the use of college students as the sample group (this also contributed to equal educational levels). As described in the Methods section, instructions were given in a standardized manner and then further elaborated as needed. No reinforcers were given for performance. No data were collected regarding substance use; however, verbal inquiry in several groups showed that approximately 1/3 of the participants drank a caffeinated beverage (e.g., coffee, cola), within two hours of the test.

A potential confounding influence that is likely relevant for all CPTs, as well as other kinds of tests, was observed during this task. The interference of jewelry, hair, watches, etc. may detract from performance, particularly on timed tasks. During administration, it was noted that several participants had to move their hair aside or to adjust bracelets and necklaces. Considering the effect of speed, this would be important, perhaps more on standardized tests, but also in similar research.

Task specific confounding influences also occurred or were identified during administration. These include the need for redrawn stimuli. The current materials were photocopied and adapted from the original Lahi, and although visual inspection was conducted to ensure clarity of all items, some appear slightly darker, or with slightly shorter protrusions. Ricco et al. (2001) cite several works on blurring or degrading stimuli and further state that blurring may "... simply enhance the higher-level processing component and not necessarily the attentional demands,

or at least not proportionally so..." (pp. 44-45). Although this problem was not severe, and was evenly distributed among all participants, it needs to be acknowledged.

Standardization of the timing should be addressed via a recording or timer, which would call out the time. Although there was an attempt to be as precise as possible, it would be better to remove the human element from the timing.

Standardization via electronic or mechanical means would ensure equal time periods both within and between administrations, as well as removing administrator error. Timing is particularly relevant when using signal detection measures, which sometimes have high sensitivity to changes.

Although external noise was constant for almost all administrations, in one instance a clock chimed during the task. Participants did not appear disturbed, but the potential distraction is noteworthy.

Although random assignment of participants to Order groups was conducted (as described in the Exclusionary Criteria section), this created unequal groups which led to an elimination of data. It is expected that the described methodological procedures prevented any systematic bias; however, this needs to be verified through replication. Two administration errors occurred, which created slightly different conditions for two of the groups. For one group, the first sheet was distributed face up, which provided longer exposure to the stimulus, but only half the practice task was completed, allowing less exposure. Although these may not have completely compensated for one another, the difference should be

negligible. Another group completed only four minutes on the second part of the task, due to administration error. This means that they began the third task having worked slightly less time. Considering randomization, and the fact that groups were relatively small, this should not have affected the results significantly.

In summary, the reality of a situation often inserts unknown or unexpected variables. This adds emphasis to conducting full pilot administrations and more so to correct randomization procedures, which should minimize the effects and allow for generalizability.

Future Directions

To continue this research, a replication that deals with several of the variables mentioned in the limitations section, is needed. Problems that need to be addressed include time of day, external noise, substance use, and lighting. Analyses should be designed to look at more specific a priori comparisons, as compared to the exploratory research conducted here.

Using clinical populations for further research may prove useful. Because d' showed almost no significant differences across all tests, it appears to be a relatively stable measure for the population used. Cohen, Malloy, and Jenkins (1998) promoted the use of d' in neuropsychological assessment to evaluate selective attention, supporting the hypothesis that people with attentional problems (e.g., Attention Deficit Hyperactivity Disorder, dementia, clinical depression) may show differential performance, as compared to those without these disorders.

Another direction available, which is aligned with Feuerstein's general notion of approaching assessments as an experiment with $n = 1$, would look at ipsative patterns. The area of pattern analysis is considered empirically unsupported by some (Watkins, 2000), and an important diagnostic tool by others (Lezak, 1995). In general, for the most part, empirical research is sparse in this area. An experiment of this kind may consist of holding the order constant and dividing patterns according to performance on a measure (e.g., number of items scanned) and grouping together. For instance $A > B > C$ or $A > C > B$ would be separate groups. Following this, means would be calculated and statistical comparisons conducted to determine the presence or absence of different patterns.

Qualitative information on how people perceive their strategies may contribute to further hypothesis, particularly regarding Model C. Even if people perceive that they are actually grouping information, however, it is possible that this contributes more to motivational aspects (e.g., 'this seems very easy'), rather than actual cognitive efficiency. In the same vein, different memory components may be perceived to be used by the individual. Some may represent the shape visually, whereas others may encode the protrusion location verbally. Although qualitative information may not give true or accurate descriptions of the processes, it will likely help generate hypothesis as to how the individual learns the model, and the subsequent interfering models.

