CPP Quick Stats

Reliability (studies 1-3, Technical Report #5)

Cognitive styles: .73 - .87

Information Processing Competencies: .77 - .94

Levels of Work: .83 - .87

Validation

Criterion	Median r	25th percentile	75th percentile	Maximum r	Study Reference
Abilities/IQ	.40	.34	.45	.69	1, 5, 6, 8
Critical Reasoning	.50	.42	.59	.64	2,7
Personality (MBTI)	.09	.04	.19	.31	9, 10, 12
Personality (Other)	.05	.02	.08	.21	11, 13, 14
Career Path Appreciation	.25	.22	.29	.45	3, 4
Job Performance	.25	.16	.33	.52	15-20
HR Assigned Competencies	.46	-	-	.52	21
University Performance	.48	.43	.53	.61	22

The CPP SEM Model-Fit (Validity)

Goodness-of-Fit index (GFI) from a RAMONA structured equation model (SEM): .98 (.97 AGFI), study 23

The CPP "Quick Stats" Evidence

21st April, 2020

Research study reports and analysis results; parameter values are summarised in the CPP "Quick Stats" slide

(extracted from the CPP Technical Manual, v.2.1)

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The Reliability Studies

The fundamental concept behind the entire CPP assessment is novelty; we are assessing an individual's cognitive processes and characteristic features when faced with an entirely unfamiliar cognitive task. If you remove that novelty, you destroy the validity of the assessment. So, how do we assess reliability of the CPP?

Consider the fundamental definition of reliability found within any science as well as in everyday usage:

> Reliability is the extent to which a second, third and onwards observations of an event, measure, rating, or occurrence, deviates from the first or proceeding observations. If they are exactly the same, there is perfect reliability. In engineering terms, reliability is referred to as repeatability.

The repeatability problem for psychological assessment is noted by Guttman as far back as 1945 in his article entitled: "A basis for analysing test-retest reliability" p. 256:

> "The problem of reliability is of course not peculiar to psychology or sociology but pervades all the sciences. In dealing with empirical data in any field, the question should be raised: if the experiment were to be repeated, how much variation would there be in the results?"

And on page 257:

> "(3) A major emphasis of this paper is that the reliability coefficient cannot in general be estimated from but a single trial-that items do not replace trials. If two trials are experimentally independent, then we show that the correlation between two trials is, with probability of unity, equal to the reliability coefficient.
>
> (4) As is well known, there may be great practical difficulties in making two independent trials; therefore, our principal focus is on what information can be obtained from a single trial. We find that lower bounds to the reliability coefficient can be computed from a single trial. Six different lower bounds are derived, appropriate for different situations. Several of these bounds are as easy as or easier to compute than are conventional formulas, and all of the bounds assume less than do conventional formulas.
>
> (5) To prove that bounds can be computed from a single trial, we use essentially one basic assumption: **that the errors of observation are independent between**

> **items and between persons over the *universe of trials***. In the conventional approach, independence is taken over *persons* rather than trials, and the problem of observability from a single trial is not explicitly analysed."

Therein lies the sleight of hand deployed by psychometricians – a hypothetical *universe of trials*. By making an assumption based upon statistical sampling theory, and invoking the concept of a universe of items which 'measure' a single attribute, from which a random sample has been drawn by the investigator *(the items in any particular test)*, it is possible to generate a variety of bounds for reliability, which is exactly what Guttman achieved in his article.

Cronbach (1951) extended Guttman's work and introduced the now famous Cronbach alpha coefficient. This made reliability assessment a routine feature of analysis, augmenting the simple definition of reliability as repeatability by using that key assumption of an investigator sampling items from a 'universe' of items, with the additional proposition stating that individuals can be administered a multitude of parallel tests drawn from that universe. From this assumption-laden test-theory definition other kinds of reliability coefficients were constructed, such as omega, factor validity, and the complex indices that have been constructed recently in Structural Equation Modeling *(Cortina (1991), Schmitt (1996), Green and Yang (2009) provide good overviews)*. However, all these indices depend for their validity upon assumptions made about test scores as quantities, hypothetical true scores, and hypothetical item universes.

The real bottom line to reliability stays the same, regardless of what psychometricians might wish otherwise. It's about answering: *'what happens with an individual's attribute indications 2nd or 3rd time around on this test'*. Not a population of tests, not a population of people, but **this person, this test, right now**.

Ordinarily retest reliability would answer this question nicely, except that retest reliability estimation now includes three sources of 'perturbation':

1. non-systematic random error associated with the internal integrity of the test itself.
2. systematic attribute variation on the attribute over periods of time within and extending across the retest duration.
3. memory of previous responses artificially causing consistency in 2nd occasion response patterns. In assessments measuring learning curves, such as the CPP, memory of previous solutions may introduce different response patterns.

The end result of a retest analysis would nevertheless be an indication of reliability, but the causes of any substantive unreliability are not able to be disentangled from each other except by further careful empirical investigation.

However, with the CPP, we know 3 will invalidate the raison d'être of the assessment, which is to investigate how a person's cognitive processes and preferences engage with a *novel* series of

tasks. Once an individual has completed the assessment, the novelty is lost. It can perhaps take months or years for the memory of the task to fade, which then brings ❷ back into focus.

If a parallel version of the CPP could be constructed, then yes, parallel form reliability could be computed. But, the CPP is not a simple assessment to construct. It assesses dynamic learning and cognitive processing using a particular kind of task structure. To produce a parallel version would perhaps take many years with no obvious guarantee of success.

However, what we do know is that if a test is not reliable, it cannot be valid. That is the simple consequence of ❶, and not knowing the conditions causing occasion-to-occasion variability in responses for ❷.

But if it is reliable, then it may be valid *(if it assesses what it claims to assess)*. That logic allows us to indirectly infer the CPP reliability from its validation investigations. But it is a logical inference following from the fact that if the assessment claims about an individual made by the CPP are shown to be 'as stated' or eventuate over time, then we know the CPP must be reliable. However, we cannot quantify that 'unreliability' except with reference to the unreliability of the 'knowledge claims' made by the test about an individual, which would also be interpreted as evidence for its validity.

For the CPP, reliability and validity are necessarily intertwined; not as a design error but as feature of the particular kind of assessment methodology which the CPP embodies.

However, while the above reasoning and logic may be valid, it is still of interest to empirically examine the reliability of the assessment. Given the complex scoring structure of the CPP attributes, and the lack of any composite-item additive sum-score scales, internal consistency and omega reliabilities are contraindicated. The only sensible reliability estimate is **retest**, answering that fundamental reliability question:
'what happens with an individual's attribute indications 2nd or 3rd time around on this test'?

Those *'indications'* are class-category preferred styles of processing, 1-5 ordered class SST "Levels of Work" attributes, and 0-100 integer-metric, ordered-class information-processing competency scores.

3.1 Reliability Study 1

Sample Size and Details: 87 students undertaking an Accounting degree course at a South African university comprised the sample who completed the CPP twice, along with the Learning Orientation Index (LOI) assessment. Specific gender information was not available at the time of analysis, although judging by the forenames, the number of male and female students were relatively similar. Their ages at the first CPP assessment are provided in Table 3.

Table 1: Reliability Study 1, Sample participant ages at the first assessment

	Descriptive Statistics						
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.	Skewness
Age at Assessment	87	24.74	24	21	32	2.461	1.141

The descriptive statistics for the retest durations (in days) between the 1st and 2nd occasion CPP assessments are provided in Table 4. The median duration is **almost 2 months** (7.9 weeks), with the range between 7 and 9.3 weeks.

Table 2: Reliability Study 1, Summary statistics for retest durations (in days)

	Descriptive Statistics						
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.	Skewness
Retest Duration	87	54.89	55	49	65	2.678	0.832

Authored by: Prinsloo and Barrett

Description

- Gower (1971) agreement indices (see Appendix 1) were used throughout to express magnitude agreement, as what matters here is answering the simple question "*how closely do the retest occasion observations agree with one another?*", and not "*do observations on the first occasion possess a monotonic relationship with those on the second occasions?*"

- Relative to the maximum possible absolute (*unsigned*) discrepancy between the two pairs of observations, the Gower discrepancy coefficient indicates the % average absolute discrepancy between all pairs of observations. When expressed as a similarity coefficient (by subtracting it from 1), it indicates the % average similarity between all pairs of observations. So, a Gower similarity coefficient of 0.90 indicates that relative to the maximum possible absolute (*unsigned*) discrepancy between them, the observations agree on average to within 90% of each other's values.

- With respect to the magnitude of Gower indices, although the possible range varies from 0 *(maximum possible disagreement)* to 1 *(identical observations),* observing the maximum possible disagreement (or a coefficient < 0.5) is very rare, as it requires a substantive number of the paired observations to be near their maximum possible discrepancy *(or all of them in the case of a 0 coefficient)*. If we assume observations are sampled randomly from a uniform distribution, it is possible to bootstrap the expected sampling distribution of a

Gower index given the number of cases and particular measurement range of the attributes. This bootstrapping provides both credibility intervals for any observed Gower coefficient and an empirical point-estimate probability of occurrence. But, more importantly, it also provides an estimate of the median expected coefficient magnitude and the lower-upper bounds of an observed coefficient given purely random sampling of observations over perhaps 10,000 random sampling occasions. This information is critical when assessing the magnitude of any observed Gower index computed over the actual data.

- Three CPP attribute sets were investigated: Ranked cognitive styles, information processing competencies, and levels of work.

Additional Information

More detailed information and discussion may be found in our Cognadev Technical Report Series; #5 downloaded from:
http://www.cognadev.com/publications/Cognadev_Technical_Report_1_Ability_24_Jul_14.pdf

Analysis Results

3.1.1 Analyses: Cognitive Styles

For every individual, the scores for each cognitive style are rank-ordered in their report (1 = most preferred, 14 = least-preferred). Table 5 provides the Gower agreement indices (reliabilities).

Table 3: Reliability Study 1, Retest Reliability CPP Ranked Styles

Ranked Style	Gower	MAD
CPP-Explorative	.81	2
CPP-Analytical	.79	3
CPP-Structured	.85	2
CPP-Holistic	.85	2
CPP-Intuitive	.88	2
CPP-Memory	.76	3
CPP-Logical	.79	3
CPP-Impulsive	.81	2
CPP-Random	.80	3
CPP-Integrative	.87	2
CPP-Learning	.79	3
CPP-Quick insight	.78	3
CPP-Reflective	.77	3
CPP-Metaphoric	.82	2

Notes: **MAD** = Mean Absolute deviation between the paired observations.
The MAD values are rounded integers as the possible 'score' ranges are integer ranks {1…14}

For these data with an integer measurement range between 1 and 14, a bootstrap analysis was undertaken, generating 20,000 random samples of n=87 cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 5 is **.76**.
- The probability of observing a coefficient computed from random data, as high or higher than our lowest observed value is **0.0001** (i.e. just 2 samples out of 20,000 produced a Gower index of .76).
- Clearly, the observed Gower indices represent an indication of non-random agreement.

The median agreement index across all 14 styles is 81%, indicating that relative to the maximum possible absolute (*unsigned*) discrepancy between them, the ranks assigned to styles across occasions agree *on average* to within 81% of each other's values.

3.1.2 Analyses: Information-Processing Competencies

Within this retest dataset, all 14 process scores were expressed on a 1 to 7 scale (low to high). Table 6 provides the Gower agreement indices between the two-occasion CPP assessments.

Table 4: Reliability Study 1, Retest Reliability CPP Process Scores {score range 1-7}

Process Score	Gower	MAD
CPP-Pragmatic	.83	1.0
CPP-Exploration	.88	0.7
CPP-Analytical	.79	1.3
CPP-Rule-Oriented	.86	0.9
CPP-Categorisation	.84	1.0
CPP-Integration	.88	0.7
CPP-Complexity	.85	0.9
CPP-Logical Reasoning	.79	1.3
CPP-Verbal Conceptualisation	.77	1.4
CPP-Use of Memory	.84	1.0
CPP-Memory Strategies	.86	0.9
CPP-Judgement	.85	0.9
CPP-Quick Insight Learning	.87	0.8
CPP-Gradual Improvement Learning	.79	1.3

Note: MAD = Mean Absolute deviation between the paired class-categories

For these data with an integer measurement range between 1 and 7, a bootstrap analysis was undertaken, generating 20,000 random samples of n=87 cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.66**.
- The lowest observed Gower index in Table 6 is **.77**.
- The probability of observing a coefficient computed from random data, as high or higher than our lowest observed value is **0.00005** (i.e. just 1 sample out of 20,000 produced a Gower index of .77).
- Clearly, the observed Gower indices represent an indication of non-random agreement.

The median agreement index across all 14 processes is 85%, indicating that relative to the maximum possible absolute (*unsigned*) discrepancy between them, the ranks assigned to processes across occasions agree *on average* to within 85% of each other's values.

The mean of the mean absolute deviations is 1.0, the median of these deviations is also 1.0 (rounded from 0.95). That is, each process rank-score is on average within ±1 of each other's values – bearing in mind the range of the scores is between 1 and 7.

3.1.3 Analyses: Levels of Work

Table 7 reports the Gower agreement indices for the current (cLOW) and potential (pLOW) Levels of Work attributes. Given the rather small range of possible values for current and potential Levels of Work, we also computed Goodman-Kruskal Gamma ordinal correlation coefficients between the two occasions' data. Gamma, like the Pearson r, is primarily a measure of monotonicity rather than absolute agreement.

Table 5: Reliability Study 1, Retest Reliability CPP Levels of Work {cLOW range 1-4, pLOW range 1-5}

Level of Work (LOW)	Gower	MAD	Gamma
CPP Current LOW	.87	.40	.91
CPP Potential LOW	.87	.53	.74

Note: **MAD** = Mean Absolute deviation between the paired class-categories
Both Gower and Gamma coefficients are statistically significant at $p < 0.0001$

For the cLOW data with an integer measurement range between 1 and 4, a bootstrap analysis was undertaken, generating 20,000 random samples of n=87 cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.65**.
- The lowest observed Gower index in Table 7 is **.87**.
- None of the 20,000 random samples produced a Gower as high as .87. The highest random-data value observed was **.76**.

For the pLOW data with an integer measurement range between 1 and 5, a bootstrap analysis was undertaken, generating 20,000 random samples of n=87 cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.66**.
- The lowest observed Gower index in Table 7 is **.87**.
- As for the cLOW index, none of the 20,000 random samples produced a Gower as high as .87. The highest random-data value observed was **.77**.

3.1.4 Conclusions

Overall, the CPP ranked styles, Levels of Work class-categories, and processing scores show good retest reliability / magnitude agreement over a 2-month duration; compatible with and in most cases exceeding such reliabilities found using conventional psychometric tests over this duration.

3.2 Reliability Study 2

Sample Size and Details: 2,724 respondents completed the CPP on at least two occasions. For the purposes of this analysis, only the 1st and 2nd occasion data were utilised. The respondent sample was comprised primarily of job applicants who had completed the CPP on two separate occasions, but also included some students, and attendees at CPP training courses.

Table 6: Reliability Study 2, Sample participant ages at the first assessment

	Descriptive Statistics (Study 2, CPP Retest dataset.sta)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Age at Assessment-1	2638	34.17	34	16	60	7.932

Table 7: Reliability Study 2, Sample participant gender mix

	Frequency table: gender (Study 2, CPP Retest dataset.sta)			
Category	Count	Cumulative Count	Percent	Cumulative Percent
F	1061	1061	38.95	38.95
M	1663	2724	61.05	100.00
Missing	0	2724	0.00	100.00

Table 8: Reliability Study 2, Sample participant ethnicity mix

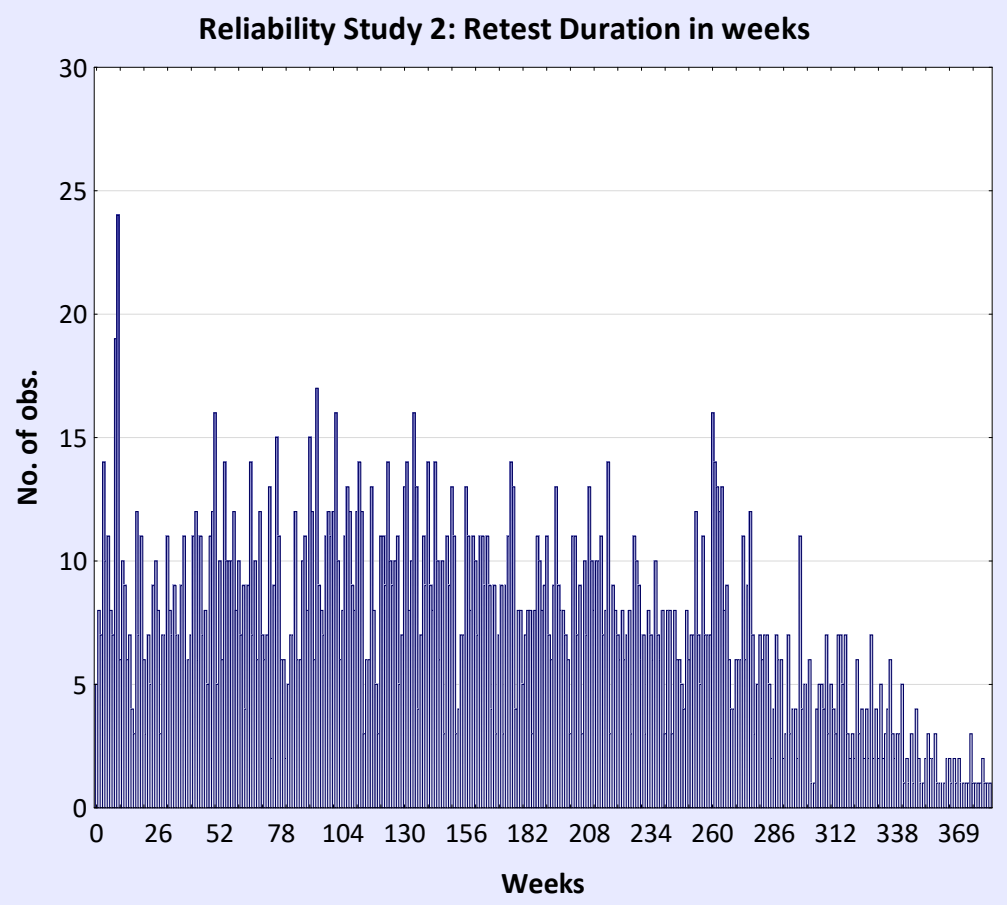
	Frequency table: ethnicity (Study 2, CPP Retest dataset.sta)			
Category	Count	Cumulative Count	Percent	Cumulative Percent
Indian	418	418	18.50	18.496
White European	636	1054	28.14	46.637
Black African	1206	2260	53.36	100.000

Table 9: Reliability Study 2, Summary statistics for retest durations (in weeks)

	Descriptive Statistics (Study 2, CPP Retest dataset.sta)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Duration	2720	157.10	149.5	0	613	95.69

Note: Four cases had invalid or missing assessment dates.

Figure 1: Reliability Study 2, Histogram of retest durations in weeks



Given the spread of durations, three relevant retest-duration groups were constructed from the weekly data, corresponding to reasonably short, medium, and long-term retest durations.

