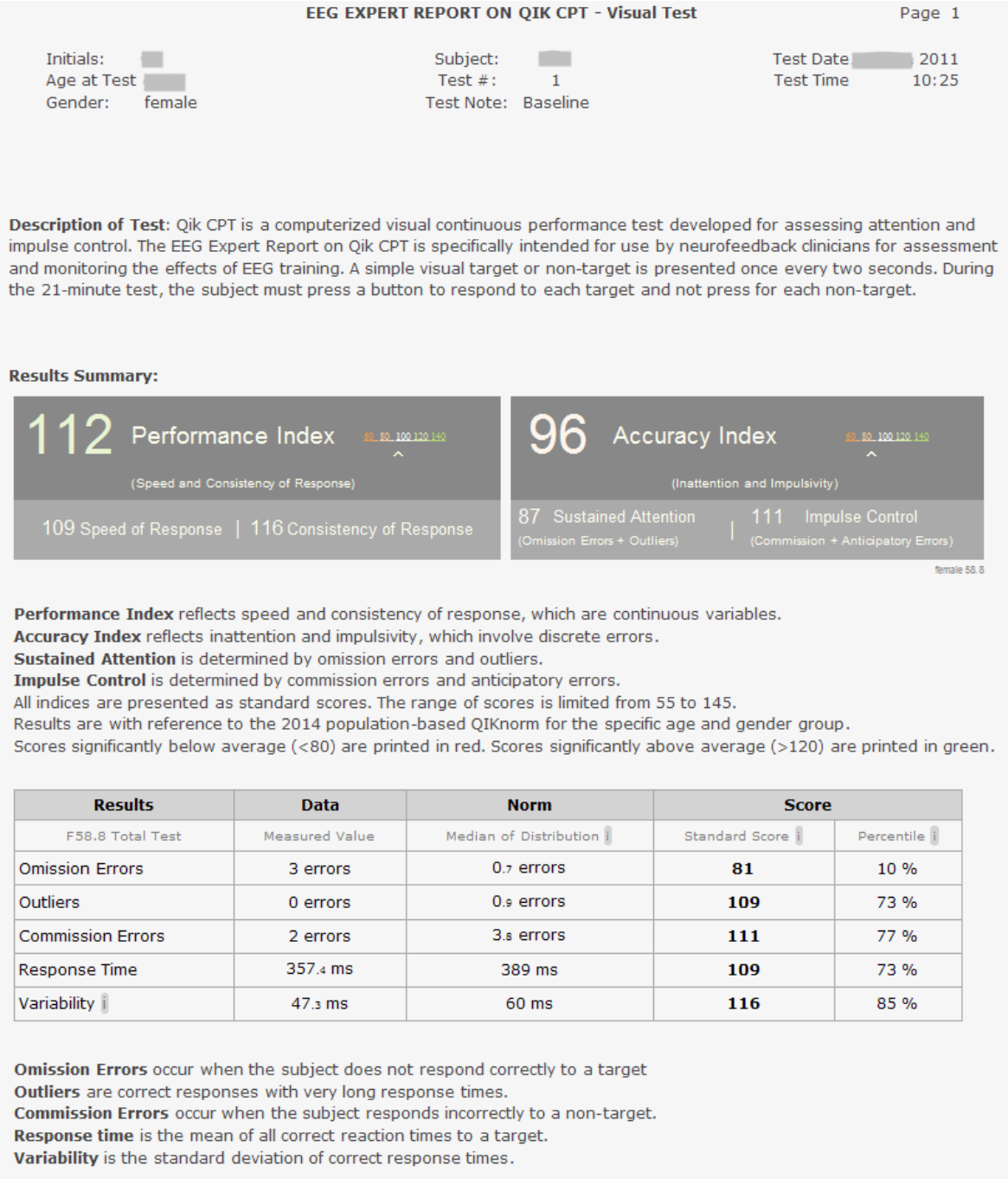
The QIKtest Report on EEG Expert

The new report introduces some innovations into the analysis of Continuous Performance Tests like the TOVA and the QIKtest. The basic philosophy is that we would like to discriminate shortcomings in cerebral regulation in a way that takes maximum advantage of the data we acquire. There is no reference back to an arbitrary diagnostic category such as ADHD. Instead the framework is that of the "Disregulation Model," which posits that cerebral dysfunction is largely traceable to deficits in a limited number of core regulatory functions. Such deficits can be observed in a variety of brain challenges, including the standard CPT.