The importance of the length of task for taxing sustained attention already has been noted in the discussion section. For evaluating the ability to learn the new

model, however, three minutes for each part of the task may be sufficient. This shorter time period also may present information on the individual's ability to shift attention on demand.

Multiple future projects have been presented here. This list is far from exhaustive, and although conclusive differences are not available from this research, it also has not been able to disconfirm that the models or orders are the same, setting a justification for further work, following successful replication.

SUMMARY AND CONCLUSIONS

Research in behavioral sciences usually seeks significant differences. There are situations, however, when non-significant statistical findings are significant. This is the case with the one-way MANOVA, which did not identify differences between the different models. Based on this, we can state that for the time period of 8 minutes, no differences were identified in performance among the models. It is possible, as indicated by the second analysis, that examining shorter time periods may show differences between the models.

Almost all differences found in performance during the full administration of the Lahi were on the number of items scanned, with only isolated differences of c and d' . The lack of differences may be useful in differentiating between groups in future research. Finally, although some differences in Order were found, these do not negate use of the test. They do reinforce the need for: (a) replication, (b) clear adherence to standardization, and (c) theoretical explanation following replication.

In summary, this project identified basic properties and differences on the Lahi. This is a small but necessary step in moving from clinical perceptions to a standardized reliable and valid measure. Replication, improving standardization requirements, and further research with various populations are needed to move this test further into the realm of measures used within best practices.

Sample Forms

Figure A1. First (large) form Model A

Figure A3. First (large) form Model C

DATE

ID#

Figure A4. Second form models A and B

DATE

NO

Figure A5. Second form models B and C

APPENDIX B

Feuerstein's Cognitive Functions (Feuerstein et. al, 1995)

Input

- Blurred and sweeping perception.
- Lack of, or impaired, receptive verbal tools which affect discrimination (e.g., objects, events, relationships, etc., do not have appropriate labels).
- Lack of, or impaired, spatial orientation; the lack of stable systems of reference impairs the establishment of topological and Euclidean organization of space.
- Lack of, or impaired, conservation of consistencies (size, shape, quantity, orientation) across variation in these factors.
- Lack of capacity for considering two or more sources of information at once. This is reflected in dealing with data in a piecemeal fashion rather than as a unit of organized facts.
- Lack of, or deficient, need for precision and accuracy in data gathering.

Elaboration

- Inability to select relevant versus non-relevant cues in defining a problem.
- Lack of spontaneous comparative behavior of limitation of its application by a restricted need system.
- Narrowness of the psychic [mental] field.
- Lack of, or impaired, need for pursuing logical evidence.

- Lack of, or impaired, planning behavior.
- Lack of, or impaired, interiorization [internalization].

Output

- Difficulties in projecting virtual relationships.
- Blocking.
- Lack of, or impaired, tools for communicating adequately elaborated responses.
- Lack of, or impaired, need for precision in communicating one's responses.
- Deficiency of visual transport.
- Impulsive, acting-out behavior.

Note. These cognitive functions are expressed in terms of deficits or impairments for two reasons. First, cognitive functions generally are clinically examined because of suspected difficulties; therefore, these difficulties are described as deficits. Second, intact cognitive functions can be viewed as the norm; therefore, deficits refer to departures from normality.

APPENDIX C

Targets Used in the Lahi

Figure C1. Model A

Figure C2. Model B

Figure C3. Model C

APPENDIX D

Copyright Permission for Zazzo's Test Des Deux Barrages

Monsieur Daniel Kretchman,

Faisant suite à votre demande, nous avons le plaisir de vous accorder les droits gracieux de l'utilisation des "TEST DES DEUX BARRAGES" dans le

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En vous remerciant de votre intérêt pour nos ouvrages, veuillez croire,

Cher Monsieur, en nos salutations les meilleures.

martine de la vallée

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APPENDIX E

Consent Form for Research

Factors Affecting Performance on the LAHI – A Complex Continuous

Performance Task

The University of Rhode Island

Department of: Psychology,

10 Chafee Rd. Suite 8

Kingston, RI 02881

TEAR OFF AND KEEP THIS FORM FOR YOURSELF

You have been asked to take part in a research project described below.

The researcher will explain the project to you in detail. You should feel free to ask questions. If you have more questions later, Prof. W. Grant Willis, the person mainly responsible for this study, or Daniel Kretchman, can be reached at (401) 874-2193, and will discuss them with you.