Table 10: Reliability Study 2, Retest-duration groups

	Frequency table: Duration Group (Study 2, CPP Retest dataset.sta)			
Category	Count	Cumulative Count	Percent	Cumulative Percent
0 <= 6 months	236	236	8.66	8.66
> 6 months <= 1 year	219	455	8.04	16.70
> 1 year	2265	2720	83.15	99.85
Missing	4	2724	0.15	100.00

Authored by: internal Cognadev R&D analysis.

Description

- Gower (1971) agreement indices (see Appendix 1) were used throughout to express magnitude agreement, as what matters here is answering the simple question "*how closely do the retest occasion observations agree with one another?*", and not "*do observations on the first occasion possess a monotonic relationship with those on the second occasions?*"

- Relative to the maximum possible absolute (*unsigned*) discrepancy between the two pairs of observations, the Gower discrepancy coefficient indicates the % average absolute discrepancy between all pairs of observations. When expressed as a similarity coefficient (by subtracting it from 1), it indicates the % average similarity between all pairs of observations. So, a Gower similarity coefficient of 0.90 indicates that relative to the maximum possible absolute (*unsigned*) discrepancy between them, the observations agree on average to within 90% of each other's values.

- As explained in Section 3.1, bootstrapped sampling distributions of Gower indices provided checks on the 'significance' of the observed Gower indices, using uniform random data with the same measurement range and sample size as the actual data.

- Three CPP attribute sets were investigated: Ranked cognitive styles, information processing competencies, and levels of work.

Additional Information

None; this was an internal Cognadev research study

Analysis Results

3.2.1 Analyses: Cognitive Styles

For every individual, the scores for each cognitive style are rank-ordered in their report; in this dataset *(unlike in Study 1)* the rank orders range from 14 = most preferred, 1 = least-preferred. Table 13 provides the Gower agreement indices (reliabilities) for the three retest-duration groups.

Table 11: Reliability Study 2, Retest Reliability CPP Ranked Styles; three retest-duration groups

Duration	<= 6 months, n=236		> 6 months but <= 1 year, n=219		> 1 year n=2,265	
Ranked Style	**Gower**	**MAD**	**Gower**	**MAD**	**Gower**	**MAD**
CPP - Explorative	.77	3	.77	3	.77	3
CPP-Analytical	.76	3	.76	3	.75	3
CPP Structured	.82	2	.82	2	.82	2
CPP Holistic	.83	2	.82	2	.82	2
CPP Intuitive	.86	2	.87	2	.87	2
CPP Memory	.77	3	.75	3	.75	3
CPP Logical	.79	3	.75	3	.75	3
CPP Impulsive	.80	3	.80	3	.82	2
CPP Random	.78	3	.79	3	.80	3
CPP Integrative	.85	2	.86	2	.85	2
CPP Learning	.81	2	.80	3	.79	3
CPP Quick insight	.82	2	.84	2	.83	2
CPP Reflective	.82	2	.82	2	.81	2
CPP Metaphoric	.77	3	.74	3	.76	3

Notes: **MAD** = Mean Absolute deviation between the paired observations.
The MAD values are rounded integers as the possible 'score' ranges are integer ranks {1…14}

Bootstrap results for Duration 1 sample (<= 6 months)
For these data with an integer measurement range between 1 and 14, a bootstrap analysis was undertaken, generating 20,000 random samples of **n=236** cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 13 is **.76**.
- None of the 20,000 random samples produced a Gower as high as .76. The highest random-data value observed was **.72**.

Bootstrap results for Duration 2 sample (> 6 months but <= 1 year)
For these data with an integer measurement range between 1 and 14, a bootstrap analysis was undertaken, generating 20,000 random samples of **n=219** cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 13 is **.74**.
- None of the 20,000 random samples produced a Gower as high as .74. The highest random-data value observed was **.73**.

Bootstrap results for Duration 3 sample (> 1 year)
For these data with an integer measurement range between 1 and 14, a bootstrap analysis was undertaken, generating 20,000 random samples of **n=2,265** cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 13 is **.75**.
- None of the 20,000 random samples produced a Gower as high as .75. The highest random-data value observed was **.68**.

Table 13 shows that the cognitive style rankings remain similar to one another across assessment occasions, whether over a short or long-term. The ranking position of each style varies between 2 and 3 ranking places on average.

So, for example, the rank-values of Quick Insight for duration-group 1 respondents (< = 6 months) agree on average to within 82% of each occasions' values. A rank assigned on the 1st occasion will, on average, possess a rank on occasion 2 within ±2 of the 1st occasion rank.

3.2.2 Analyses: Information-Processing Competencies

Within this retest dataset, all 14 process scores were expressed on a 0 to 100 integer scale. Table 14 provides the Gower agreement indices between the two-occasion CPP assessments for the three duration groups.

Table 12: Reliability Study 2, CPP Information Processing Competencies; three retest-duration groups

Duration	<= 6 months, n=236		> 6 months but <= 1 year, n=219		> 1 year n=2,265	
Processing Scores	**Gower**	**MAD**	**Gower**	**MAD**	**Gower**	**MAD**
CPP-Pragmatic	.89	11	.89	11	.89	11
CPP-Exploration	.94	6	.93	7	.94	6
CPP-Analytical	.84	16	.83	17	.84	16
CPP-Rule-Oriented	.90	10	.90	10	.90	10
CPP-Categorisation	.93	7	.92	8	.93	7
CPP-Integration	.92	8	.93	7	.93	7
CPP-Complexity	.90	10	.90	10	.91	9
CPP-Logical Reasoning	.86	14	.86	14	.86	14
CPP-Verbal Conceptualisation	.86	14	.88	12	.87	13
CPP-Use of Memory	.92	8	.91	9	.91	9
CPP-Memory Strategies	.92	8	.91	9	.92	8
CPP-Judgement	.90	10	.90	10	.90	10
CPP-Quick Insight Learning	.92	8	.92	8	.92	8
CPP-Gradual Improvement Learning	.89	11	.90	10	.89	11

Notes: **MAD** = Mean Absolute deviation between the paired observations.
The MAD values are rounded integers as the possible 'score' ranges are integers {0 ...100}

Bootstrap results for Duration 1 sample (<= 6 months)

For these data with an integer measurement range between 0 and 100, a bootstrap analysis was undertaken, generating 20,000 random samples of **n=236** cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 14 is **.84**.
- None of the 20,000 random samples produced a Gower as high as .84. The highest random-data value observed was **.72**.

Bootstrap results for Duration 2 sample (> 6 months but <= 1 year)

For these data with an integer measurement range between 0 and 100, a bootstrap analysis was undertaken, generating 20,000 random samples of **n=219** cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 14 is **.83**.
- None of the 20,000 random samples produced a Gower as high as .83. The highest random-data value observed was **.73**.

Bootstrap results for Duration 3 sample (> 1 year)

For these data with an integer measurement range between 0 and 100, a bootstrap analysis was undertaken, generating 20,000 random samples of **n=2,265** cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 14 is **.84**.
- None of the 20,000 random samples produced a Gower as high as .84. The highest random-data value observed was **.69**.

3.2.3 Analyses: Levels of Work

Table 15 reports the Gower agreement indices for the current (cLOW) and potential (pLOW) Levels of Work attributes. Given the rather small range of possible values for current and potential Levels of Work, we also computed Goodman-Kruskal Gamma ordinal correlation coefficients between the two occasions' data. Gamma, like the Pearson r, is primarily a measure of monotonicity rather than absolute agreement.

Table 13: Reliability Study 2, Retest Reliability CPP Levels of Work {cLOW range 1-4, pLOW range 1-5}

Duration	**<= 6 months, n=236**			**> 6 months but <= 1 year n=219**			**> 1 year n=2,265**		
Level of Work(LOW)	**Gower**	**MAD**	**Gamma**	**Gower**	**MAD**	**Gamma**	**Gower**	**MAD**	**Gamma**
CPP Current (cLOW)	.84	.48	.92	.83	.50	.81	.83	.51	.82
CPP Potential (pLOW)	.86	.56	.82	.86	.55	.76	.86	.54	.78

Note: **MAD** = Mean Absolute deviation between the paired class-categories
Both Gower and Gamma coefficients are statistically significant at $p < 0.0001$

For the cLOW data with an integer measurement range between 1 and 4, a bootstrap analysis was undertaken, generating 20,000 random samples of for each duration number of cases, forming empirical sampling distributions of possible Gower indices.

- The median expected random-data Gower varied between **.65** and **.66.**
- The lowest observed Gower index in Table 15, any duration is **.83**.
- None of the 20,000 random samples produced a Gower as high as .83. The highest random-data value observed was **.73**.

For the pLOW data with an integer measurement range between 1 and 5, a bootstrap analysis was undertaken, generating 20,000 random samples of for each duration number of cases, forming empirical sampling distributions of possible Gower indices.

- The median expected random-data Gower index was **.66**.
- The lowest observed Gower index in Table 15 is **.86**.
- As for the cLOW index, none of the 20,000 random samples produced a Gower as high as .86. The highest random-data value observed was **.73**.

3.2.4 Conclusions

Overall, the CPP ranked styles, Levels of Work class-categories, and processing scores in Study 2 show reasonable to excellent retest reliability / magnitudes agreement over three durations; compatible with and in most cases exceeding such reliabilities found using conventional psychometric tests over this duration. Clearly, the attributes assessed here seem to be relatively stable over time.

3.3. Reliability Study 3

Of interest perhaps is evaluating the CPP retest reliability of the same attributes reported for Study 2 in section 3.2 above, but where we only include cases whose 2nd retest occasion was more than 5 years since their 1st test occasion. Within the Study 2 dataset, we have **475** cases whose durations extend from **261 weeks** (5 years, 1 week) through to **613 weeks** (11 years, 41 weeks).

3.3.1 Analyses: Cognitive Styles

For every individual, the scores for each cognitive style are rank-ordered in their report; in this dataset *(unlike in Study 1)* the rank orders range from 14 = most preferred, 1 = least-preferred. Table 16 provides the Gower agreement indices (reliabilities) for this long-duration group.

Table 14: Long-Duration (> 5 years) Retest Reliability CPP Ranked Styles

Ranked Style	Gower	MAD
CPP - Explorative	.78	3
CPP-Analytical	.73	4
CPP Structured	.82	2
CPP Holistic	.82	2
CPP Intuitive	.87	2
CPP Memory	.73	4
CPP Logical	.75	3
CPP Impulsive	.83	2
CPP Random	.81	3
CPP Integrative	.85	2
CPP Learning	.80	3
CPP Quick insight	.81	2
CPP Reflective	.81	3
CPP Metaphoric	.74	3

Notes: **MAD** = Mean Absolute deviation between the paired observations.
The MAD values are rounded integers as the possible 'score' ranges are integer ranks {1…14}

For these data with an integer measurement range between 1 and 14, a bootstrap analysis was undertaken, generating 20,000 random samples of n=475 cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 16 is **.73**.
- None of the 20,000 random samples produced a Gower as high as .73. The highest random-data value observed was **.71**.

For two styles, Analytical and Memory, a ±4 average rank-discrepancy between occasions is fairly substantive.

3.3.2 Analyses: Information-Processing Competencies

Within this retest dataset, all 14 process scores were expressed on a 0 to 100 integer scale. Table 17 provides the Gower agreement indices between the two-occasion CPP assessments for the three duration groups.

Table 15: Long-Duration (> 5 years) Retest Reliability CPP Information Processing Competencies

Process Score	Gower	MAD
CPP-Pragmatic	.88	12
CPP-Exploration	.94	6
CPP-Analytical	.84	16
CPP-Rule-Oriented	.91	9
CPP-Categorisation	.93	7
CPP-Integration	.93	7
CPP-Complexity	.91	9
CPP-Logical Reasoning	.86	14
CPP-Verbal Conceptualisation	.87	13
CPP-Use of Memory	.91	9
CPP-Memory Strategies	.92	8
CPP-Judgement	.90	10
CPP-Quick Insight Learning	.93	7
CPP-Gradual Improvement Learning	.89	11

Note: MAD = Mean Absolute deviation between the paired class-categories

For these data with an integer measurement range between 0 and 100, a bootstrap analysis was undertaken, generating 20,000 random samples of **n=475** cases forming an empirical sampling distribution of possible Gower indices.

- The median expected random-data Gower index was **.67**.
- The lowest observed Gower index in Table 17 is **.84**.
- None of the 20,000 random samples produced a Gower as high as .84. The highest random-data value observed was **.71**

Some of the processing competency scores remain remarkably similar over a 5 year or longer retest duration, especially Exploration, Categorisation, Integration, and Quick Insight Learning. The Analytical competency shows the greatest discrepancy – with a ±16 average score-discrepancy between occasions, although relative to a 0-100 integer possible score-range.

3.3.3 Analyses: Levels of Work

Table 18 reports the Gower agreement indices for the current (cLOW) and potential (pLOW) Levels of Work attributes. Given the rather small range of possible values for current and potential Levels of Work, we also computed Goodman-Kruskal Gamma ordinal correlation coefficients between the two occasions' data. Gamma, like the Pearson r, is primarily a measure of monotonicity rather than absolute agreement.

Table 16: Long-Duration (> 5 years) Retest Reliability CPP Levels of Work

Level of Work (LOW)	Gower	MAD	Gamma
CPP Current LOW	.84	.48	.81
CPP Potential LOW	.87	.53	.78

Note: **MAD** = Mean Absolute deviation between the paired class-categories
Both Gower and Gamma coefficients are statistically significant at $p < 0.0001$

For the cLOW data with an integer measurement range between 1 and 4, a bootstrap analysis was undertaken, generating 20,000 random samples of for each duration number of cases, forming empirical sampling distributions of possible Gower indices.

- The median expected random-data Gower was **.65.**
- The cLOW Gower index in Table 18 is **.84**.
- None of the 20,000 random samples produced a Gower as high as .84. The highest random-data value observed was **.70**.

For the pLOW data with an integer measurement range between 1 and 5, a bootstrap analysis was undertaken, generating 20,000 random samples of for each duration number of cases, forming empirical sampling distributions of possible Gower indices.

- The median expected random-data Gower index was **.66**.
- The observed pLOW Gower index in Table 18 is **.87**.
- As for the cLOW index, none of the 20,000 random samples produced a Gower as high as .87. The highest random-data value observed was **.70**.

3.3.4 Conclusions

Overall, the CPP ranked styles, Levels of Work class-categories, and processing scores for the longer-duration subsample of Study 2's data, show reasonable to excellent retest reliability / magnitudes agreement over three durations; exceeding such reliabilities found using conventional psychometric tests over this long-duration. Clearly, many of the attributes assessed here seem to be relatively stable over time, reflecting their substantive, but not identical, relationship with cognitive ability *(as shown in the next chapter).*

The Validation Studies

4.1 Abilities

4.1.1 Validation Study 1: CPP Competencies with WAIS-R IQ scores

Table 17: Study 1 Details: CPP Information Processing Competencies and WAIS-R IQ scores

Study 1: CPP vs WAIS-R	
Date:	1995-1996
Authored by:	Prinsloo
Sample Size:	100
Age:	Mainly between the range 30-40
Gender:	Mixed gender, majority male
Ethnicity:	Four race groups but primarily Caucasian
Language Groups:	Different groups but all were fluent in English
Education:	Various levels of educational qualifications *(with 70% having post graduate qualifications)*
Source:	South African corporate environment comprising various organisations within the financial sector *(including banking, insurance and accounting)*
Additional Information	• Pearson correlations were computed between the CPP and WAIS-R IQ scores • CPP Information Processing competencies were assessed using a 0-100 scale

Table 18: Study 1 Results – Information Processing scores and WAIS-R IQs

Process Score	WAIS Verbal IQ	WAIS Performance IQ	WAIS Full Scale IQ
Exploration	.63	.42	.52
Analysis / Linking	.67	.41	.60
Complexity / Structuring	.67	.46	.63
Logical reasoning	.69	.46	.64
Memory	.59	.41	.57
Metacognition	.68	.46	.64

Note: All correlations are significant at $p < 0.001$, two-tail

Generally, higher correlations were obtained between CPP processing scores and the verbal, as opposed to the performance, subtests of the WAIS. This can be attributed to the relatively strong reliance of CPP measurements on conceptualisation skills: the CPP focuses on cognitive processes that are used to meaningfully interpret one’s world. This CPP aspect is, however, not related to language proficiency or to grammar, spelling, or vocabulary as in the case of IQ tests.

4.1.2 Validation Study 2: CPP Competencies with Psytech Critical Reasoning scores

Table 19: Study 2 Details: CPP Information Processing Competencies and Psytech's CRTB scales

Study 2: CPP vs Psytech Critical Reasoning Test Battery (Verbal & Numerical scales)	
Date:	1999
Authored by:	Prinsloo
Sample Size:	44
Age:	25 to 35 years
Gender:	23 men and 21 women
Ethnicity:	Black and white South Africans
Language Groups:	No information available except that all were fluent in English
Education:	All academic performers – mostly with multiple degrees in diverse disciplines (Sciences, Business, Humanities).
Source:	Employees; members of a banking group's general leadership development programme. All were regarded as "high-fliers".
Additional Information	• Pearson correlations were computed between the CPP and CRTB scores • CPP Information Processing competencies were assessed using a 0-100 scale

Table 20: Study 2 Results - Information Processing scores and CRTB scores

Process Score	CRTB Verbal	CRTB Numerical
Analytical	.61	.55
Logical Reasoning	.60	.56
Use of Memory	.32*	.31*
Integration	.60	.60
Verbal conceptualisation	.48	.42

Note: correlations marked with a * are significant at $p < 0.05$, all others at $p < 0.01$, two-tail

Both the CRTB scales of verbal evaluation and numerical evaluation correlated significantly with the CPP processing dimensions of "Logical reasoning", "Analytical", "Integration"," Verbal conceptualisation", and "Memory usage". The verbal dimension shows a slightly higher correlation, but this particular difference was neither statistically nor conceptually significant.