EEG EXPERT REPORT ON QIK CPT - Visual Test Page 1

Initials: [redacted] Subject: [redacted] Test Date [redacted] 2011
Age at Test [redacted] Test #: 1 Test Time 10:25
Gender: female Test Note: Baseline

Description of Test: Qik CPT is a computerized visual continuous performance test developed for assessing attention and impulse control. The EEG Expert Report on Qik CPT is specifically intended for use by neurofeedback clinicians for assessment and monitoring the effects of EEG training. A simple visual target or non-target is presented once every two seconds. During the 21-minute test, the subject must press a button to respond to each target and not press for each non-target.

Results Summary:

112 Performance Index (Speed and Consistency of Response)
109 Speed of Response | 116 Consistency of Response

96 Accuracy Index (Inattention and Impulsivity)
87 Sustained Attention (Omission Errors + Outliers) | 111 Impulse Control (Commission + Anticipatory Errors)

female 58.8

Performance Index reflects speed and consistency of response, which are continuous variables.
Accuracy Index reflects inattention and impulsivity, which involve discrete errors.
Sustained Attention is determined by omission errors and outliers.
Impulse Control is determined by commission errors and anticipatory errors.
All indices are presented as standard scores. The range of scores is limited from 55 to 145.
Results are with reference to the 2014 population-based QIKnorm for the specific age and gender group.
Scores significantly below average (<80) are printed in red. Scores significantly above average (>120) are printed in green.

Results	Data	Norm	Score	
F58.8 Total Test	Measured Value	Median of Distribution	Standard Score	Percentile
Omission Errors	3 errors	0.7 errors	**81**	10 %
Outliers	0 errors	0.9 errors	**109**	73 %
Commission Errors	2 errors	3.8 errors	**111**	77 %
Response Time	357.4 ms	389 ms	**109**	73 %
Variability	47.3 ms	60 ms	**116**	85 %

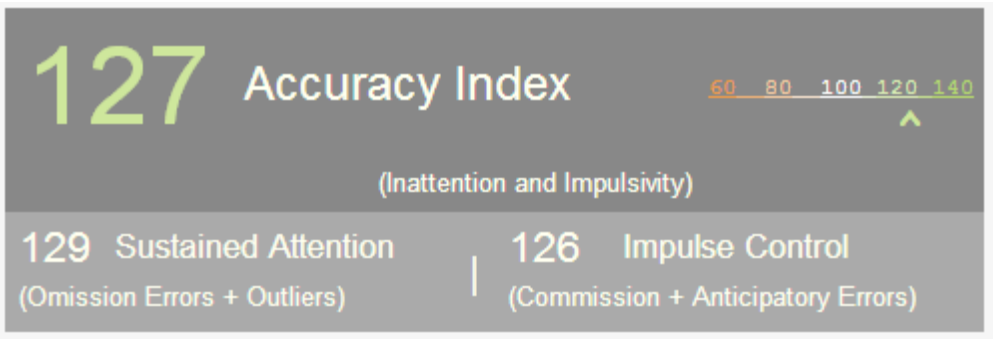
Omission Errors occur when the subject does not respond correctly to a target
Outliers are correct responses with very long response times.
Commission Errors occur when the subject responds incorrectly to a non-target.
Response time is the mean of all correct reaction times to a target.
Variability is the standard deviation of correct response times.

First Page of EEG Expert QIKtest Report: Overview

The intention is to complement the information gleaned from interviewing and observing the client, and from their history, with information derived from testing. A lot of information bearing on brain self-regulatory status and on self-regulatory capacity cannot be obtained any other way. There are two types of measurements of interest: brain behavior in the unchallenged baseline state and brain behavior under challenge. The CPT test involves a repetitive challenge that offers some predictability to the testee. That allows the person to settle in to a state characteristic of that person. This might range from lethargy to hyper-vigilance, boredom to frustration, irritation to agitation. Performance under those conditions is then evaluated over the duration of the test. It is often found that with training the challenge is tolerated a lot better on re-test.