You should be at least 18 years old to be in this experiment

Project Description:

You have been asked to take part in a study that will examine performance on a task that requires identifying specific symbols within a field of similar symbols. This study has two main purposes, (a) performing an initial examination of the task's structure, and (b) interpreting the results according to theoretical models.

What will be done:

If you decide to take part in this study here is what will happen: You will receive a large sheet of paper with many repetitions of eight symbols. You will receive detailed instructions and practice time, on what symbols you need to identify and how to mark them off. After this is clear to all participants, you will work on the task for a given period of time (less than ten minutes). After this, there will be a brief break in which sheets will be changed, and you will be requested to perform the same task twice more, with changes in the symbols.

Total expected time for administration will not exceed 40 minutes.

Risks or discomfort:

This test has no known risks involved. It does require your concentration and undivided attention for up to 10 minutes at a time.

Benefits of this study:

Although there will be no direct benefit to you for taking part in this study, the researcher may learn more about factors that affect human's performance on this task.

Anonymity:

Your part in the study is anonymous. None of your work here will identify you by name. You will receive an information sheet with a number to fill out. That number will be on your task sheets and will be the only connecting information between you and the sheet. The principal investigator will keep the information sheets separate, locked, and inaccessible to others, except when

demographic information is compiled. Your name will not appear in any part of the materials.

Decision to quit at any time:

The decision to take part in this study is up to you. You do not have to participate. If you decide to take part in the study, you may quit at any time. Whether you decide to participate or not will in no way penalize you. If you wish to quit, you simply inform the person in charge of the administration of your decision. If you decide to leave the study, please do so at the end of an administration period or stop working and wait quietly until the end of the administration period (less than 10 minutes). You may stop at any point; however, if you can wait until the end of the period, others will not be interrupted.

Rights and Complaints:

If you are not satisfied with the way this study is performed, you may discuss your complaints with Prof. W. Grant Willis, or Daniel Kretchman, anonymously if you wish. In addition, you may contact the office of the Vice Provost for Graduate Studies, Research and Outreach, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone (401) 874-2635.

Thank you,

Dan Kretchman

APPENDIX F

Demographic and General Information Form

Please fill out the information below. Do not enter your name.

Form ID number: _____

**Date of
Birth**

Gender:

Female

Male

**How do you
define your
Race /
Ethnicity?**

White /
Caucasian

Black /
Afro-
American

Hispanic
/ Latino-a

Asian-
America
n

Native
America
n

Other

Have you ever suffered from a serious head injury?

Yes

If yes, please explain.

No

APPENDIX G

Administration Instructions

After reading and signing the informed consent (or leaving the room), the nature of the project as a component of a thesis will be explained verbally. The instructions below will be read verbatim, but any adaptation or explanation is allowed.

First Form

Time: 8 minutes.

“The sheet you have received is divided into three parts: At the top are three squares with lines going out in different directions. We will call this a model. The second part is a single row of similar shapes with a border around them. The third section is a large area with many rows of similar shapes.

The goal is to find and cross off any of the three shapes that appear in the model, as quickly as possible. We will begin with a few practice items in the bordered area. Also after each minute elapses I will call “minute” and you should put a line at the point you are scanning (between two items). In order to mark off an item, put a slash through it. Are there any questions?”

Conduct practice on 3-4 items with transparency, then ask if there are any problems. Show correct completion with transparency.

“When I tell you to begin, you are to begin scanning and marking off items from the top left corner of the large area across the row. When you reach the end of the row, return to the left side and begin the next row. Continue this marking of

each item you think is the same as in the model, and marking off the place you are scanning when 'minute' is called. If decide you have made a mistake in crossing out an item, just use your pencil to make it clear. Do not try to erase it." Show example on transparency or board.

"After completing this form, you will receive another similar sheet, with two different models, and no practice section. You will complete those in a similar manner. Are there any questions?"

"Please work as quickly and as correctly as you can."

"Start"

Second Form

Time: 5 minutes each.

"As you see, this is similar to the first form. When I tell you to start, mark off each item that appears in the top model, and mark off the place you are scanning when 'minute' is called. Do the top half only. Any questions?"

"Please work as quickly and as correctly as you can."

"Start"

"When I tell you to start, mark off each item that appears in the second model on the bottom half, and mark off the place you are scanning when 'minute' is called. Any questions?"

"Please work as quickly and as correctly as you can."

"Start"

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