4.1.3 Validation Study 3: CPP and CPA Style Ranks and Levels of Work

Table 21: Study 3 Details: CPP and CPA Style ranks and Levels of Work

Study 3: CPP vs Career Path Assessment (CPA) attributes	
Date:	1999
Authored by:	Prinsloo
Sample Size:	83
Age:	From 21 to 48 years
Gender:	52 men and 31 women
Ethnicity:	Black and white South Africans
Language Groups:	No information available except that all were fluent in English
Education:	Almost all were graduates – some with multiple degrees. Operational candidates that were included were all highlevel performers and earmarked for "fast tracking" in the organisation.
Source:	Employees within a South African public media-communications company; primarily drawn from management and specialist positions with approximately 20% of the participants from Operational positions
Additional Information	The CPA is a structured interview developed by Gillian Stamp consisting of: • Phrase cards, • Symbol cards and • A discussion of a person's career history and career ambitions. The Phrase Cards form the major component of the test and are meant to trigger thinking around preferred approach to work. Based on the discussion of this, the CPA practitioner extracts themes of work. The Symbol cards, or card sorting exercise, looks at a person's approach to unfamiliar problems. Here the practitioner again observes and infers the subject's stylistic tendencies in terms of cognitive functioning. The interview focuses on a person's career history and ambitions. The interview also explores the person's long-term future career orientation, or personal ambition. CPA results primarily indicate the person's current level of capability and describes one of five cognitive styles (plus their combinations) in dealing with uncertainty. It also provides an indication of the person's potential based on a projection of predefined curves and age. Like the CPP, the CPA assesses aspects of learning potential and level of work in terms of Jacques' Stratified Systems Theory (SST). From: Oosthuizen, Coetzee, & Kruger (2014) ,page 2:

	"The CPA measure is used in the recruitment, mentoring and development of people in a variety of organisations and industries locally and internationally (Comaroff, 2012; Kitching, 2005). In South Africa, approximately 3500 CPAs are conducted annually on average. The CPA procedure is utilised to assist in the identification of potential talent at an early stage and to help organisations to fast-track and develop talent for the future (Kruger, 2013). CPA provides results indicating the probable rate of growth of current levels of work decision-making capability in individuals and their organisations. The instrument can therefore assist individuals in making more informed career-related decisions, in pacing themselves in their career growth and in preparing for additional responsibilities" • All correlations are Spearman rho indices • One single CPA assessor

Within these data, the CPA decision-making styles are treated as ordered classes, varying from fact-based (grounded) through to entirely intuitive (abstract) decision-making style. The styles comprise five different preferred approaches a person would use to carry out a specific task under normal circumstances:

A. Pragmatic Intuition
B. Pragmatic Analysis
C. Analytical Intuition
D. Conceptual Analysis
E. Intuitive Analysis

Table 22: Study 3 Results

Attributes	Spearman rho Correlation
CPP Style ranks with CPA Style ranks	.45
CPP Current Level of Work (cLOW) with CPA cLOW estimate	.35
CPP Potential Level of Work (pLOW) with CPA pLOW estimate	.37

Note: All correlations are significant at $p < 0.005$, two-tail

These correlations between the CPP and the CPA's assessment of current and potential levels of job-related functioning are not as high as one might expect given both assessments claim to assess similar constructs. However, the CPA relies to a very great extent upon subjective interviewer appraisal rather than the more formal performance-based scoring methodology of the CPP.

4.1.4 Validation Study 4: CPP Competencies, Levels of Work, and CPA Levels of Work

Table 23: Study 4 Details: CPP Competencies and Levels of Work with CPA Levels of Work and Styles

<table>
<tr><th colspan="2">Study 4: CPP vs Career Path Assessment (CPA) attributes</th></tr>
<tr><td>Date:</td><td>2001-2004</td></tr>
<tr><td>Authored by:</td><td>Prinsloo and Ashton</td></tr>
<tr><td>Sample Size:</td><td>266-268</td></tr>
<tr><td>Age:</td><td>
<table>
<tr><th></th><th colspan="6">Study 4: Age descriptive statistics</th></tr>
<tr><th>Variable</th><th>Valid N</th><th>Mean</th><th>Median</th><th>Minimum</th><th>Maximum</th><th>Std.Dev.</th></tr>
<tr><td>Age</td><td>209</td><td>36.6</td><td>36</td><td>24</td><td>55</td><td>6.39</td></tr>
</table>
</td></tr>
<tr><td>Gender:</td><td>
<table>
<tr><th></th><th colspan="4">Study 4: Frequency table: Gender</th></tr>
<tr><th>Category</th><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>Male</td><td>222</td><td>222</td><td>82.84</td><td>82.84</td></tr>
<tr><td>Female</td><td>46</td><td>268</td><td>17.16</td><td>100.00</td></tr>
<tr><td>Missing</td><td>0</td><td>268</td><td>0.00</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Ethnicity:</td><td>
<table>
<tr><th></th><th colspan="4">Study 4: Ethnicity mix (119 cases with no information)</th></tr>
<tr><th>Category</th><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>White</td><td>116</td><td>116</td><td>77.85</td><td>77.85</td></tr>
<tr><td>Coloured</td><td>6</td><td>122</td><td>4.03</td><td>81.88</td></tr>
<tr><td>Asian</td><td>4</td><td>126</td><td>2.68</td><td>84.56</td></tr>
<tr><td>Black</td><td>23</td><td>149</td><td>15.44</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Language Groups:</td><td>No information available except that all were fluent in English</td></tr>
<tr><td>Education:</td><td>Mixed range of education</td></tr>
<tr><td>Source:</td><td>Employees within a South African corporate environment; primarily drawn from Retail, Mining, Insurance, Consulting and Telecommunications. A majority were managers or specialists</td></tr>
<tr><td>Additional Information</td><td>

Pearson correlations reported throughout
CPP Information Processing competencies were assessed using a 1-7 scale
CPP Levels of Work were assessed using a 1-5 scale
Many different CPA practitioners conducted the interviews – some of which were more effective than others.

</td></tr>
</table>

Table 24: Study 4 Results – CPP and CPA attributes

CPP Attributes	CPA Current Level of Work (Capability)	CPA Potential Level of Work (Mode)	CPA Decision-Style
Current Level of Work	.25	.34	.25
Potential Level of Work	.28	.38	.26
Pragmatic	.26	.37	.25
Analytical	.21	.29	.24
Structuring	.17	.29	.24
Complexity	.21	.30	.23
Logical	.20	.28	.23
Verbal Abstraction	.17	.29	.24
Memory	.17	.26	.21
Judgement	.20	.27	.21
Learning potential	.24	.31	.25

Note: All correlations are significant at $p < 0.006$, two-tail

The above findings indicate small to moderate correlations between CPP Level of work, as well as CPP processing constructs, and CPA level of work indications. Some relationship has thus been found between the thinking skills as measured by the CPP and the capacity to cognitively manage complexity as measured by the CPA structured interview.

It should however be pointed out that the low correlations found in this study in comparison to the previous CPP-CPA study #3 may be attributed to the large number of CPA practitioners involved in gathering the CPA scores in this study. In the previous study only one expert CPA practitioner was involved. Because of the subjective nature of interview-based evaluations, a core challenge of structured interview methodology remains that of inter-rater reliability.

However, Kitching (2005) provides a paragraph which would seem to contraindicate such a conclusion in her Master's thesis relating to the interrater reliability of the CPA (p. 19-20):

> "Given the nature of the CPA, the most appropriate approach is that of inter-rater reliability. Several studies conducted in the US Army Research Institute for the Behavioural and Social Sciences (ARI) yielded coefficients ranging between 0.79 and 0.81, which are excellent in view of the complexity of the scoring procedure that is used (Lewis, 1993). In other studies, the percentage of agreement between judges was used as an indication of reliability. The mean absolute agreements for current levels of work were 95 percent, 90 percent for current level of capability and 94 percent for likely growth capability (Rossan & Topham, 1996). In an investigation of 74 CPA protocols for workers in Botswana, a 100 percent agreement in mode placement was found between two raters. Taking the intermode placements into account, the percentage agreement was 91 percent" (Mushayandebvu, 1991).

Only one study (Lewis, 1993) was published and available for 3rd-party access; this study used just two raters.

More very high CPA interrater reliability coefficients were reported in a summary of all such research in another Masters' thesis (Kruger, 2013; pp 49-54), but none of the reported studies except for Lewis (1993) were published / available for 3rd party evaluation. Two were repeated from Kitching (2005) thesis.

It remains the case that until publicly available evidence is forthcoming concerning multi-rater (more than 2) ratings of CPA attributes, or as with the Psychopathy Checklist- Revised assessment (Hare, 1990), formal accuracy-evaluation of raters against a fixed 'standard' of criterion target interview ratings is part of the training process *(where a minimal standard of rating accuracy is required to be met prior to 'certification')*, doubt remains concerning the quality of ratings provided by multiple CPA raters.

4.1.5 Validation Study 5: CPP Competencies, Levels of Work, Cognitive Style, and Psychometric IQ

In this study, prorated IQ was assessed using subtests from the Multidimensional Aptitude Battery (MAB: Jackson, 1984), marketed by Sigma Assessment Systems Inc.).
From Vernon (2000, p. 195-6):

> "The Multidimensional Aptitude Battery (MAB; Jackson, 1984) is a multiple-choice, group-administrable test of intelligence patterned quite closely after the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). Like the WAIS-R, the MAB consists of two subscales, Verbal and Performance, each comprising five subtests. The MAB is designed to be used with adolescents and adults between 16 and 74 years of age and is scored to provide Verbal, Performance, and Full-Scale IQs as well as subtest profiles.
>
> In the **Verbal Scale**, subtests include *Information* (a 40-item test of general knowledge), *Comprehension* (a 28-item test measuring a person's understanding of various social situations or conventions); *Arithmetic* (26 items ranging in difficulty from simple arithmetic to complex numerical reasoning); *Similarities* (a 34-item test in which people must decide in what way two things are alike); and *Vocabulary* (46 items). Each of these subtests taps the same constructs as those in the WAIS-R, though all of the actual items are different. Note also that there is no MAB subtest comparable to the WAIS-R's Digit Span.
>
> In the **Performance Scale**, the MAB subtests include *Digit Symbol* (a 35-item test in which the digits 1 to 9 are matched [or coded] with different symbols. Subjects are presented with strings of from 1 to 9 symbols and must identify which of five accompanying strings of digits correctly matches the symbols); *Picture Completion* (35 items in which pictures of objects with one missing part are presented. Accompanying each picture are the first letters of five possible missing parts. Subjects must first identify the correct missing part in each picture and then choose its first letter correctly from among the distractors); *Spatial* (a 50-item test in which subjects must spatially rotate a figure and match the rotation to one of five possible answers. This is the only MAB subtest that does not have a precise counterpart in the WAIS-R; it is the MAB's alternative to the WAIS-R's Block Design); *Picture Arrangement* (21 items in which subjects must mentally rearrange between 3 and 6 cartoon panels to tell a sensible story); and *Object Assembly* (a 20-item test in which between 3 and 6 numbered silhouetted parts of common objects are presented in the wrong order. Subjects must first identify the objects and then mentally rearrange their parts into the correct order).
>
> Internal consistency reliability coefficients are reported in the MAB Manual (Jackson, 1984) for each of its subtests and for Verbal, Performance, and Full-Scale IQ scores {FSIQ}. Subtest reliabilities range from .70 to. 96 and VIQ, PIQ, and FSIQ

> reliabilities range from .94 to .98 in different age groups. Test-retest stability and split-half reliability coefficients are also reported in the MAB Manual: subtest stability coefficients range from .83 to .97, VIQ, PIQ, and FSIQ stability coefficients are .95, .96, and .97, respectively; subtest split-half reliabilities (Spearman-Brown corrected) range from .55 to .87, VIQ, PIQ, and FSIQ corrected reliabilities are .92, .94, and .95. Clearly, the MAB Scale scores are highly reliable and the reliabilities of its individual subtests are at least satisfactory."

Age-Corrected Scaled Scores (standardised / normalised) for the subtests, and prorated Age-Corrected Full-Scale IQ scores were used for all subsequent data analyses.

Respondents were assessed on the CPP and MAB under proctored conditions. Because of specific language and cultural concerns *(many potential respondents did not always possess the same educational exposure to words, phrases, and information content which are common to many European and North American countries),* and time constraints on assessment, not all MAB subtests were used in this study. In fact, only four out of 10 were used:

- Comprehension
- Similarities
- Picture Arrangement
- Object Assembly

Therefore, Verbal, Performance, and Full-Scale IQ are prorated estimates.

Table 25: Study 5 Details: CPP Styles, Competencies, and Levels of Work with MAB Ability and IQ scores

<table>
<tr><th colspan="2">Study 5: CPP vs MAB Abilities and IQ scores</th></tr>
<tr><td>Date:</td><td>2014</td></tr>
<tr><td>Authored by:</td><td>Barrett and Prinsloo</td></tr>
<tr><td>Sample Size:</td><td>149-161</td></tr>
<tr><td>Age:</td><td>
<table>
<tr><th></th><th colspan="6">Study 5: Age Descriptive statistics</th></tr>
<tr><th>Variable</th><th>Valid N</th><th>Mean</th><th>Median</th><th>Minimum</th><th>Maximum</th><th>Std.Dev.</th></tr>
<tr><td>Age</td><td>161</td><td>21.5</td><td>19</td><td>17</td><td>50</td><td>5.91</td></tr>
</table>
</td></tr>
<tr><td>Gender:</td><td>
<table>
<tr><th></th><th colspan="4">Study 5: Frequency table: Gender</th></tr>
<tr><th>Category</th><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>F</td><td>136</td><td>136</td><td>84.47</td><td>84.47</td></tr>
<tr><td>M</td><td>25</td><td>161</td><td>15.53</td><td>100.00</td></tr>
<tr><td>Missing</td><td>0</td><td>161</td><td>0.00</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Ethnicity:</td><td>Mixed</td></tr>
<tr><td>Language Groups:</td><td>No information available except that all were fluent in English</td></tr>
<tr><td>Education:</td><td>All completing first or postgraduate degrees</td></tr>
<tr><td>Source:</td><td>The sample comprised a mixture of university students, employees, and adult volunteers, all tested within South Africa. Of these respondents, 149 completed the CPP.</td></tr>
<tr><td>Additional Information</td><td>

The CPP was always administered via computer, as it can only be administered this way. The MAB was sometimes administered via computer in a group setting (using a university computer lab), but mostly via paper and pencil.
The CPP was completed by all respondents prior to them being administered the MAB. But never in the same session as CPP completion could take up to 2½hrs.
The CPP is an open-ended-duration assessment unlike the MAB where each subtest is a fixed 7-minutes duration.
CPP cognitive styles were assessed using a 0-100 scale
CPP Information Processing competencies were assessed using a 0-100 scale
CPP Levels of Work were assessed using a 1-4 scale
Comprehensive study details are available for download in Technical Report #1: (http://www.cognadev.com/publications/Cognadev_Technical_Report_1_Ability_24_Jul_14.pdf)

</td></tr>
</table>

CPP Intellectual Styles and MAB Ability Correlations

Table 26: Pearson correlations between the CPP intellectual styles and MAB ability scales (n=149, casewise)

Variable	CPP Intellectual styles vs MAB Ability scales						
	Comprehension	Similarities	Picture Arrangement	Object Assembly	Verbal IQ	Performance IQ	Full Scale IQ
T-score_61: CPP: Explorative style	0.01	0.05	0.17	0.08	-0.02	0.10	0.05
T-score_62: CPP: Analytical style	0.34	0.39	0.40	0.35	0.26	0.35	0.35
T-score_63: CPP: Structured style	0.38	0.43	0.44	0.36	0.32	0.40	0.41
T-score_64: CPP: Holistic style	0.45	0.44	0.51	0.37	0.36	0.45	0.45
T-score_65: CPP: Intuitive style	0.49	0.44	0.55	0.38	0.40	0.48	0.49
T-score_66: CPP: Memory style	0.47	0.42	0.40	0.39	0.38	0.41	0.45
T-score_67: CPP: Logical style	0.39	0.43	0.45	0.33	0.31	0.38	0.39
T-score_68: CPP: Impulsive style	-0.29	-0.36	-0.37	-0.33	-0.25	-0.35	-0.34
T-score_69: CPP: Random style	-0.46	-0.47	-0.48	-0.39	-0.37	-0.42	-0.45
T-score_70: CPP: Integrative style	0.44	0.44	0.49	0.38	0.37	0.45	0.46
T-score_71: CPP: Systems style	0.44	0.45	0.50	0.39	0.38	0.46	0.47
T-score_72: CPP: Learning style	0.36	0.38	0.45	0.35	0.32	0.41	0.41
T-score_73: CPP: Quick insight style	0.51	0.50	0.55	0.41	0.41	0.47	0.49
T-score_74: CPP: Reflective style	0.24	0.30	0.36	0.26	0.19	0.30	0.27
T-score_75: CPP: Metaphoric style	0.27	0.29	0.40	0.28	0.26	0.36	0.35

Note: Correlations above **0.16** are significant at $p < 0.05$, two-tail.

Small to moderate relationships are seen throughout this matrix. To further show the separability between the CPP intellectual styles and the MAB ability scales, a 2-dimensional non-metric MDS was undertaken on the 15 style scores + 7 MAB ability scale scores. Initial variable distances were computed using the Gower agreement coefficient (expressed as similarities). The 2- dimensional solution indicated a normalised stress[1] value of 0.10.

[1] Normalised stress *(the Kruskal/Stressform1 version*) indexes the disparity between the observed variable distances minus their monotone regressed 'pseudo-distances'. The square root is taken of the result of dividing the sum of squared {observed distances– model-constructed distances} by the sum of squared actual distances. It varies between 0 and a maximum if (1-(2/p)) where p= the number of variables, and where 0 = perfect recovery of inter-variable distances. A value > 0.2 is conventionally taken as indicative of unacceptable fit, although as Borg and Groenen (1997) point out (*pp. 337-38*), this should not be used as a precise threshold

Figure 2: Study 5: Non-metric MDS of 15 CPP intellectual style scores and 7 MAB ability scales

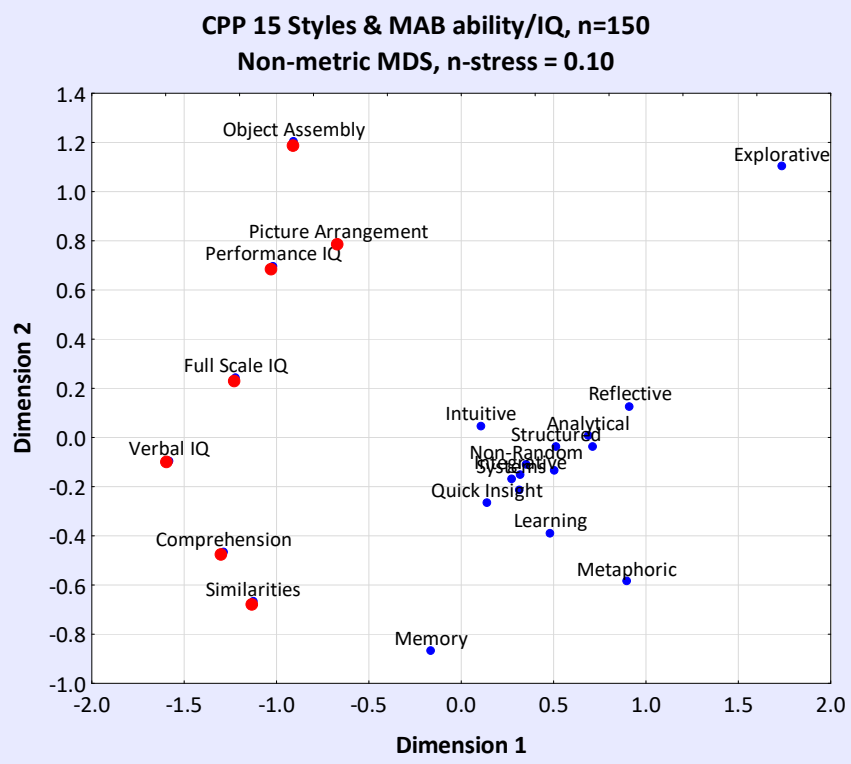


Table 27: Study 5: Pearson correlations between the CPP Information Processing Competencies and MAB ability scales

Variable	CPP Information Processing Competencies vs MAB ABility and IQ scores (n=149)						
	Comprehension	Similarities	Picture Arrangement	Object Assembly	Verbal IQ	Performance IQ	Full Scale IQ
Pragmatic	0.36	0.36	0.36	0.33	0.28	0.34	0.35
Exploration	0.39	0.39	0.43	0.41	0.33	0.42	0.42
Analytical	0.30	0.36	0.36	0.33	0.23	0.32	0.31
Rule Oriented	0.36	0.38	0.41	0.38	0.33	0.41	0.42
Categorisation	0.37	0.36	0.36	0.31	0.29	0.32	0.34
Integration	0.41	0.41	0.45	0.36	0.34	0.41	0.43
Complexity	0.44	0.45	0.50	0.37	0.34	0.43	0.43
Logical Reasoning	0.36	0.40	0.45	0.30	0.30	0.36	0.37
Verbal Conceptualisation	0.35	0.33	0.46	0.26	0.29	0.38	0.38
Use of Memory	0.20	0.14	0.16	0.17	0.21	0.24	0.25
Memory strategies	0.35	0.33	0.41	0.35	0.29	0.37	0.37
Judgement	0.45	0.45	0.46	0.37	0.36	0.41	0.44
Quick insight learning	0.42	0.41	0.47	0.41	0.35	0.44	0.44
Gradual improvement learning	0.02	0.11	0.16	0.07	0.08	0.16	0.13

Note: Correlations above **0.16** are significant at $p < 0.05$, two-tail.