In the Disregulation Model, the CNS is regarded from the perspective of a control hierarchy. The most basic requirement that needs to be met by a control system is overall stability. Is the system always ready to respond, and to respond appropriately? The secondary criteria are the particulars with regard to state regulation. Is the system in an optimally responsive state, one that is matched to the prevailing demand? And is it able to maintain itself in that state over an extended period of time? CPTs such as the TOVA and QIKtest set out to test these basic control variables under highly constrained conditions. On the one hand, the challenge to the brain is maximized by putting the testee under pressure to respond as rapidly as possible (consistent with maintaining accuracy), and on the other, state regulation is challenged by testing the person under boringly repetitive conditions over an extended period of time. And the question is asked, is the response accurate, rapid, and consistent from one trial to the next?

In this test we seek to characterize the disregulation status of the testee as the top-level appraisal. The issues are two-fold. The primary issue is whether the responses are accurate. Can the nervous system handle the challenge being presented correctly? To maximize this challenge, the person is asked to respond as quickly as can be done consistent with accuracy. The secondary issue is then the quality and consistency of the performance. How fast are the responses, and how consistent from one event to the next?



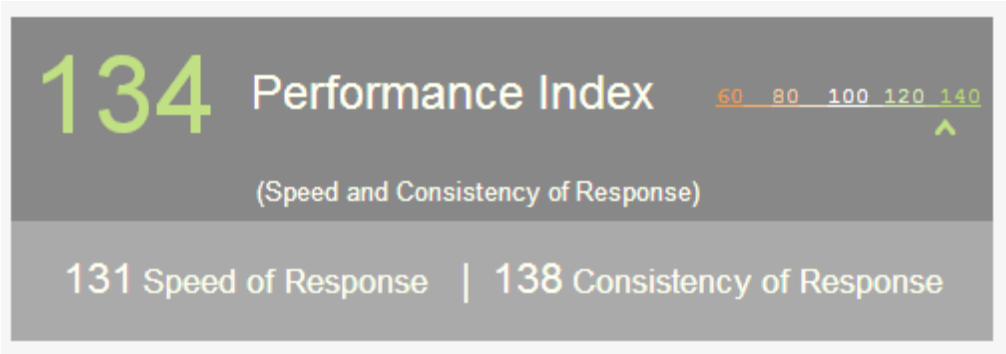
Accuracy Index

The issue of response appropriateness is expressed in the **Accuracy Index**. This index is entirely based on the discrete errors, the countable errors. These consist of the errors of omission, the errors of commission, and the extreme outliers in reaction time. This last category consists of those events in which the reaction time falls outside of the “normal” range where it may be expected for the particular age range. We are dealing here with an unambiguously ‘delayed’ response that is readily distinguishable from the ‘typical’ responses.

The three types of discrete errors are all highly correlated with each other in terms of incidence, which implicates a common failure mechanism. This further supports the overarching concept that we are calling *disregulation*. The observed degree of mutual correlation allows them to be taken jointly to specify the Accuracy Index. More specifically, errors of omission correlate highly with reaction time outliers. The latter can be seen as attentional deficits analogous to omission errors. For this reason we combine omission errors with reaction time outliers in order to specify a subsidiary measure, the "Index of Inattention." Commission errors continue to specify an "Index of Impulsivity," as before. The only new element here is the fact that anticipatory responses are also counted as errors of commission. This is of minor consequence, as anticipatory errors are quite rare. The **Index of Inattention** and the **Index of Impulsivity** are used jointly to specify the **Accuracy Index**.

It remains to characterize the quality of the responses in terms of the task objective of the speed of response, firstly, and the consistency of the response characteristic secondarily. The distribution of reaction times (with outliers now removed) yields two parameters of interest, the mean reaction time and the variability, the standard deviation of the sample. In the report, these are presented as standard scores for the **Speed of Response** and for the **Consistency of Response**.

These two variables are combined to determine the **Performance Index**. This is justifiable on the basis that the mean reaction time and the variability are significantly correlated. When reaction times are short, the variability also tends to be small, and when the mean reaction time is large, the variability tends to be large as well. So the two measures jointly specify the quality of performance as it applies to correct responses.



Performance Index

The Accuracy Index, by contrast, refers to the incidence of incorrect responses. Both parameters are needed in order to characterize the test performance adequately, and to inform us with respect to the disregulation status. Both parameters tend to respond differentially in training, which further justifies their distinct categorization.

The term disregulation is preferred here over "dysregulation" that is standardly used in the medical literature. The reason is that the latter term tends to imply that organicity is implicated in the deficit at issue. The term disregulation is intended to emphasize that the focus here is on functionally-based deficits, without the assumption of organicity. So the term is intended to be more inclusive.

Both the Accuracy Index and the Performance Index are needed to characterize the test performance adequately and to appraise the disregulation status. We have refrained, however, from combining the two measures into a single score that would serve as the Index of Disregulation. Such a top level

score would obscure more than it would reveal, in that the person under test is likely to assign the greatest weight to that single top-level score. It is preferable to focus the attention of the client on the constituent scores, and on the accuracy index particularly. This is because brain stability is the most foundational requirement for good brain function. A second consideration is that both parameters tend to respond differentially in training, and that requires us to focus on the test results individually.

Summary Table, Page 1

In this table we enumerate all of the elements that combine to make up the Accuracy Index and the Performance Index. (Anticipatory errors are not shown explicitly, as they occur only rarely.)

Results	Data	Norm	Score	
M14.5 Total Test	Measured Value	Median of Distribution	Standard Score	Percentile
Omission Errors	5 errors	2.6 errors	**91**	27 %
Outliers	1 error	2.2 errors	**109**	72 %
Commission Errors	31 errors	9.0 errors	**76**	6 %
Response Time	329.9 ms	379 ms	**114**	82 %
Variability	73.1 ms	87 ms	**110**	75 %

Summary Table

The table also adds a column for the percentile scores from which the standard scores are derived. The percentile scores may be received poorly by the client, so one may want to be judicious in referring to these scores. It sounds very different to a client to be told that his score is a ‘normal’ 100 versus being told that he is scoring at the 50th percentile. It is more acceptable to be told that one is scoring within one standard deviation of the norm (85) than to be told one is scoring at the 16th percentile. The red scores indicate values below 80 in standard score, the equivalent of 9th percentile. Likewise the green scores highlight values above 120, or the 91st percentile.

Data Tables, Page 2

RAW DATA	Period 1 Sect. 1 Low Demand	Period 2 Sect. 1 Low Demand	Period 3 Sect. 2 High Demand	Period 4 Sect. 2 High Demand	Period 5 Sect. 3 Low Demand	Sect. 1	Sect. 2	Sect 3	Total
Omissions(#)	0	1	4	**5**	**3**	1	**9**	**3**	**13**
Outliers	0	0	0	1	1	0	1	1	2
Commissions(#)	2	0	**18**	14	2	2	**32**	2	**36**
Response time(ms)	398	398	280	326	429	398	303	429	335
Variability(ms)	81	48	91	111	**124**	67	104	**124**	91

Raw Data Table

In the top table the raw data are segregated by period and by section to allow the discernment of trends over the session at a glance. One looks for obvious trends within the first two sections, and trends between sections (sections 1 vs. 2, and also sections 1 vs. 3).

STANDARD SCORES	Period 1	Period 2	Period 3	Period 4	Period 5	Section s1	Section s2	Section s3	Total
Omission Errors	104	89	80	**77**	**79**	94	**77**	**79**	**79**
Outliers	104	105	108	98	93	107	103	93	100
Commission Errors	85	104	**40**	81	84	88	**70**	84	**40**
Response Time	102	107	122	105	100	104	112	100	110
Variability	94	117	96	87	**77**	106	90	**77**	92

Standard Scores Table

In the second table on page 2, the data for the primary variables are mapped into the equivalent standard scores in order to appraise their significance, given the age and gender of the client. Once again, one wants to look for trends between sections and trends within sections one and two. Such trends are more meaningful when the data are expressed in terms of standard scores.