The observed range of the Level of Work attributes was {1...4}, for both current and potential designations. Given the Levels of Work are clearly ordered-class attributes, Goodman-Kruskal gamma correlations were computed between the two CPP Level of Work attributes and MAB ability scales.

Table 28: Study 5: Gamma correlations between the CPP Levels of Work and MAB ability scales

Variable	Study 5: Gamma correlations	
	Level of Work	Potential Level of Work
Comprehension	0.47	0.40
Similarities	0.45	0.42
Picture Arrangement	0.49	0.41
Object Assembly	0.46	0.33
Verbal IQ	0.34	0.34
Performance IQ	0.41	0.34
Full Scale IQ	0.41	0.37

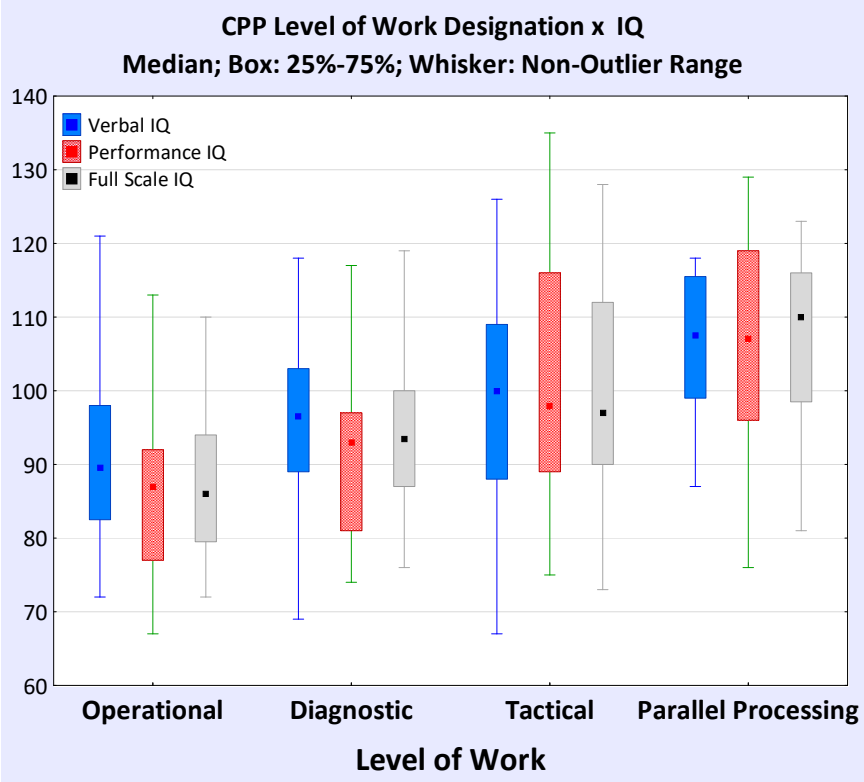
Notes:

- All correlations are significant at $p < 0.01$, two-tail.
- The number of cases for the Comprehension, Picture Arrangement, Object Assembly, and Performance IQ correlations is 150, the remaining correlations were calculated over 149 cases.

In terms of the actual MAB ability score levels and variability associated with each current Level of Work designation, a box-plot was generated showing the full-scale IQ variable characteristics as a function of Level of Work. This is presented in Figure 9.

For each ability variable, there is a monotonic relationship between median IQ and Level of Work designation. But, there is also considerable overlapping variation between levels, indicating that Level of Work is not simply a proxy for ability, but contains substantive individual difference information beyond cognitive ability.

Figure 3: Study 5: CPP Level of Work designation x MAB full-scale IQ variables



4.1.6 Validation Study 6: The CPP vs Psytech International's General Reasoning Test Battery (GRT2)

The GRT2

From the product website: http://www.psytech.com/psytech-assessments/aptitude-ability/general-reasoning-test/

> "A comprehensive and in-depth measure of mental agility, GRT2 has been designed to assess general reasoning ability. Suitable for non-graduate level applicants, it consists of three sections which can be administered individually or together, measuring Verbal, Numerical and Abstract reasoning ability.
>
> The **Abstract Reasoning** scale measures the ability to understand abstract logical problems and use new information outside the range of previous experience. This is the purest form of mental ability and is least affected by previous education and achievement. It is therefore ideally suited to assess individuals of various educational backgrounds and cultural groups"

Completion time for the Abstract subscale is 10 minutes (it is a timed test), with number-correct score-range between 0 and 25 (p. 18, GRT2 Technical manual).

Table 29: Study 6 Details: CPP Styles, Competencies, and Levels of Work with GRT2 Abstract scores

Study 6: CPP vs GRT2 Abstract	
Date:	2013
Authored by:	Prinsloo
Sample Size:	138-259 cases with complete data on some CPP attributes and GRT2 Abstract
Age:	Not recorded
Gender:	Mixed
Ethnicity:	Not recorded
Language Groups:	No information available except that all were fluent in English
Education:	Not recorded
Source:	South African employment candidates assessed within a recruitment process by an organisational development consultancy
Additional Information	• CPP cognitive styles were assessed using a 0-100 scale • CPP Information Processing competencies were assessed using a 0-100 scale • CPP Levels of Work were assessed using a 1-4 scale

	• Only partial CPP data was recorded / made available for analysis • Comprehensive study details are available for download in Technical Report #1: (http://www.cognadev.com/publications/Cognadev_Technical_Report_1_Ability_24_Jul_14.pdf)

Table 30: Study 6: Pearson correlations between the CPP Intellectual Style scores and GRT2 Abstract scores

	Study 6: CPP styles vs GRT2 Abstract scores (n=138)
Variable	GRT2 Abstract
Explorative style	0.19
Analytical style	0.53
Structured style	0.54
Holistic style	0.53
Intuitive style	0.46
Memory style	0.40
Logical style	0.55
Impulsive style	-0.53
Random style	-0.54
Integrative style	0.54
Systems style	0.51
Learning style	0.50
Quick insight style	0.49
Reflective style	0.51
Metaphoric style	0.33

Note: All correlations are significant at $p < 0.01$, two-tail, except for Explorative, which is significant at $p = 0.026$, two-tail.

Table 31: Study 6: Pearson correlations between the CPP Information Processing scores and GRT2 Abstract scores

	Study 6: CPP Information Processing Competencies (n=138)
Variable	GRT2 Abstract
Pragmatic	0.42
Exploration	0.50
Analytical	0.52
Rule Oriented	0.45
Categorisation	0.40
Integration	0.53
Complexity	0.53
Logical Reasoning	0.52
Verbal Conceptualisation	0.37
Use of Memory	0.12
Memory strategies	0.42
Judgement	0.48
Quick insight learning	0.52
Gradual improvement learning	0.29

Note: All correlations are significant at $p < 0.001$, two-tail (Use of Memory $p = 0.16$, n.s.)

Table 32: Study 6: Gamma correlations between the CPP Levels of Work rankings and GRT2 Abstract scores

Variable	Study 6: Gamma correlations (n=259)
	GRT2 Abstract
Current Level of Work	0.52
Potential Level of Work	0.49

Note: All correlations are significant at $p < 0.001$

In conclusion, very similar results to those computed using the MAB (Study 5). Moderate relationships among many CPP attributes and GRT2 Abstract reasoning, but a substantive degree of variation in CPP scores not accounted for by the GRT2 Abstract scores.

4.1.7 Validation Study 7: The CPP vs Psytech International's Critical Reasoning Test Battery (CRTB2)

The CRTB2

From the product website: http://www.psytech.com/psytech-assessments/aptitude-ability/critical-reasoniong-test/

> "**Critical Reasoning** is an ability that is central to all roles that require the incumbent to take logical decisions based on complex information. CRTB2 has been developed to this core ability in a time and cost effective manner. CRTB2 comprises two sub-tests which measure verbal and numerical critical reasoning. These can be administered either individually or together.
>
> **Verbal Critical Reasoning** measures the ability to understand and accurately draw logical conclusions and inferences from complex reports. Consequently, it forms a key assessment for managerial and professional roles which require accurate interpretation of written reports and rational decision making.
>
> **Numerical Critical Reasoning** measures the ability to understand and critically evaluate a wide range of numerical data and draw logical conclusions from this. Consequently, it forms a key assessment for managerial and professional roles which require the ability to understand financial, numerical and statistical information."

Completion time for the Verbal subscale is 15 minutes (the CRTB2 is a timed test), with number-correct score-range between 0 and 40 (p. 32, CRBT2 Technical manual). Completion time for the Numerical subscale is 25 minutes, with number-correct score-range between 0 and 25 (p. 35, CRBT2 Technical manual).

Table 33: Study 7 Details: CPP Competencies, and Levels of Work with CRTB2 Abstract scores

Study 7: CPP vs CRTB2 Verbal and Numerical Critical Reasoning	
Date:	2013
Authored by:	Prinsloo
Sample Size:	128
Age:	Not recorded
Gender:	Mixed
Ethnicity:	Not recorded
Language Groups:	No information available except that all were fluent in English

Education:	Not recorded
Source:	South African employment candidates assessed within a recruitment process by an HR consultancy.
Additional Information	• CPP Information Processing competencies were assessed using a 0-100 scale • CPP Levels of Work were assessed using a 1-4 scale • Comprehensive study details are available for download in Technical Report #1: (http://www.cognadev.com/publications/Cognadev_Technical_Report_1_Ability_24_Jul_14.pdf)

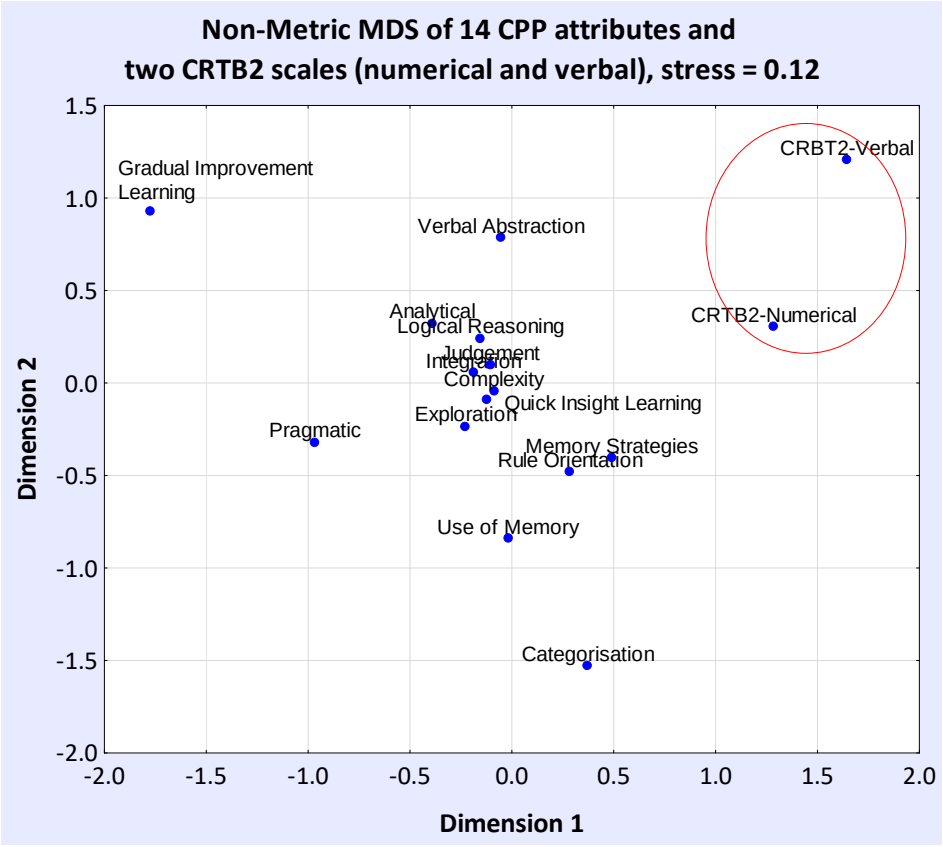
Table 34: Study 7: Pearson correlations between the CPP Information Processing scores and CRBT2 Abstract scores

Variable	Study 7: CPP Information Processing Competencies (n=128)	
	CRTB2-Numerical	CRBT2-Verbal
Pragmatic	0.42	0.26
Exploration	0.56	0.44
Analytical	0.57	0.41
Rule Oriented	0.60	0.44
Categorisation	0.47	0.33
Integration	0.64	0.50
Complexity	0.63	0.48
Logical Reasoning	0.58	0.41
Verbal Conceptualisation	0.54	0.41
Use of Memory	0.48	0.43
Memory strategies	0.59	0.52
Judgement	0.64	0.49
Quick insight learning	0.62	0.50
Gradual improvement learning	0.37	0.27

Note: All correlations are significant at $p < 0.005$

In order to view the relationships in Table 36 graphically, a non-metric MDS was undertaken on the CPP information processing competencies and the two CRTB2 critical reasoning scales; input coefficients were Pearson correlations. A 2-dimensional solution was selected with a normalised stress of 0.12. Figure 10 shows the resulting coordinates.

Figure 4: Non-metric MDS of the CPP information-processing competencies and CRTB2 numerical and verbal scales



The two CRTB2 scales are located in a semi-discrete region of the 2-D space, indicating some degree of separability between the CRTB2 attributes and the CPP information-processing competencies.

Table 35: Study 7: Gamma correlations between the CPP Levels of Work rankings and CRTB2 scores

	Study 7: Gamma correlations (n=128)	
Variable	CRTB2-Numerical	CRBT2-Verbal
Level of Work	0.62	0.48
Potential Level of Work	0.60	0.37

Note: All correlations are significant at $p < 0.01$

In conclusion, very similar results to those of the MAB and GRT2, with moderate relationships among 14 CPP information processing attributes and the CRTB2 numerical and verbal critical reasoning scores. Interestingly, the numerical critical reasoning scale scores showed a higher median correlation with the CPP attributes than did the verbal scale; 0.58 vs 0.43 respectively.

4.1.8 Validation Study 8: The CPP & the Figure Classification Test (FCT)

The FCT

From van Zyl & Visser (1988),

> "The FCT is a test of abstract reasoning ability which was developed in 1974. It was developed with the specific objective of overcoming problems being experienced with 'verbal' tests (i.e. Mental Alertness) that were administered to different racial groups and which could lead to accusations of cultural bias, unfairness and poor predictability (Werbeloff & Taylor, 1982). In this test, abstract reasoning is used as a measure of Spearman's g factor. Gregory (1996, p. 235). reminds that Spearman referred to g as the 'eduction of correlates' and that the term 'eduction' in this context refers to a 'process of figuring out relationships based on perceived fundamental similarities between stimuli'. The FCT is a 36-item test designed for people with a schooling range of seven to nine years. Each test item consists of six drawings that must be classified into two groups of three. The criterion is the presence of an underlying concept or similarity which is shared by all drawings that are organised in the same class. These concepts or similarities can inter alia be categorised as uniformity, symmetry, inversion, repetition and series. Initial studies showed that the FCT has a reliability coefficient of 0.90 (Werbeloff & Taylor, 1982)", p. 28.

Table 36: Study 8 Details: CPP Competencies and FCT Abstract scores

Study 8: CPP vs FCT Abstract scale scores	
Date:	1998
Authored by:	Prinsloo
Sample Size:	59
Age:	Not recorded
Gender:	Mixed
Ethnicity:	Black South Africans
Language Groups:	No information available except that all were fluent in English
Education:	First year university students
Source:	First year engineering students from disadvantaged socio-economic background
Additional Information	• CPP Information Processing competencies were assessed using a 0-100 scale • Pearson correlations indexed the association between scores

Table 37: Study 8: Pearson correlations between CPP Information Processing scores and FCT scores (n=59)

Process Score	Pearson r
CPP-Pragmatic	.51
CPP-Exploration	.38
CPP-Analytical	.46
CPP-Rule-Oriented	.47
CPP-Categorisation	.40
CPP-Integration	.41
CPP-Complexity	.42
CPP-Logical Reasoning	.46
CPP-Verbal Conceptualisation	.32
CPP-Use of Memory	.39
CPP-Memory Strategies	.43
CPP-Judgement	.48
CPP-Quick Insight Learning	.61
CPP-Gradual Improvement Learning	.51

Note: All correlations are significant at $p < 0.05$, two-tail

The FCT correlated r= .28 ($p < 0.05$) with first year engineering pass rate. The CPP competencies correlated between r =.48 and r = .61in the case of the CPP process "managing complexity" ($p< 0.0005$) with the same.

4.1.9 Overall Conclusion

The two assessment methodologies as investigated here, namely the differential and the information processing approaches to the measurement of cognitive skill thus differ:

- In the case of ability tests, the convergent application of logical-analytical and memory skills in highly structured, domain-specific content areas are largely measured. Response time also impacts on performance as "speed" and "power" are assessed simultaneously.

- In the case of the CPP, information processing preferences and capabilities as applied to unfamiliar, relatively content-free tasks are externalised and tracked. No time limitations or "right and wrong" answers apply. The thinking processes tracked form part of an integrated, holonic model of information processing, where various processes may contain similar "building blocks", arranged in different orders and magnitudes.

- The research findings as documented here, indicate that while the CPP attributes are related to WAIS, MAB abilities / IQ, and GRT2, CRTB2 reasoning scales, there is substantive additional information assessed by the CPP which is not assessed by the ability assessments. From a theoretical perspective, this is just about right as the CPP would be expected to engage an individual's cognitive abilities, but not to the extent that performance on the CPP would be a direct function of those abilities.

4.2 Personality

4.2.1 Validation Study 9: CPP and MBTI attributes

Table 38: Study 9 (Personality) Details: CPP styles, Levels of Work, and MBTI Type Dimensions

Study 9: CPP vs MBTI	
Date:	1992
Authored by:	Richter
Sample Size:	22
Age:	All were aged between 30 and 50
Gender:	The majority were males
Ethnicity:	All were Caucasian (white South Africans)
Language Groups:	All were English and Afrikaans speaking
Education:	All respondents were graduates in IT
Source:	Banking IT managers
Additional Information	Only MBTI type was recorded, along with CPP Levels of Work, and the three most preferred cognitive styles

For the analysis of CPP style vs MBTI allocated type-dimension, the three CPP styles for an individual were re-expressed as three separate records (one per style) – for which the four MBTI type-dimensions were indicated as a binary present / absent code against each of the 8 possible MBTI dimensions. So, for a case with the data:

CPP			**MBTI type dimension**							
CPP style 1	**CPP Style 2**	**CPP Style 3**	**E**	**I**	**S**	**N**	**T**	**F**	**J**	**P**
Memory	Structured	Learning		1	1		1		1	

This would be expanded for analysis purposes as:

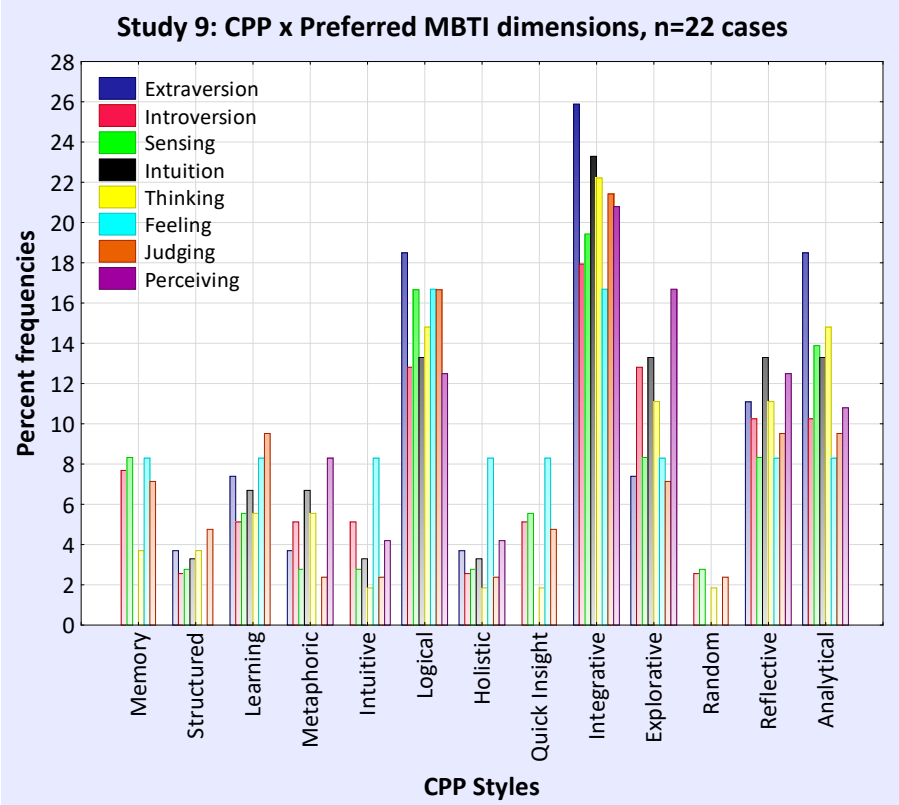
	MBTI type dimension							
CPP styles	**E**	**I**	**S**	**N**	**T**	**F**	**J**	**P**
Memory		1	1		1		1	
Structured		1	1		1		1	
Learning		1	1		1		1	

The frequencies of the component dimensions of the MBTI types can now be associated with the frequencies of the top three reported CPP styles for an individual (expressed as % of totals rather than raw counts) and are presented in Figure 11.

The percentage frequencies of the component dimensions of the MBTI types associated with each current (cLOW) and Potential (pLOW) Level of Work magnitude are presented in Figures 12 and 13.

For cLOW, magnitudes ranged from 2 to 4. For pLOW, percentages were computed for magnitudes ranging from 3 to 5 (with only I case possessing a value of 2).

Figure 5: MBTI type dimensions as a function of the top three reported CPP preferred cognitive styles



As can be seen in the above figure, the three most dominant preferred cognitive styles in this group are: Logical, Integrative, Reflective, and Analytical, with some moderate differential differentiation associated with the MBTI dimensions. However, with just 22 cases from within a very specific job-role and domain (banking), the results must be interpreted accordingly.

Figure 6: MBTI type dimensions as a function of the current Level of Work (cLOW) magnitudes

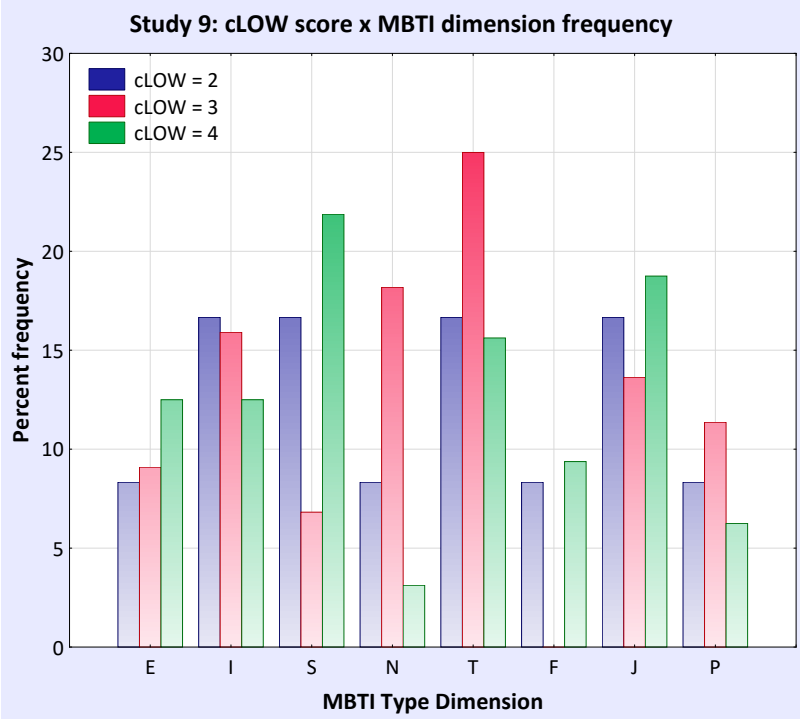
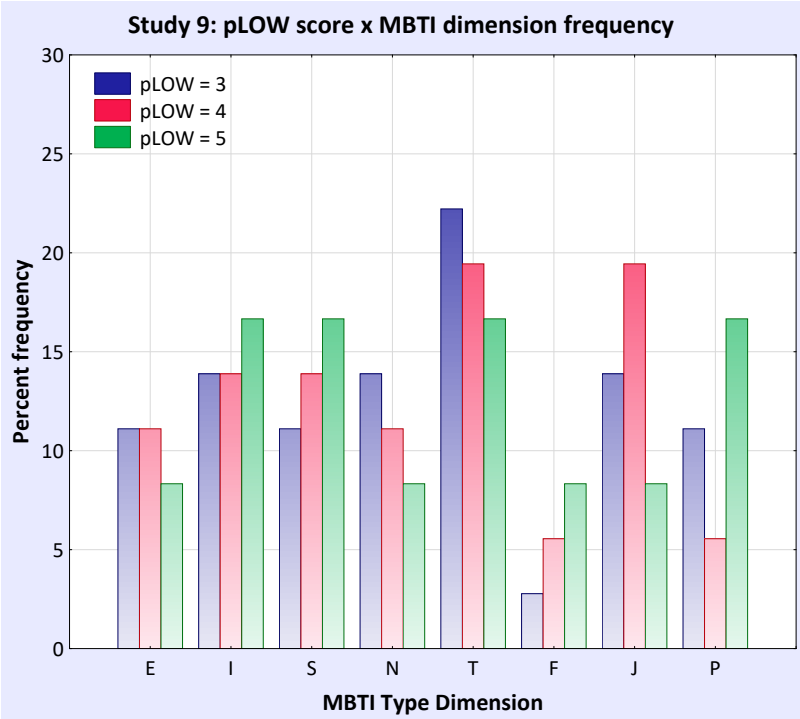


Figure 7: MBTI type dimensions as a function of the potential Level of Work (pLOW) magnitudes



In Figure 12, we see that the Thinking MBTI dimension if the most prevalent one within this particular sample, with some clear differentiation between cLOW magnitude groups on Sensing and Intuition. For pLOW, the same prevalence of the Thinking dimension is apparent, but it is now Judging and Perceiving which show the clearest differentiation between groups. However, with only 22 cases in the sample, cLOW and pLOW score-group sizes are naturally very low.

4.2.2 Validation Study 10: CPP and MBTI attributes

Table 39: Study 10 (Personality) Details: CPP styles and MBTI Type Dimensions

Study 10: CPP vs MBTI	
Date:	2000
Authored by:	Hardijzer
Sample Size:	123
Age:	*1x* 20-29, *45x* 30-39, *61x* 40-49, *16x* 50+ years of age
Gender:	98 males, 28 females
Ethnicity:	111 White, 7 Asian, 4 Black, and 1 Coloured; all South African
Language Groups:	All were English and Afrikaans speaking
Education:	All respondents possessed IT degrees
Source:	Individuals within a large financial institution who manage Information Technology projects at either technical or managerial level
Additional Information	• South African Master's thesis • Four continuous MBTI scores were used • CPP Style scores range from 0-100

The continuous MBTI scores were computed in the manner described in Carlyn (1977):

> "Determining continuous scores with the Myers-Briggs Type Indicator is a more complex procedure than determining type-category scores. For each of the four scales, the difference between the person's two numerical scores is calculated and then transformed into one continuous score using the process described in the manual (Myers, 1962; pp 8-10). Four continuous scores are thus calculated for each person, one score for each scale.
>
> Continuous scores are all odd numbers, ranging from 33 to 161, with 100 serving as the division-point which separates the two opposing preferences. For example, a person with a continuous score of 143 on the E-I continuum is regarded as strongly introverted." p. 462.

So, the higher the score, the more it indicates a tendency to show / prefer the cognitions / behaviour denoted by the right-hand name of each type pairing:

- **E-I** *{Extraversion-Introversion}*
- **S-N** *{Sensing-Intuition}*
- **T-F** *{Thinking-Feeling}*
- **J-P** *{Judging-Perceiving}*

Table 40: Study 10 (Personality): Pearson correlations between the CPP Style scores and MBTI Bipolar Continuous Scores

Style Scores	EI	SN	TF	JP
Explorative	.03	.09	**.18**	**.21**
Analytical	-.08	-.15	-.04	-.01
Structured	-.17	-.14	-.11	-.06
Holistic	-.16	**-.19**	-.09	-.07
Intuitive	**-.19**	-.12	-.03	-.03
Memory	-.10	**-.25**	**-.18**	-.12
Logical	-.11	-.16	-.05	-.03
Integrative	**-.18**	-.17	-.06	-.07
Random	.16	**.19**	.08	.05
Learning	-.12	**-.21**	-.07	-.03
Quick Insight	-.15	**-.22**	-.07	-.03
Reflective	-.07	-.06	.00	.05
Impulsive	.10	.10	.05	.01
Metaphoric	**-.23**	-.11	-.02	-.05

Note: Correlations at or above |0.18| are significant at $p < 0.05$, two-tail

The findings point to a relationship between personality type and cognitive style and provide support for the concurrent validity of the CPP in assessing "stylistic preference", given the view of "style" as a generalised construct that incorporates both personality and cognitive factors.

4.2.3 Validation Study 11: CPP and Emotional Intelligence Attributes

Table 41: Study 11 (Personality) Details: CPP styles and Emotional Intelligence Questionnaire (EIQ)

Study 11: CPP vs EIQ	
Date:	2003
Authored by:	A presentation made by John Queripel and Dr David Thompson at the 2003 Annual Conference of the Association of Business Psychologists.
Sample Size:	171
Age:	Not recorded
Gender:	Not recorded
Ethnicity:	Not recorded
Language Groups:	English speaking (UK sample)
Education:	Most were graduates.
Source:	Mostly engineers, senior engineers and managers at a Public, Postal services company in the UK.
Additional Information:	Only significance probabilities were provided throughout for reported Pearson correlations, not the actual correlation magnitudes themselves. So, we have reported the minimum Pearson correlation which would be significant given a particular probability statement such as "$p < 0.01$". For example, with a sample size of n=171, a correlation of at least r = .15014 would be significant at $p < 0.05$, two-tail.

The Emotional Intelligence Questionnaire (EIQ): Managerial 360 degree

The EIQ used in this study was the 360-degree version of the instrument, with data acquired from self-ratings and ratings from "others" such as peers, direct reports and managers who rated work colleagues. The following dimensions are measured in the EIQ:

- A - Self-awareness
- B - Emotional resilience
- C - Motivation
- D - Interpersonal sensitivity
- E - Influence
- F - Intuitiveness
- G – Conscientiousness

Table 42: Study 11: CPP Levels of Work attributes and EIQ Self / Other ratings (estimated minimum correlations)

CPP Attributes	Levels of Work	
	Current	Potential
EIQ Self Ratings: Self-awareness		
Emotional resilience	-.15	
Motivation	-.20	-.15
Interpersonal sensitivity		
Influence		
Intuitiveness		
Conscientiousness		
EIQ "Other" Ratings: Self-awareness		
Emotional resilience		
Motivation	-.15	
Interpersonal sensitivity		
Influence		
Intuitiveness		
Conscientiousness		

Table 43: Study 11: CPP work-related processing preferences and EIQ Self / Other ratings (estimated minimum correlations)

CPP Attributes	Work Related Processing Preferences and Capabilities				
	Detailed Complexity	Dynamic Complexity	Strategic Long-Term	Strategic Unstructured	Operational Short-Term
EIQ Self Ratings: Self-awareness					
Emotional resilience			-.15	-.15	
Motivation	-.15	-.15	-.15	-.15	.15
Interpersonal sensitivity					
Influence					
Intuitiveness					
Conscientiousness					
EIQ "Other" Ratings: Self Awareness					
Emotional resilience					
Motivation					
Interpersonal sensitivity					
Influence					
Intuitiveness					
Conscientiousness					

From the Queripel and Thompson report, pp. 7-8:

> It appears that those whose responses on CPP would be deemed to be more suited to work with "tangible elements" in short time frames, in a structured work environment (Levels 1 and 2 in CPP and Stratified Systems terms) are likely to see themselves and to be seen by others as more motivated - having more drive and energy to achieve results, balance short-term and long-term goals, and pursue demanding goals.
>
> The people who see themselves as more motivated and able to overcome adversity are also likely to score lower on measures of handling cognitive complexity, exercising judgement in an unstructured context and lower indications of dealing at a strategic level rather than dealing with tangibles. The EI items which appear to load on factors B and C are phrased in terms of setting high and stretching goals, able to maintain effectiveness in the face of setbacks, and being forceful in dealing with others. These would seem to be more short-term focused than visionary, but as this information is not published one cannot be certain.
>
> If high motivation means energy focused on short term results, it appears that some of these more motivated or driven individuals have CPP profiles which indicate that they require feedback in the short-term in order to retain direction. They tend to prefer to deal with concrete issues rather than more abstract issues and they avoid paradox, ambiguity and unstructured problems. A possible explanation for these findings is that people who report high levels of motivation in self-report EI questionnaires may be more operationally inclined and thrive in more tangible/concrete environments where they deal directly with outcomes (rather than abstract concepts). The operational focus may be characterised by stimulation by the immediacy of fast-moving events and perhaps interpersonal excitement.
>
> This explanation is also in line with the common-sense and intuitive understanding that people who are not necessarily intellectually inclined can achieve a great deal in business by showing high levels of ambition, drive, energy and self-belief. These people are likely to see themselves and be seen by others to be "highly motivated".

4.2.4 Validation Study 12: CPP and MBTI attributes

Table 44: Study 12 (Personality) Details: CPP attributes and MBTI types

Study 12: CPP vs MBTI	
Date:	2014
Authored by:	Barrett and Prinsloo
Sample Size:	265-323
Age:	Study 12: Age distribution

From To	Count	Cumulative Count	Percent	Cumulative Percent
20 <x<=30	14	14	4.75	4.75
30 <x<=40	42	56	14.24	18.98
40 <x<=50	135	191	45.76	64.75
50 <x<=70	104	295	35.25	100.00

Gender:

Study 12: Gender

Category	Count	Cumulative Count	Percent	Cumulative Percent
F	40	40	12.38	12.38
M	283	323	87.62	100.00

Ethnicity:	Organisational executives from all continents in the world. They are very diverse from different language backgrounds.
Language Groups:	All speak English but some did their tests in other languages.
Education:	All graduates, most multiple degrees
Source:	All high-level executives – most of them have been with the respective companies one or two decades. Both organisations are in Production and Manufacturing; both are global. The respondents were VP, EVP and CEOs of regional subsidiaries.

As for Study 9, the top three CPP ranked cognitive styles for an individual were re-expressed as three separate records (one per style) – for which the four MBTI type-dimensions were indicated as a binary present / absent code against each of the 8 possible MBTI dimensions. E.g.

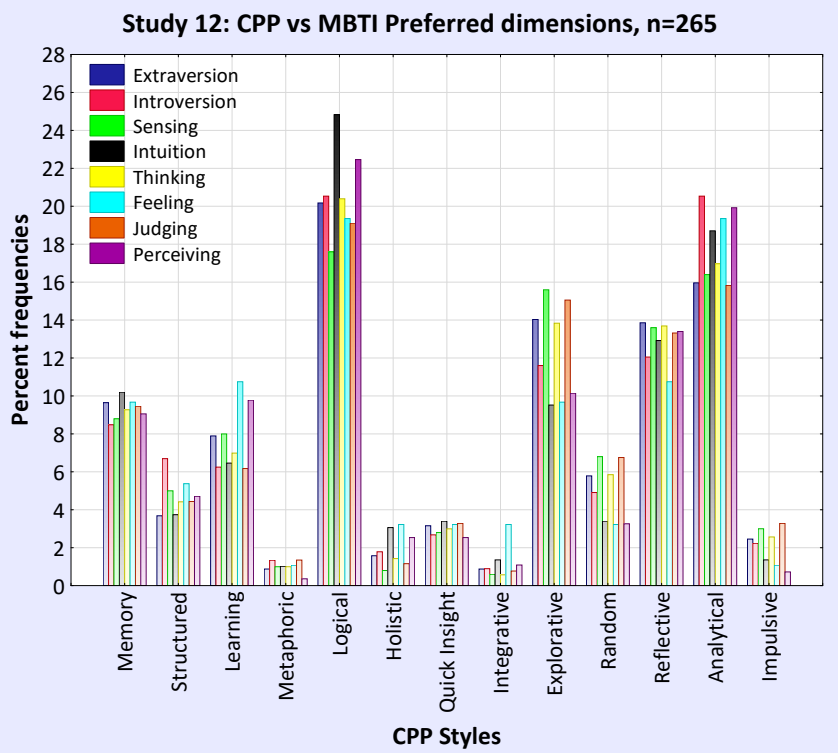
CPP			**MBTI type dimension**							
CPP style 1	**CPP Style 2**	**CPP Style 3**	**E**	**I**	**S**	**N**	**T**	**F**	**J**	**P**
Memory	Structured	Learning		1	1		1		1	

This would be expanded for analysis purposes as:

	MBTI type dimension							
CPP styles	**E**	**I**	**S**	**N**	**T**	**F**	**J**	**P**
Memory		1	1		1		1	
Structured		1	1		1		1	
Learning		1	1		1		1	

The frequencies of the component dimensions of the MBTI types can now be associated with the frequencies of the top three reported CPP styles for an individual (expressed as % of totals rather than raw counts) and are presented in Figure 14.