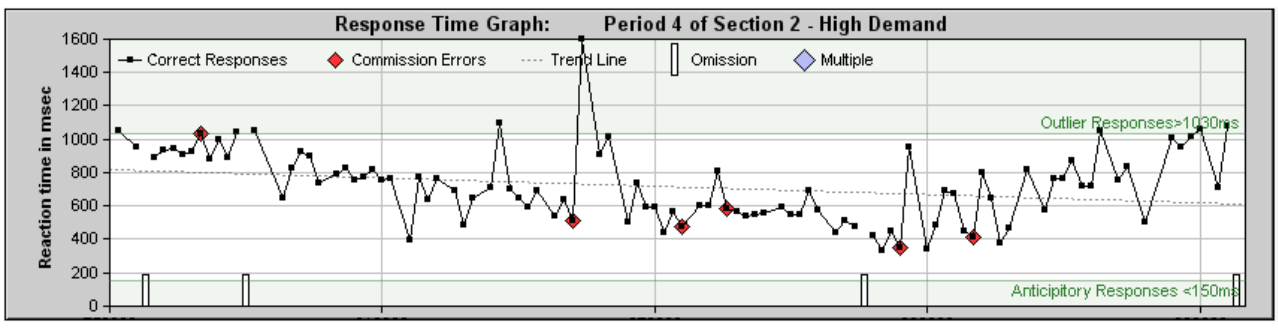
OTHER RESPONSES	Period 1	Period 2	Period 3	Period 4	Period 5	Section s1	Section s2	Section s3	Total
Anticipatory Resp. (#)	0	0	10	1	0	0	11	0	11
Multiple Responses (#)	0	0	6	3	0	0	9	0	9
Post-commission RT (ms)	416	0	282	**283**	454	416	**282**	454	**304**

Other Responses Table

Subsidiary measures are also tabulated. Anticipatory errors and multiple responses are called out in the third table, along with post-commission response times. With respect to the latter, one is interested in how the client responds to a commission error. Did he react by becoming more cautious, or did he respond by moving toward higher levels of expectancy, or toward a more pressured response? These data must be interpreted in light of the time series plots, which may show that the commission errors nearly always occur at extremely short reaction times. In those events, the post-commission response times will necessarily always show an increase. If one is focused on such an outlier, the likelihood is for subsequent regression to the mean.

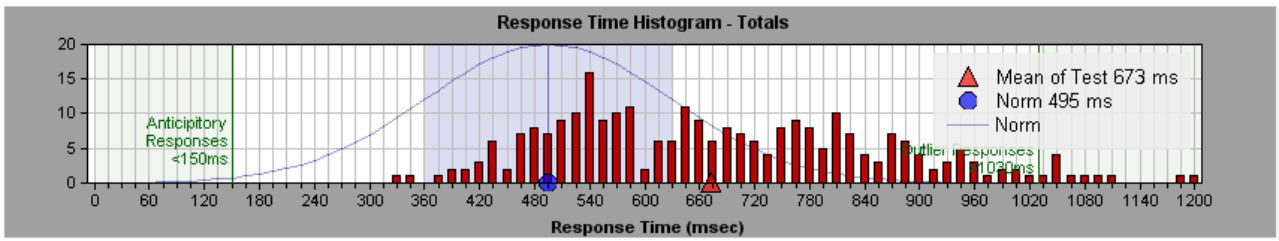
Reaction Time and Histogram Charts

A fuller picture of the performance of the client is obtained when we look at the distribution of **reaction times** for correct responses, and when we look at the time series presentation over the test period. The two representations of the data are nicely complementary. The time series data allow one to appraise the factors that limit the uniformity of responding.



Reaction Time Chart

Is the time series dominated by drift factors, for example, as in the case example shown? Are the extreme responses isolated events, as also illustrated in the above case example? Are there systematic trends over the individual periods, the sections, or even the whole test? Is there evidence of difficulty at the onset of a shift to a different test condition? Do the commission errors tend to happen at the shortest reaction times, indicating a characteristic impulsive error?