Figure 8: Study 12 MBTI type dimensions as a function of the top three reported CPP preferred cognitive styles



As can be seen in the above figure, the four most dominant preferred cognitive styles in this group are: Logical, Explorative, Reflective, and Analytical, with some small differential differentiation associated with the MBTI dimensions.

Table 45: Study 12 CPP Information Processing Competency scores x MBTI Dimension scores

CPP Competency	Study 12: CPP Information Processing Competencies x MBTI Dimensions Pearson correlations, n=265							
	I	E	S	N	F	T	P	J
Discrimination	-0.08	0.08	-0.18	0.18	0.03	-0.03	0.20	-0.20
Analysis	0.06	-0.06	-0.22	0.22	0.04	-0.04	0.16	-0.16
Rule-Orientation	0.01	-0.01	-0.24	0.24	0.04	-0.04	0.17	-0.17
Categorisation	-0.01	0.01	-0.19	0.19	0.08	-0.08	0.14	-0.14
Quick Insight Learning	0.03	-0.03	-0.27	0.27	0.05	-0.05	0.23	-0.23
Integration	0.03	-0.03	-0.27	0.27	0.08	-0.08	0.23	-0.23
Complexity	0.05	-0.05	-0.26	0.26	0.05	-0.05	0.21	-0.21
Logical	0.04	-0.04	-0.25	0.25	0.04	-0.04	0.18	-0.18
Verbal-Conceptualisation	-0.00	0.00	-0.26	0.26	0.00	-0.00	0.14	-0.14
Memory	-0.03	0.03	-0.16	0.16	0.08	-0.08	0.13	-0.13
Memory Strategies	0.02	-0.02	-0.20	0.20	0.05	-0.05	0.17	-0.17
Exploring	-0.03	0.03	-0.26	0.26	0.07	-0.07	0.22	-0.22
Gradual Learning	-0.05	0.05	-0.09	0.09	0.03	-0.03	0.09	-0.09
Judgement	0.05	-0.05	-0.27	0.27	0.04	-0.04	0.22	-0.22

Note: Highlighted (red) correlations are significant at $p < 0.05$, two-tail

Table 46: Study 12 CPP Levels of Work x MBTI Dimension scores

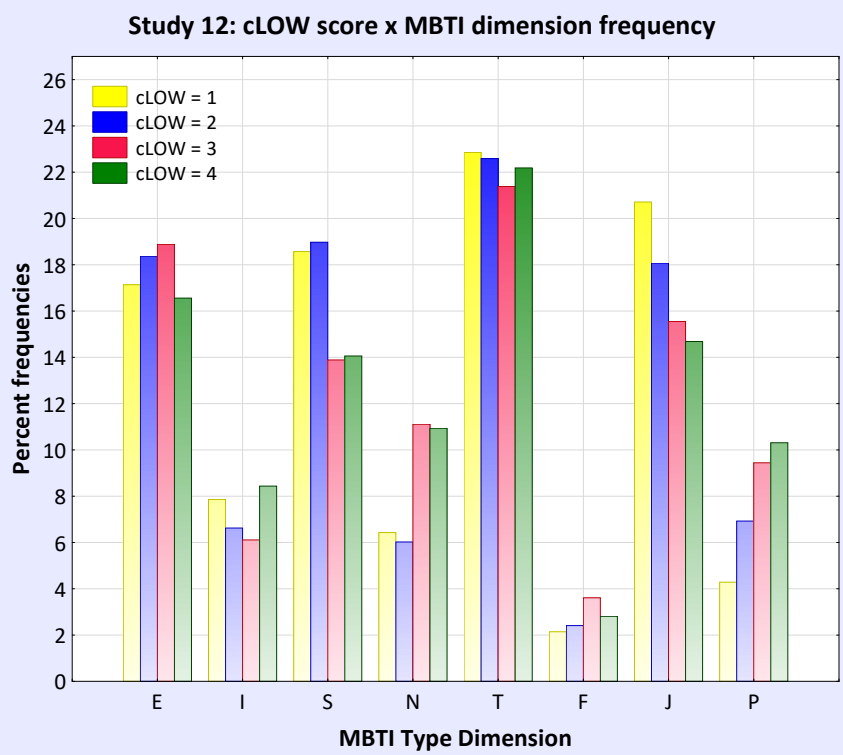
Variable	Study 12: Gamma Correlations n=265	
	cLOW	pLOW
MBTI-Introversion	0.04	-0.01
MBTI-Extraversion	-0.04	0.01
MBTI-Sensing	-0.26	-0.31
MBTI-Intuition	0.26	0.31
MBTI-Feeling	0.08	0.12
MBTI-Thinking	-0.08	-0.12
MBTI-Perceiving	0.17	0.19
MBTI-Judging	-0.17	-0.19

Note: Highlighted (red) correlations are significant at $p < 0.01$, two-tail

The four MBTI attribute-scores: Sensing, Intuition, Perceiving, and Judging, are those showing the highest association with the CPP Levels of Work ratings, using the non-parametric Gamma correlation coefficient.

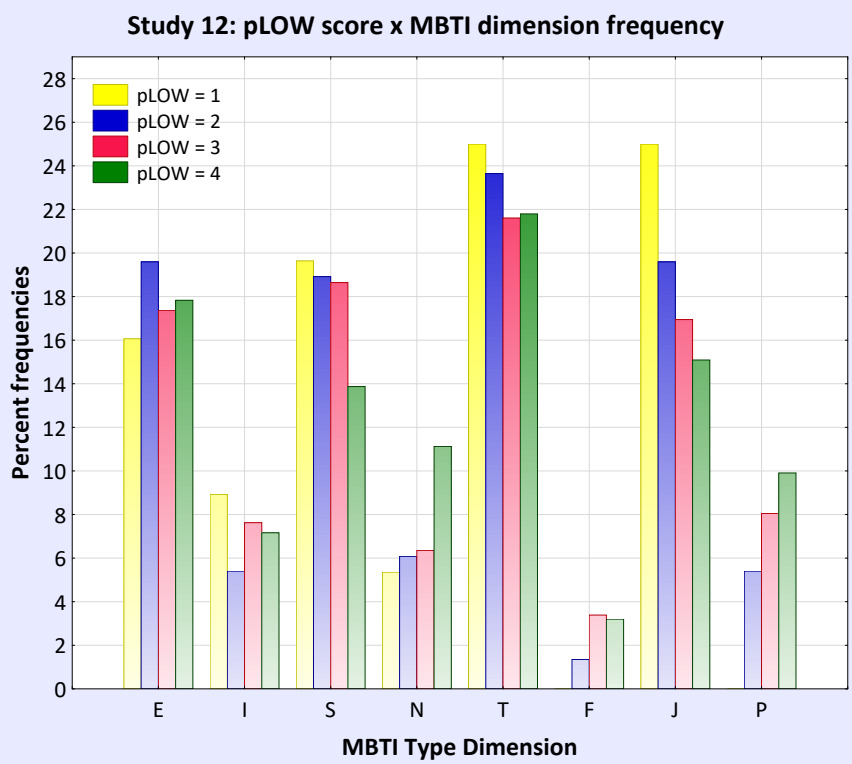
The percentage frequencies of the component dimensions of the MBTI types associated with each current (cLOW) and Potential (pLOW) Level of Work magnitude are presented in Figures 15 and 16. For both cLOW and pLOW, magnitudes ranged from 1 to 4.

Figure 9: Study 12 MBTI type dimensions as a function of the current Level of Work (cLOW) magnitudes



In Figure 15, we see that the Thinking MBTI dimension if the most prevalent one within this particular sample, with some clear differentiation between cLOW magnitude groups on Sensing, Intuition, Judgement, and Perceiving.

Figure 10: MBTI type dimensions as a function of the potential Level of Work (pLOW) magnitudes



In Figure 16 for pLOW, the same prevalence of the Thinking dimension is apparent, with the MBTI dimensions of Sensing, Intuition, Judgement, and Perceiving showing a noticeable degree of differentiation between Levels of Work ordered classes.

4.2.5 Validation Study 13: CPP and Belbin types

Here, we investigate the relationship between Belbin Team-Types and the CPP attributes. The expectation is that few, if any, substantive correlations should be present given the completely different kinds of attributes being assessed by both tests. But it is useful nevertheless to compute such relationships if only to confirm "nothing to see here".

Table 47: Study 13 (Personality) Details: CPP attributes and Belbin team-types

<table>
<tr><th colspan="2">Study 5: CPP vs Belbin</th></tr>
<tr><td>Date:</td><td>2014</td></tr>
<tr><td>Authored by:</td><td>Barrett and Prinsloo</td></tr>
<tr><td>Sample Size:</td><td>205-220</td></tr>
<tr><td>Age:</td><td>
<table>
<tr><th rowspan="2">From To</th><th colspan="4">Study 13: Age</th></tr>
<tr><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>20 <=x<33</td><td>17</td><td>17</td><td>8.02</td><td>8.02</td></tr>
<tr><td>33 <=x<46</td><td>73</td><td>90</td><td>34.43</td><td>42.45</td></tr>
<tr><td>46 <=x<59</td><td>112</td><td>202</td><td>52.83</td><td>95.28</td></tr>
<tr><td>59 <=x<72</td><td>10</td><td>212</td><td>4.72</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Gender:</td><td>
<table>
<tr><th rowspan="2">Category</th><th colspan="4">Study 13: Gender</th></tr>
<tr><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>F</td><td>20</td><td>20</td><td>9.09</td><td>9.09</td></tr>
<tr><td>M</td><td>200</td><td>220</td><td>90.91</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Ethnicity:</td><td>Organisational executives and managers from international and South African divisions of global corporates. They are from different language and educational backgrounds.</td></tr>
<tr><td>Language Groups:</td><td>All speak English but some completed their tests in other languages.</td></tr>
<tr><td>Education:</td><td>All graduates, most multiple degrees including many in the sciences</td></tr>
<tr><td>Source:</td><td>A diverse sample of employees; many high-level executives but also some managers and supervisors in IT, Finance, and HR. The organisations span pharmaceuticals, manufacturing, and production.</td></tr>
</table>

Table 48: The Belbin Team Roles descriptions

Plant	Tend to be highly creative and good at solving problems in unconventional ways
Investigator	They use their inquisitive nature to find ideas to bring back to the team
Team Worker	Help the team to gel, using their versatility to identify the work required and complete it on behalf of the team
Coordinator	Needed to focus on the team's objectives, draw out team members and delegate work appropriately
Implementer	Needed to plan a workable strategy and carry it out as efficiently as possible
Completer	Most effectively used at the end of tasks to polish and scrutinise the work for errors, subjecting it to the highest standards of quality control
Monitor	Provides a logical eye, making impartial judgements where required and weighs up the team's options in a dispassionate way
Shaper	Provide the necessary drive to ensure that the team keeps moving and does not lose focus or momentum

from: http://www.belbin.com/about/belbin-team-roles/

The Pearson correlations between CPP Information Processing Competencies and Belbin scores are set out in Table 51.

Table 49: Study 13 (Personality) CPP Information Processing Competency scores x Belbin scores

Variable	Study 13: CPP Information Processing Competencies N=205 (Casewise deletion of missing data)							
	Plant	Investigator	Teamworker	Coordinator	Implementer	Completer	Monitor	Shaper
Pragmatic	-0.00	0.02	-0.00	-0.05	0.00	-0.14	0.18	0.03
Exploration	0.06	0.02	-0.04	-0.03	0.03	-0.14	0.15	0.03
Analytical	0.10	-0.05	-0.03	-0.06	0.04	-0.09	0.11	0.09
Rule Oriented	0.02	0.06	-0.08	-0.04	-0.00	-0.11	0.17	0.07
Categorisation	-0.00	0.13	-0.12	-0.03	0.01	-0.08	0.15	-0.00
Integration	0.07	-0.01	-0.04	-0.05	0.06	-0.18	0.13	0.08
Complexity	0.11	-0.05	-0.02	-0.07	0.05	-0.13	0.12	0.06
Logical Reasoning	0.13	-0.04	-0.01	-0.06	0.03	-0.11	0.10	0.05
Verbal Conceptualisation	0.10	0.01	-0.02	-0.05	0.04	-0.07	0.04	0.04
Use of Memory	-0.01	0.14	-0.11	-0.02	-0.00	-0.06	0.15	-0.04
Memory strategies	-0.06	0.08	-0.08	-0.01	0.05	-0.17	0.18	0.06
Judgement	0.08	-0.03	-0.02	-0.07	0.04	-0.13	0.13	0.07
Quick insight learning	0.04	-0.00	-0.03	-0.05	0.06	-0.16	0.14	0.08
Gradual improvement learning	0.01	-0.03	-0.03	-0.04	0.04	-0.08	0.09	0.12

Note: Highlighted (red) correlations are significant at $p < 0.05$, two-tail

Goodman-Kruskal gamma correlations between CPP ranked styles and Belbin scores are presented in Table 52.

Table 50: Study 13 (Personality) CPP ranked cognitive styles x Belbin scores

Variable	Study 13: CPP Ranked Styles, Gamma Correlations N=205 (Casewise deletion of missing data)							
	Plant	Investigator	Teamworker	Coordinator	Implementer	Completer	Monitor	Shaper
Explorative	0.05	0.01	0.05	-0.13	0.12	-0.16	0.01	0.01
Analytical	0.01	0.07	0.10	-0.04	-0.08	-0.02	-0.01	-0.04
Structured	0.04	-0.01	0.19	-0.01	-0.09	-0.09	0.04	0.03
Holistic	0.03	-0.06	0.01	-0.04	0.01	0.06	-0.09	-0.01
Intuitive	-0.05	0.01	-0.12	0.02	0.10	0.13	-0.05	-0.08
Memory	0.01	-0.13	0.12	0.06	-0.02	-0.11	0.05	0.08
Logical	-0.06	0.02	0.10	-0.01	-0.12	-0.11	0.05	0.09
Impulsive	0.08	-0.03	-0.17	0.01	0.09	0.11	0.00	-0.05
Random	0.05	0.00	-0.13	0.02	0.11	0.05	0.01	-0.06
Integrative	-0.05	-0.08	0.01	-0.02	-0.04	0.13	-0.03	0.05
Learning	-0.01	0.01	-0.11	0.02	-0.10	0.16	0.05	-0.04
Quick insight	-0.00	0.12	0.13	-0.01	-0.06	-0.13	0.01	-0.01
Reflective	-0.04	-0.01	0.01	-0.01	-0.17	0.09	0.04	0.07
Metaphoric	-0.04	-0.09	-0.13	0.11	0.03	0.05	0.02	0.03

Note: Highlighted (red) correlations are significant at p < 0.05, two-tail

Gamma correlations between CPP Levels of Work and Belbin scores are presented in Table 53.

Table 51: Study 13 (Personality) CPP Levels of Work x Belbin scores

Variable	Study 13: CPP Levels of Work Marked correlations are significant at p <.05000	
	cLOW	pLOW
Plant	-0.00	-0.03
Investigator	0.01	0.01
Teamworker	0.01	-0.00
Coordinator	-0.02	0.03
Implementer	-0.08	0.13
Completer	-0.10	-0.00
Monitor	0.15	-0.09
Shaper	0.08	-0.04

Note: Highlighted (red) correlations are significant at p < 0.05, two-tail

As expected, while there are many small correlations between the Belbin Team Role scores and CPP attributes, none are at or above the minimum recommended practical effect size of 0.20, as set out in Ferguson (2009), Table 1. The attributes assessed by the CPP and Belbin are very different in some respects, so the small correlations are simply reflecting that conceptual difference.

4.2.6 Validation Study 14: CPP and the Hogan Personality Inventory (HPI)

As an ancillary feature of our work within an organization, we had access to some Hogan data from the HPI. While we did not expect to observe any substantive correlations with these trait personality attributes, again, as with the Belbin analyses above, it is useful to confirm our expectations with such data.

Table 52: Study 14 (Personality) Details: CPP attributes and the HPI

Study 14: CPP vs Hogan HPI

Date: 2014

Authored by: Barrett and Prinsloo

Sample Size: 301-322

Age:

From To	Study 14: Age Distribution Count	Cumulative Count	Percent	Cumulative Percent
18 <x<=28	19	19	6.05	6.05
28 <x<=38	132	151	42.04	48.09
38 <x<=48	110	261	35.03	83.12
48 <x<=58	47	308	14.97	98.09
58 <x<=68	6	314	1.91	100.00

Gender:

Category	Study 14: Gender Count	Cumulative Count	Percent	Cumulative Percent
F	113	113	35.09	35.09
M	209	322	64.91	100.00

Ethnicity:

Category	Study 14: Ethnicity Count	Cumulative Count	Percent	Cumulative Percent
Black African	128	128	44.60	44.60
White European	94	222	32.75	77.35
Indian	43	265	14.98	92.33
Black	17	282	5.92	98.26
Afro-Caribbean	5	287	1.74	100.00

Language Groups: English speaking

Education: Most with tertiary-level qualifications in engineering and science

Source: A diverse range of employees working in a South African public infrastructure and private mining / energy supply organisations

Notes:

- HPI are percentile scores

Table 53: The HPI descriptions

Adjustment	confidence, self-esteem, and composure under pressure
Ambition	initiative, competitiveness, and desire for leadership roles
Sociability	extraversion, gregarious, and need for social interaction
Interpersonal Sensitivity	tact, perceptiveness, and ability to maintain relationships
Prudence	self-discipline, responsibility, and thoroughness
Inquisitive	imagination, curiosity, and creative potential
Learning Approach	achievement orientation, valuing education

From the information provided at:
https://www.hoganassessments.com/assessment/hogan-personality-inventory/

Table 56: Study 14 (Personality) Pearson correlations between CPP Information Processing Competency scores x HPI scores

Variable	Study 14: CPP Information Processing Competencies & HPI scales N=301 (Casewise deletion of missing data)						
	Adjustment	Ambition	Sociability	Interpersonal Sensitivity	Prudence	Inquisitive	Learning Approach
Pragmatic	-0.01	-0.03	0.00	-0.09	0.05	0.00	0.03
Exploration	0.03	-0.06	0.01	-0.04	-0.02	0.01	0.07
Analytical	0.09	0.02	0.04	0.02	0.02	0.01	0.12
Rule Oriented	0.11	0.04	0.10	0.06	-0.01	0.05	0.06
Categorisation	0.06	-0.03	-0.02	0.03	0.05	0.02	0.06
Integration	0.00	-0.04	0.07	0.00	-0.04	0.01	0.07
Complexity	0.05	-0.03	0.06	0.02	-0.03	-0.00	0.09
Logical Reasoning	0.08	-0.03	0.05	0.05	0.01	-0.03	0.06
Verbal Conceptualisation	0.02	-0.00	0.12	0.07	-0.08	0.04	0.02
Use of Memory	0.07	0.00	-0.00	0.08	0.01	0.02	0.05
Memory strategies	0.10	0.00	0.09	0.05	-0.03	0.06	0.05
Judgement	0.06	-0.05	0.05	0.02	0.02	0.01	0.08
Quick insight learning	0.05	-0.03	0.05	0.04	-0.02	0.02	0.09
Gradual improvement learning	0.06	-0.04	-0.02	0.02	-0.02	-0.10	-0.02

Note: Highlighted (red) correlations are significant at $p < 0.05$, two-tail

Table 57: Study 14 (Personality) Pearson correlations between CPP cognitive style scores x HPI scores

Variable	Study 14: CPP Cognitive stye scores & HPI scales N=301 (Casewise deletion of missing data)						
	Adjustment	Ambition	Sociability	Interpersonal Sensitivity	Prudence	Inquisitive	Learning Approach
Explorative	-0.04	-0.03	-0.04	-0.10	-0.03	-0.08	-0.07
Analytical	0.09	0.01	0.04	0.02	0.01	0.00	0.10
Structured	0.09	0.01	0.04	0.03	0.00	0.00	0.10
Holistic	0.03	-0.04	0.08	0.04	-0.06	0.01	0.07
Intuitive	0.05	-0.03	0.13	0.06	-0.08	0.05	0.09
Memory	0.07	-0.02	0.03	0.06	0.01	0.05	0.08
Logical	0.07	-0.04	0.05	0.04	-0.01	-0.03	0.06
Impulsive	-0.06	0.03	-0.03	0.01	0.01	0.01	-0.07
Random	-0.05	0.03	-0.05	-0.01	0.00	-0.01	-0.07
Integrative	0.01	-0.05	0.07	0.02	-0.05	0.02	0.07
Learning	0.06	-0.04	0.03	0.04	-0.02	-0.02	0.06
Quick insight	0.06	-0.01	0.10	0.04	-0.03	0.04	0.11
Reflective	0.04	-0.05	0.01	-0.01	0.00	-0.06	0.04
Metaphoric	-0.04	-0.01	0.11	0.04	-0.14	0.03	0.00

Note: Highlighted (red) correlations are significant at $p < 0.05$, two-tail

Table 58: Study 14 (Personality) Gamma correlations between CPP Levels of Work x HPI scores

Variable	Study 14: CPP Levels of work & HPI scores N=301 cases	
	cLOW	pLOW
Adjustment	0.05	0.07
Ambition	0.02	-0.03
Sociability	0.08	0.02
Interpersonal Sensitivity	0.03	0.09
Prudence	-0.02	0.01
Inquisitive	0.04	-0.02
Learning Approach	0.05	0.04

While there a many small correlations between the Hogan Personality scale scores and CPP attributes, none are at or above the minimum recommended practical effect size of 0.20 (Ferguson, 2009).

These results confirm our theoretical expectations and serve to show that the CPP adds a completely different kind/layer of information to an assessment process when combined with standard trait personality and/or trait motivation assessments.

Ferguson, C.J. (2009). An effect size primer: A guide for clinicians and researchers. *Professional Psychology: Research and Practice*, 40, 5, 532-538.

4.3 Job Performance

4.3.1 Study 15: CPP Attributes and Job Performance Ratings

Table 54: Study 15 Details: CPP attributes and Job Performance Ratings

Study 15: CPP vs Job Performance Ratings	
Date:	2006
Authored by:	Prinsloo
Sample Size:	69
Age:	Not recorded
Gender:	Mixed
Ethnicity:	South African
Language Groups:	English-speaking
Education:	Not recorded
Source:	Employees within a major South African Accountancy & Management consulting organisation
Notes:	Job Performance supervisor-rated on a three-point scale: Poor, Average, Top

Given the job-performance ratings are ordered-classes, Goodman-Kruskal Gamma ordinal correlation coefficients are computed between the CPP and Job-Performance variables. Gamma, like the Pearson r, is primarily a measure of monotonicity rather than absolute agreement, varying between -1.0 and +1.0, with 0 = no monotonic relationship.

Table 55: Study 15: Gamma correlations between CPP ranked styles and Job Performance

	Gamma Correlations, Study 15: Ranked Cognitive Styles x Job Performance Ranked Style: 14 = Most Preferred, 1 = Least Preferred Marked correlations are significant at p <.05000
Variable	Performance Rating
Explorative	-0.24
Analytical	0.01
Structured	0.15
Holistic	0.23
Intuitive	-0.13
Memory	0.12
Logical	0.19
Impulsive	0.16
Random	-0.46
Integrative	0.26
Learning	-0.07
Quick insight	0.06
Reflective	-0.14
Metaphoric	0.13

The largest correlation of -.46 is between the ranked Random style and Job Performance, indicating that as Job Performance ratings increase from Poor to Top, so does the ranking for the Random cognitive style decrease i.e. the Random style tends to be less preferred by those with higher job performance ratings).

Table 56: Study 15: Gamma correlations between CPP Competencies and Job Performance

Variable	Gamma Correlations, Study 15: Information Processing Competencies x Job Performance Marked correlations are significant at p <.05000
	Performance Rating
Pragmatic	-0.00
Exploration	0.21
Analytical-p	0.12
Rule Oriented	0.16
Categorisation	0.32
Integration	0.37
Complexity	0.16
Logical Reasoning	0.20
Verbal Abstraction	0.33
Use of Memory	0.18
Memory strategies	0.24
Judgement	0.17
Quick Insight Learning	0.28
Gradual Improvement Learning	0.00

Here we see some differentiation between CPP competencies and how they relate to ratings of Job Performance.

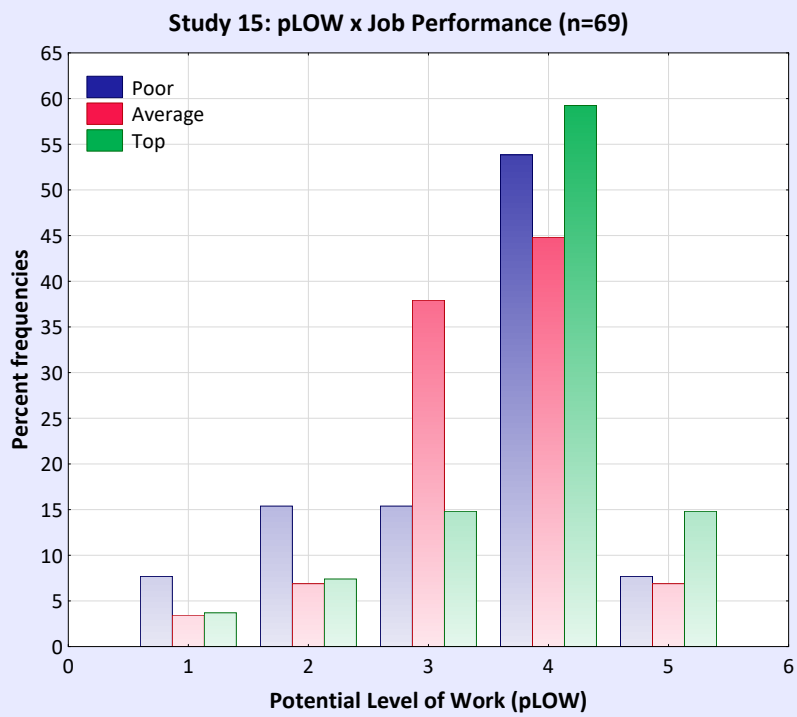
Table 57: Study 15: Gamma correlations between CPP Levels of Work and Job Performance

Variable	Gamma Correlations, Study 15: CPP Levels of work x Job Performance Marked correlations are significant at p <.05000
	Performance Rating
cLOW	0.36
pLOW	0.23

In order to better evaluate the relationship between CPP Levels of Work and Job Performance ratings, it is useful to plot the percentage frequencies of Job Performance ratings at each Level of Work. The percentages at each level of work magnitude for a performance group are relative to the total number of cases for that group. Figures 17 and 18 provide the bar-charts.

Figure 11: Study 15: Percent cases CPP Current Level of Work (cLOW) x Job Performance

Figure 12: Study 15: Percent cases CPP Potential Level of Work (cLOW) x Job Performance



The monotonic relationship between the CPP Current Level of Work and job-performance rating is perfect for the Top performance-rating group. For the CPP Potential Level of Work, the same monotonic relationship is present, except for Level 5 cases, where there is little differentiation between performance groups.

4.3.2 Study 16: CPP Attributes and 360-degree Job Performance Appraisal Ratings

Table 58: Study 16 Details: CPP attributes and 360-degree Job Performance Appraisals

Study 16: CPP vs 360-degree appraisals of Performance	
Date:	2006
Authored by:	Prinsloo
Sample Size:	33
Age:	Not recorded
Gender:	Mixed
Ethnicity:	South African
Language Groups:	English-speaking
Education:	Not recorded
Source:	Trainee Chartered Accountants at an Auditing Firm in South Africa
Notes:	Mentor-rated on an aggregate-component three-point scale: Poor, Average, Top

The purpose of the study was to identify guidelines for future selection and training initiatives in the accounting environment. The CPP results were compared to the personal appraisals of the trainee CAs by their mentors in terms of the following criteria (making use of a simple 3-point Likert-type scale):

- Business and financial acumen
- Motivation
- Interpersonal skills
- Work performance
- Academic achievement skills
- Logical-analytical skills
- Judgement in unstructured situations
- Preference for structure
- Self-improvement and learning

The highest correlations between CPP attributes and the aggregated performance-criteria ratings are:

Table 59: Study 16: Pearson correlations between CPP Attributes x 360-degree performance appraisals (n=33)

CPP attribute	Pearson r
Metacognitive awareness	.44
Analytical skills	.46
Managing complexity	.43
Integration and synthesis	.44
Application of task instruction	.52
Logical reasoning processes	.45
Abstract conceptualisation and verbalisation	.47
Flexible learning	.43
Clarifying vague issues	.42
Impulsivity	-.40

Note: correlations equal to or greater than 0.45 are significant at $p < 0.01$, two-tail
correlations equal to or greater than 0.35 are significant at $p < 0.05$, two-tail

As seen from this table there are high correlations between the CPP dimensions and the job-related rating of the trainee CA's especially regarding logical-analytical, goal-directed, integrated and verbal approaches. A significant proportion of the rating was also explained by metacognitive awareness - a key prerequisite for effective problem solving. Another interesting finding was that the majority of the trainee accountants were reluctant to use their judgement and intuition. This may be related to the culture of accounting firms and the serious implications of mistakes. In the long term, however, this tendency impacts on the development of business intuition and contributes to the creation of operational, tactical, specialist and hands-on approaches.

4.3.3 Study 17: CPP Attributes and Job Performance Appraisal Ratings

Table 60: Study 17 Details: CPP attributes and Job Performance appraisals

Study 17: CPP vs Performance Appraisals	
Date:	2004
Authored by:	De Villiers
Sample Size:	38 business consultants
Age:	Not recorded
Gender:	Not recorded - mixed
Ethnicity:	Not recorded – mostly Caucasian

A comparison was undertaken investigating the validity of the MBTI and that of the CPP in predicting job performance within the consulting milieu (RSA). The performance appraisals of the sample (n = 38) of business consultants were compared to their CPP "level of work" indicators.

In terms of the CPP results of the consultants, one showed a SST level 2; 3 a level 2 with potential for level 3; 7 a level 3; 11 a level 3 with potential for level 4, 9 a level 4; and 7 a level 4 with potential for level 5.

A total of 14 significant correlations between CPP scores and performance appraisal scores and 3 between the MBTI and performance appraisal scores were obtained. A correlation equal to or greater than .**33** would be significant at $p < 0.05$, two-tail.

The study indicated that consultants who show a CPP result of SST level 3 with potential for SST level 4, were rated as most effective by their clients. This may be ascribed to the level 3 culture that tends to permeate most organisations, and the fact that most client company cultures do not exceed level 3 in terms of the SST criteria.

De Villiers came to the conclusion that the cognitive tendency (and comfort with) working with highly abstract, interactive and intangible concepts, which is common amongst business consultants, needs to be balanced with a more "operational" approach when dealing with corporate clients. A somewhat operational focus often results in the conceptualisation of more tangible and easily understood solutions which a wider audience may appreciate. Higher CPP scores (in terms of SST "levels of work") therefore do not necessarily predict higher levels of the perceived performance of consultants. In fact, consultants with a current SST Level 4 with potential for level 5 on the CPP, achieved the lowest performance ratings from their corporate clients. She regards the CPP and MBTI as a useful psychometric combination and concluded that the MBTI provides incremental validity to CPP results.

4.3.4 Study 18: CPP Attributes & Job Performance 360-degree Ratings

Table 61: Study 18 Details: CPP attributes and Job Performance 360-degree appraisals

<table>
<tr><th colspan="2">Study 18: CPP vs 360-degree ratings of Performance</th></tr>
<tr><td>Date:</td><td>2009</td></tr>
<tr><td>Authored by:</td><td>Prinsloo & Sebata</td></tr>
<tr><td>Sample Size:</td><td>734</td></tr>
<tr><td>Age:</td><td>
<table>
<tr><th rowspan="2">From To</th><th colspan="4">Study 18: Sample Age DIstribution</th></tr>
<tr><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>19 <x<=27</td><td>71</td><td>71</td><td>9.77</td><td>9.77</td></tr>
<tr><td>27 <x<=35</td><td>310</td><td>381</td><td>42.64</td><td>52.41</td></tr>
<tr><td>35 <x<=43</td><td>220</td><td>601</td><td>30.26</td><td>82.67</td></tr>
<tr><td>43 <x<=51</td><td>88</td><td>689</td><td>12.10</td><td>94.77</td></tr>
<tr><td>51 <x<=59</td><td>33</td><td>722</td><td>4.54</td><td>99.31</td></tr>
<tr><td>59 <x<=67</td><td>5</td><td>727</td><td>0.69</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Gender:</td><td>
<table>
<tr><th rowspan="2">Category</th><th colspan="4">Study 18: Gender</th></tr>
<tr><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>Female</td><td>378</td><td>378</td><td>51.50</td><td>51.50</td></tr>
<tr><td>Male</td><td>356</td><td>734</td><td>48.50</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Ethnicity:</td><td>Diverse groups within South Africa</td></tr>
<tr><td>Language Groups:</td><td>English-speaking</td></tr>
<tr><td>Education:</td><td>Diverse spanning high-school / diploma qualifications through tertiary degrees.</td></tr>
<tr><td>Source:</td><td>Incumbent candidates for promotion drawn from various divisions and levels within a retail organisation, as well as different biographical profiles, training backgrounds and years of experience, for whom both CPP and Performance data for two years (2006 and 2007) were available.</td></tr>
<tr><td>Notes:</td><td>

CPP styles were ranked 14 = most-preferred, 1 = least preferred
CPP [0-100 range] Competencies were expressed using a 1 = Low, 7 = High scale
Performance ratings were real-valued percent totals which could exceed or range below 100% (indicating performance above an expected value of 100%)
A performance trend variable was created, being the difference between 2007 and 2006 ratings. A three-point classification was constructed indicating a Decrease, No Change, or Increase in rated performance
A Jacques Stratified Systems Theory (SST) Job-level was subjectively created by an external consultant for each job-role in which the candidate was currently employed. This variable ranged from [1-4].

</td></tr>
</table>

No substantive relationship was found between any CPP attribute and 360-degree rated job performance. However, this was a diverse range of employees working a variety of Jobs, which we can see from the values of the SST job-level classification variable.

Qualitative observations of the statistical results indicated:

- The more Operational jobs (SST level 1 and 2, but also level 3 to some extent) accommodated candidates who apply a somewhat slower, more operational approach to work, namely the "Explorative" and "Reflective" styles. Both these styles, however, negatively correlated with job effectiveness. In the case of the SST Level 1 actual jobs, a fair proportion of candidates also applied weak problem-solving strategies and went about in a "Random" (unplanned) and "Impulsive" manner. In the case of the level 1 positions, the "Analytical", "Integrative", "Logical" and "Holistic" cognitive styles were rarely applied by job incumbents.
- In the case of candidates employed in SST levels 3 and 4 of work, more "Intuitive" and knowledge-based "Memory" CPP styles prevailed. It was interesting to note that people at this strategic level in the organisation also reverted to an "Impulsive" approach when confronted with unfamiliar information - as in the case of the CPP. This is probably a company specific finding as the Retail Industry in RSA largely recruits from a very specific talent pool. It nevertheless is a controversial finding which may be a reflection the industry and / or organisational culture where quick decision making is regarded as desirable. A "Reflective" CPP style also significantly correlated with lower performance ratings at the higher job levels.

In order to compare CPP level of work indications with actual jobs, the SST levels of actual jobs were rated by experts:

Table 62: Study 18: Subjective external consultant-assigned SST Job levels of actual jobs

	Study 18: Consultant-assigned SST current job levels for candidates			
Category	Count	Cumulative Count	Percent	Cumulative Percent
1	425	425	57.90	57.90
2	202	627	27.52	85.42
3	91	718	12.40	97.82
4	16	734	2.18	100.00

Looking at the relationship between CPP attributes and SST job levels, we can observe some clear relationships.

Table 63: Study 18: Gamma correlations between CPP ranked styles and actual SST Job Levels

Variable	Study 18: Gamma correlations, CPP Ranked Styles Marked correlations are significant at p <.00100 SST Job Level
Explorative	-0.09
Analytical	0.22
Structured	0.17
Holistic	0.21
Intuitive	-0.31
Memory	0.01
Logical	0.31
Impulsive	-0.35
Random	-0.39
Integrative	0.21
Learning	0.11
Quickinsight	0.08
Reflective	0.14
Metaphoric	0.01

Table 64: Study 18: Gamma correlations between CPP competencies and actual SST Job Levels

Variable	Study 18: Gamma correlations, CPP Information Processing Competencies Marked correlations are significant at p <.00100 SST Job Level
Pragmatic	0.31
Exploration	0.42
Analytical_A	0.29
Rule-Oriented	0.29
Categorisation	0.29
Integration	0.40
Complexity	0.39
Logical Reasoning	0.34
Verbal Abstraction	0.29
Use of Memory	0.30
Memory strategies	0.29
Judgement	0.35
Quick Insight Learning	0.41
Gradual Improvement Learning	0.25

CPP information processing competencies significantly correlated with the actual level of work at which candidates were employed.

Table 65: Study 18: Gamma correlations between CPP Levels of Work and actual SST Job Levels

Variable	Study 18: Gamma correlations, CPP Levels of Work Marked correlations are significant at p <.00100 SST Job Level
cLOW	0.44
pLOW	0.42

CPP current and potential SST level of work indices significantly correlated with the actual level of work at which candidates were employed.

It is perhaps useful to plot the relationship between CPP Levels of Work and SST levels, where the percent frequencies of cases at each SST level are plotted against the discrete CPP Current and Potential Levels of Work classifications.