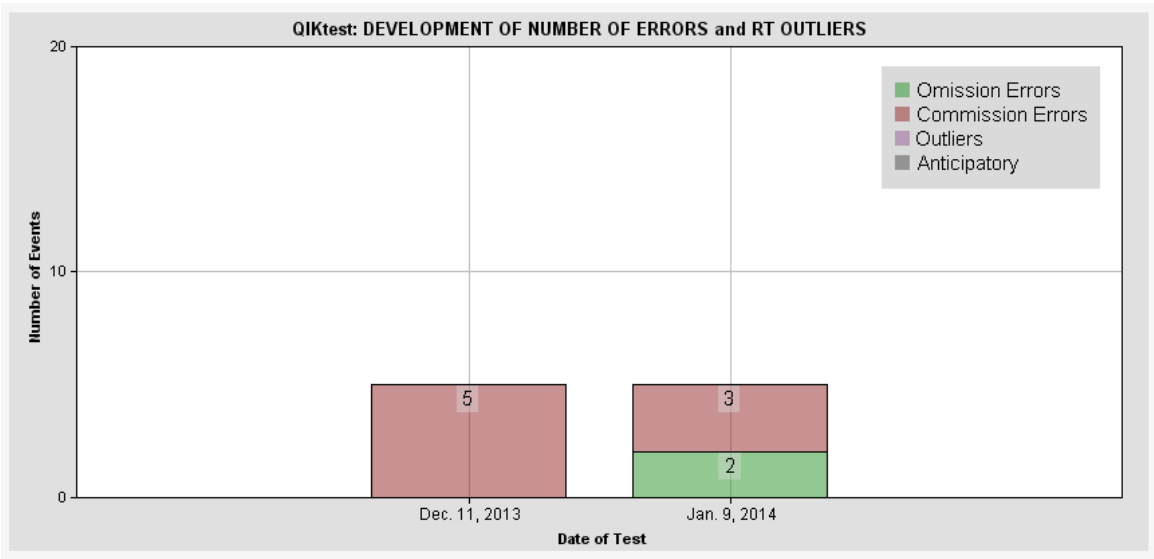


Histogram Chart

The histogram display allows one to note the character of the distribution. Is the distribution roughly bell-shaped, with a slight skew toward longer response times? Is the distribution double-humped, with a secondary peak at short response times? That would point to 'pure' reaction time events as opposed to 'choice' reaction time events, a response pattern that can often be seen in young children. The data can be readily compared against appropriate norms, which are also plotted.

Pre-Post Charts

Because of the importance of the discrete errors in indexing brain stability, the trend in all of the discrete errors from one test to the next is shown separately in the plot below. In the hierarchy of concerns, omission errors rank highest, with reaction time outliers following closely behind. The world is much more forgiving of commission errors, and their incidence is higher in general.

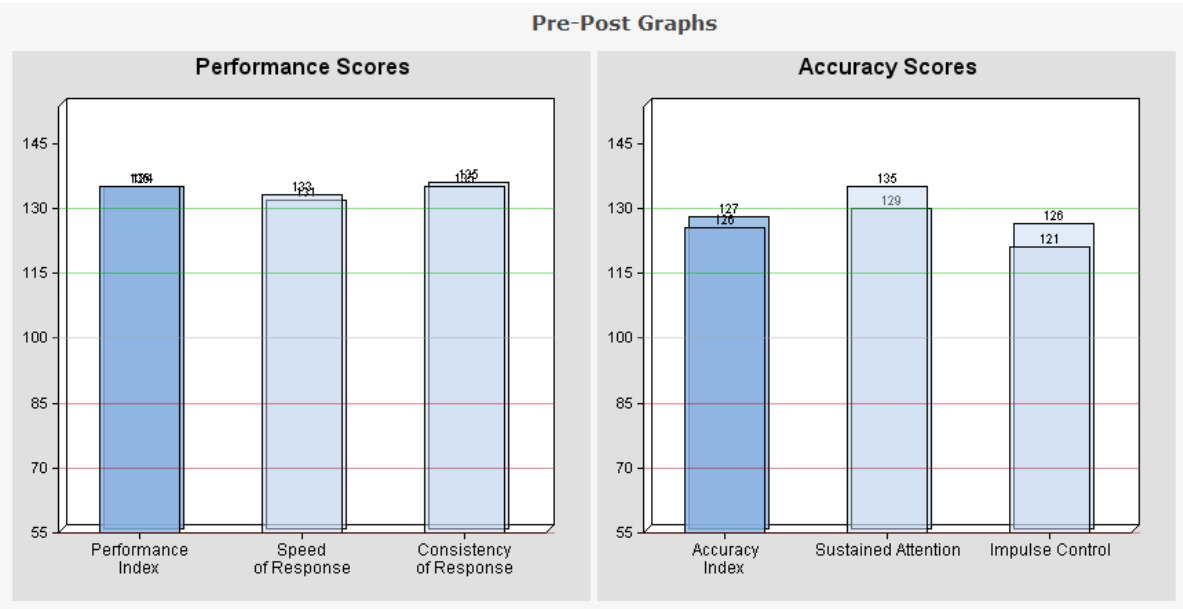


Pre-Post Chart: Errors

Pre-post standard scores are shown separately for the dimensions of accuracy and performance and their constituent variables. The entire analysis of the reference database for these reports is done without assuming that the data are Gaussian-distributed (bell-shaped). The analysis is performed

“non-parametrically” in terms of percentiles. These are then converted into standard scores just as if the distribution had been Gaussian originally.
This is being done because CPT data are conventionally presented in terms of standard scores. It is defensible on the basis that the proper rank-ordering is being maintained in this conversion. It should be remembered, though, that the validity of the analysis does not hinge on the assumption that the data are Gaussian-distributed.

A somewhat arbitrary choice had to be made in one respect, and that needs to be called to the attention of the test giver. If someone makes zero omission errors and zero outliers, and hence scores perfectly on the inattention scale, what score should be assigned? One could make the case for the 99th percentile. But if we are dealing with an adult male in his thirties, there is perhaps a 50% likelihood of that outcome. We cannot very well assign a score of 99th percentile to half the population in that category! What score, then, would give us the least error for all the people in that category? To answer that question, let us be more specific regarding what we actually know from the test. We know that the testee remained free of omission errors for a period of 21 minutes. We don’t know how long that might have continued. Every testee is only some minutes away from their first omission error, but we have no idea how many. If we did know, we could do the ranking and assign a more valid score. What is to be done in the absence of any such information? If we assign a score of 75th percentile, or half-way between 50 and 100, then we would know that half of the people are getting a score that is too generous, and half would be getting a score that is too harsh. That is the proper balance. The best we can say is that whereas assigning the 75th percentile in this case is the wrong answer for nearly everyone in the category, it is also the “least wrong” answer for all of them. It’s the best that can be done with the information we have.



Pre-Post Chart: Indices and Scores

Despite very explicit verbal instructions on how the test is to be taken, clients will demonstrate a range of behavioral responses to the testing challenge. Some will be driven by an aversion to errors to be more cautious going forward. Others cannot resist operating at the very threshold of automaticity lest they be found to be slow, the occasional error notwithstanding. Along those lines, the test giver should be alert to the existence of a tradeoff between mean reaction time and commission errors. In the initial testing, a client may well bias responses in the direction of fast responding at the cost of the

occasional error of commission. After training, the client may be more deliberate in the test-taking, making fewer commission errors but at the cost of a slower mean reaction time. This has been looked at extensively, and it has been established that this pattern is not typical. More typical is an improvement in both areas, and it is clear that rapid responding can be consistent with a dearth of commission errors. This is an instance of a coupling between the two principal indices, accuracy and performance.

How to use

To turn on the new norm and report format, click on the gray button:

QIKnorm is currently off

Then the button lights up to showing activation:

QIKnorm is on

Click on the green button again to switch back to off.

Introduction

(a) During the introductory phase you will be able to switch between the default classic report and the new report. (b) In two weeks, we will set your account to automatically start with the new report, but you can still opt-out and use the old report. (c) In two months we will be turning off the classic report to better focus on the current technology.

The Report for QIKtest is available online on EEG Expert at www.eegexpert.net.

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