Figure 13: Study 18: Actual SST Job levels vs CPP Current Level of Work classifications

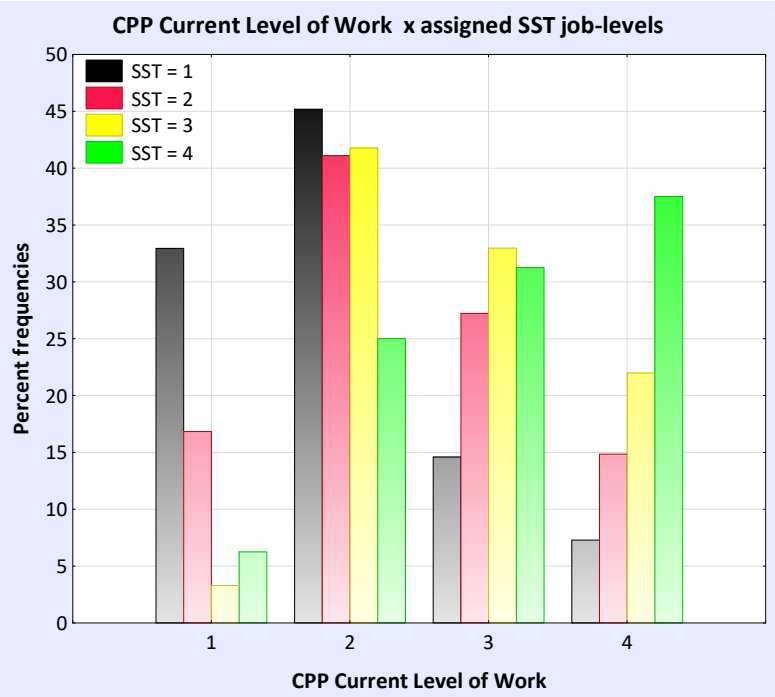
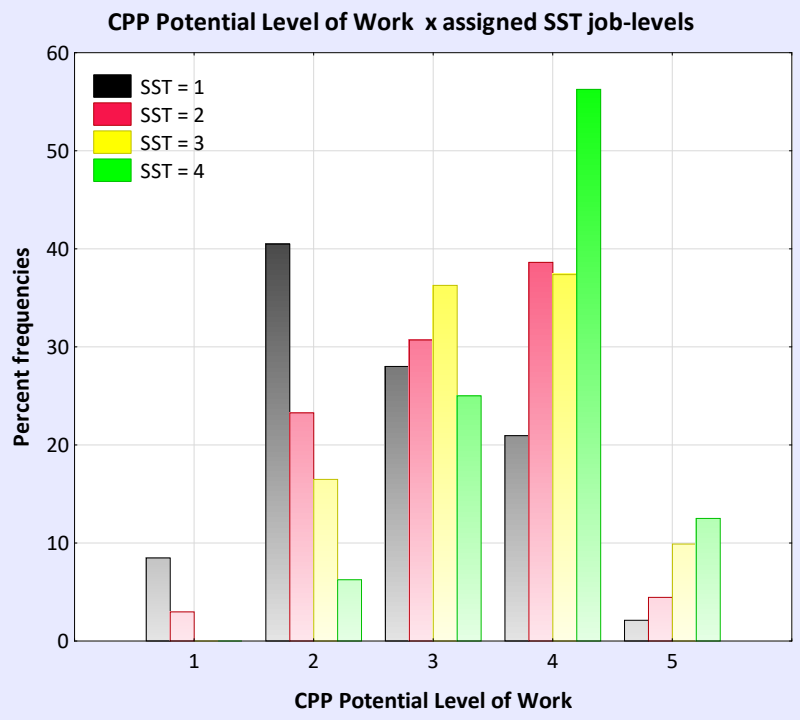


Figure 14: Study18: Actual SST Job levels vs CPP Potential Level of Work classifications



Interestingly, none of the correlations between SST Job Level and the two annual job performance ratings, or trend in ratings, achieved statistical significance at $p < 0.05$, two-tail, with all correlations less than 0.075. Perhaps of additional concern is that job performance ratings *decreased* overall from 2006 to 2007 in this organisation.

Table 66: Study 18: Annual Job Performance Ratings 2006 and 2007

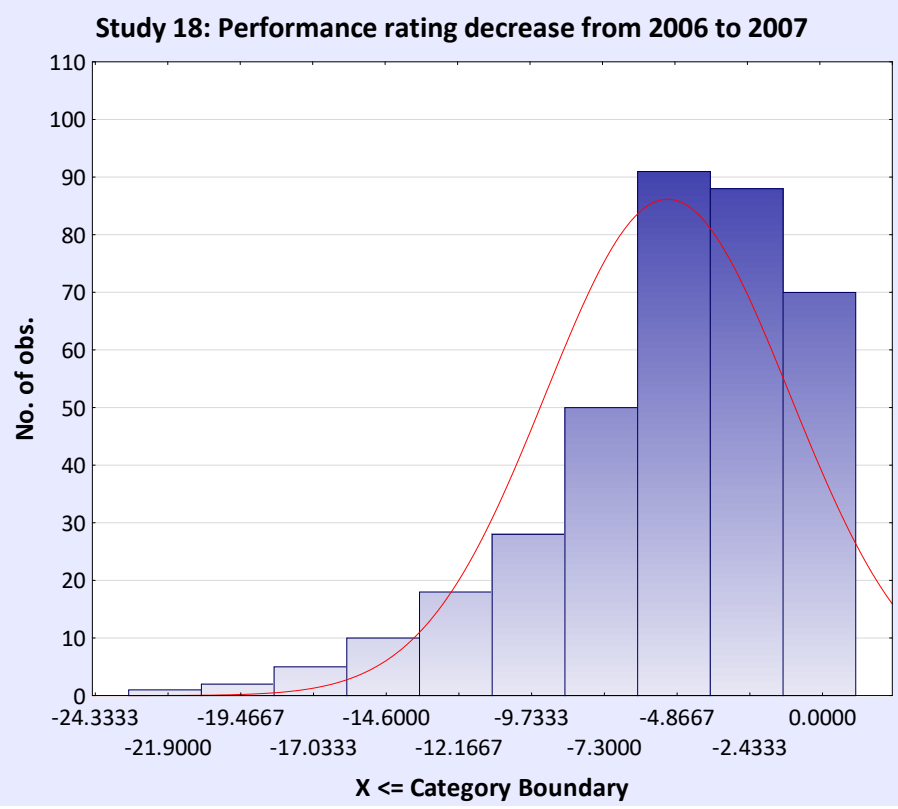
Variable	Study 18: Job Performance Ratings, 2006 & 2007					
	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Job Performance 06	637	105.5	105.0	92.0	119.0	4.57
Job Performance 07	727	104.0	104.3	86.0	117.1	4.91

Table 67: Study 18: Trend in Job Performance Ratings 2006 and 2007

Category	Study 18: Frequency table: Performance Trend			
	Count	Cumulative Count	Percent	Cumulative Percent
Decrease	363	363	57.08	57.08
No change	36	399	5.66	62.74
Increase	237	636	37.26	100.00

57% of employees were rated as having decreased their job-performance between 2006 and 2007. The distribution of performance decrements is:

Figure 15: Study 18 Histogram of year-on-year decrements in 57% of cases with annual Job Performance ratings



The job performance ratings for 2006 and 2007 correlated at **0.25** (n=633, $p < 0.0001$, Pearson correlation).

4.3.6 Study 19: CPP Attributes and Annual Job Performance

Table 68: Study 19 Details: CPP attributes and Annual Job Performance

Study 19: CPP vs Job Performance	
Date:	2014
Authored by:	Barrett & Prinsloo
Sample Size:	195-234
Age:	Mostly 40 – 55
Gender:	Almost all male
Ethnicity:	Caucasian – mostly from the EU, UK and USA
Language Groups:	Diverse – all English proficient
Education:	Tertiary degrees in various subjects possessed by all cases in the sample
Source:	Employed incumbent executives within a manufacturing industrial organisation
Notes:	• Job Performance assessed annually over three years, 2011-2013, using a 1-5 rating scale, where 1 = low performance and 5 = excellent performance

Table 69: Study 19: Gamma correlations between annual ratings of Job Performance

Variable	Study 19. : Gamma correlations between Job Performance Ratings Marked correlations are significant at p <.05000		
	2011 Rating n=196	2012 Rating n=196	2013 Rating n=194
2011 Rating	1.00	0.44	0.28
2012 Rating	0.44	1.00	0.58
2013 Rating	0.28	0.58	1.00

The 2012 performance ratings show the highest correlation with the ratings of other years.

Clearly, there seems to be a problem with years 2011 and 2013 ratings as they seem more unrelated to one another than might be expected given the same cases are being rated over three years.

Table 70: Study 19 Gamma correlations between CPP processing competencies and Job Performance

Variable	Study 19: Information Processing Competencies x Job Performance Ns vary from 189-198 Marked correlations are significant at p <.05000		
	2011 Rating	2012 Rating	2013 Rating
Pragmatic	-0.08	0.17	0.10
Exploration	-0.00	0.24	0.15
Analytical_A	0.01	0.20	0.13
Rule-Oriented	0.07	0.17	0.18
Categorisation	0.02	0.13	0.06
Integration	0.00	0.25	0.18
Complexity	-0.02	0.23	0.12
Logical Reasoning	-0.01	0.17	0.08
Verbal Abstraction	0.00	0.10	0.03
Use of Memory	-0.01	0.05	-0.02
Memory strategies	0.06	0.13	0.13
Judgement	-0.03	0.23	0.11
Quick Insight Learning	-0.03	0.17	0.12
Gradual Improvement Learning	-0.07	-0.03	0.02

Table 71: Study 19: Gamma correlations between CPP Levels of Work and Job Performance

Variable	Study 19: CPP Levels of Work x Job Performance ratings Marked correlations are significant at p <.05000		
	2011 Rating, n=190	2012 Rating, n=198	2013 Rating, n=189
cLOW	.06	.33	.15
pLOW	-.06	.22	.02

A number of cognitive information processing competencies as well as the CPP level of work indications, correlated significantly with the performance ratings of 2012.

The problem as ever with using job performance ratings is that these kinds of rating data are invariably 'noisy'. Many investigators using such ratings correct the observed correlations for 'unreliability' in the criterion, expressing the resulting correlation as 'operational validity'. But as LeBreton, Scherer & James (2014) note, these corrections are highly suspect; a result confirmed by Roth, Huy, In-Sue, Van Iddekinge, & Robbins (2017).

4.3.8 Study 20: The relationship between Rated Job Performance, Potential for Performance, and CPP attributes

This study sought to establish the relationships between organization-rated job Performance and Potential for Performance with CPP cognitive style preferences, competencies, and Current and Potential Level of Work.

Table 72: Study 20 Details: Rated job performance and potential

<table>
<tr><th colspan="2">Study 20: Rated job performance and potential and CPP attribute associations</th></tr>
<tr><td>Date:</td><td>2017</td></tr>
<tr><td>Authored by:</td><td>Barrett & Prinsloo</td></tr>
<tr><td>Sample Size:</td><td>150 (but only 140 cases completed the CPP)</td></tr>
<tr><td>Age:</td><td>
<table>
<tr><th></th><th colspan="4">Study 20: Sample Age Distribution</th></tr>
<tr><th>From To</th><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>10 <x<=20</td><td>1</td><td>1</td><td>0.67</td><td>0.67</td></tr>
<tr><td>20 <x<=30</td><td>0</td><td>1</td><td>0.00</td><td>0.67</td></tr>
<tr><td>30 <x<=40</td><td>13</td><td>14</td><td>8.67</td><td>9.33</td></tr>
<tr><td>40 <x<=50</td><td>65</td><td>79</td><td>43.33</td><td>52.67</td></tr>
<tr><td>50 <x<=60</td><td>27</td><td>106</td><td>18.00</td><td>70.67</td></tr>
<tr><td>60 <x<=70</td><td>1</td><td>107</td><td>0.67</td><td>71.33</td></tr>
<tr><td>70 <x<=80</td><td>0</td><td>107</td><td>0.00</td><td>71.33</td></tr>
<tr><td>Missing</td><td>43</td><td>150</td><td>28.67</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Gender:</td><td>
<table>
<tr><th></th><th colspan="4">Study 20: Gender</th></tr>
<tr><th>Category</th><th>Count</th><th>Cumulative Count</th><th>Percent</th><th>Cumulative Percent</th></tr>
<tr><td>Male</td><td>114</td><td>114</td><td>76.00</td><td>76.00</td></tr>
<tr><td>Female</td><td>19</td><td>133</td><td>12.67</td><td>88.67</td></tr>
<tr><td>Missing</td><td>17</td><td>150</td><td>11.33</td><td>100.00</td></tr>
</table>
</td></tr>
<tr><td>Ethnicity:</td><td>Over 70% of cases from USA, EU - Switzerland, and Singapore</td></tr>
<tr><td>Language Groups:</td><td>No information available</td></tr>
<tr><td>Education:</td><td>All possessed tertiary degrees in various subjects.</td></tr>
<tr><td>Source:</td><td>Employees an international infrastructure corporate; all at managerial/executive level</td></tr>
<tr><td>Notes:</td><td>Criterion measures were organization-rated employee potential and job performance</td></tr>
</table>

Job performance was rated using four categories, although only three were allocated among this group of employees.

Table 73: Study 20: Rating scheme for job performance

Category	Study 20: Rated Performance			
	Count	Cumulative Count	Percent	Cumulative Percent
Meets	60	60	41.67	41.67
Exceeds	78	138	54.17	95.83
Outstanding	2	140	1.39	97.22
Missing	4	144	2.78	100.00

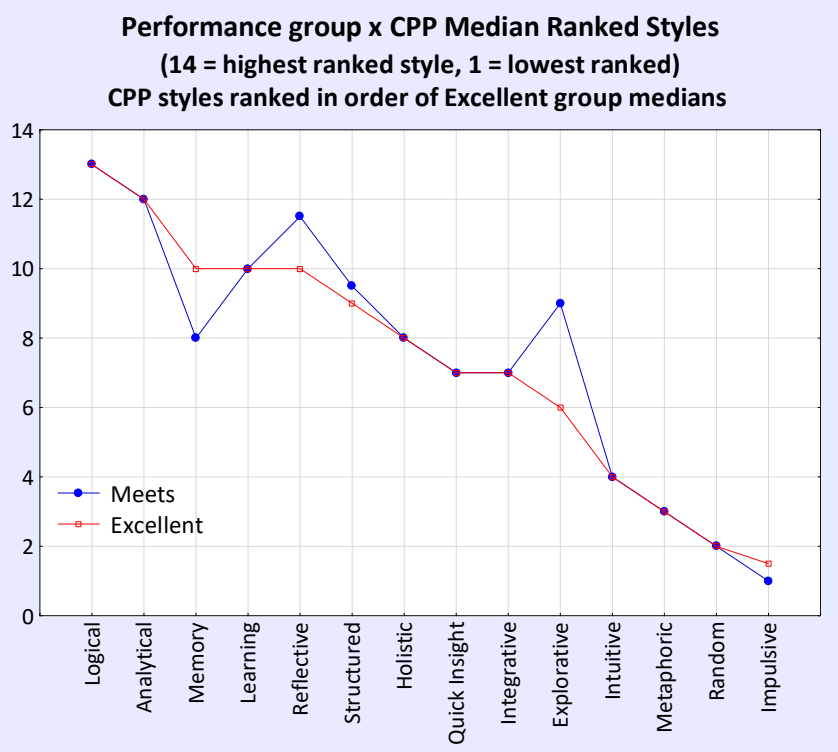
Employee potential was also rated using four categories, although again, only three were allocated among this group of employees.

Table 74: Study 20: Rating scheme for potential

Category	Study 20: Rated Potential			
	Count	Cumulative Count	Percent	Cumulative Percent
Stable	54	54	37.50	37.50
High Potential	71	125	49.31	86.81
Very High Potential	3	128	2.08	88.89
Missing	16	144	11.11	100.00

The first investigation of the data was to examine the relationship between rated job performance group and the CPP ranked cognitive styles. We collapsed the 2 cases in Table 103 for the *Outstanding Performance* group into the *Exceeds Performance group* calling the final group "*Excellent*" (n=80). We then ordered the CPP median ranks for each style, in order of the size of each median rank for the *Excellent Performance group*. Then we plotted the medians for the *Meets Expectations* (n=60) group in that same *Excellent Performance Group* order. There are some differences in monotonicity but these are trivial in the grand scheme of the trend. For each performance group, we computed the Pearson correlation between the median value of CPP style-rank in a group and the order of that style (as shown on the X-axis). Both correlations are strongly negative indicating the directionality of the monotonic trend i.e. for both the "Meets" and "Excellent" groups, the highest median-rank CPP style is "Logical", the lowest is "impulsive".

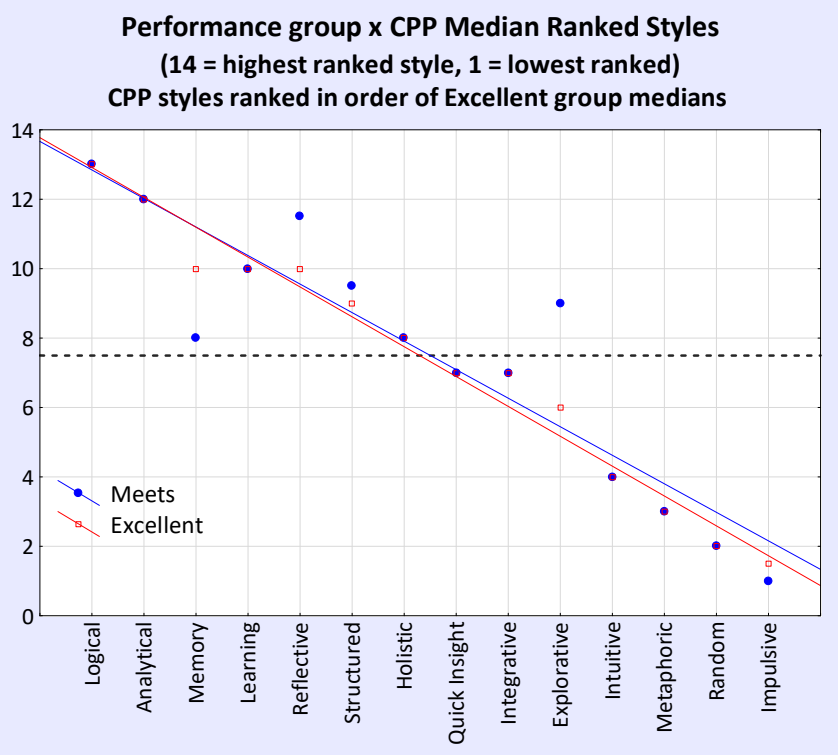
Figure 16: Study 20: Job Performance Group and median ranked CPP style



What this graph shows is the strong monotonic trend of the median ranks (the preferred cognitive style), where the incumbent executive-level employees show the strongest preference for Logical and Analytical styles, with the least preference for Random and Impulsive styles of thinking, For the "Meets Performance Expectation" group, the magnitude of the Pearson correlation was 0.91, for the "Excellent" group, the correlation was 0.98 *(of course, both correlations were negative but what's important here is the magnitude of the coefficient, not its sign).*

If we plot the linear trends onto Figure 22 data, we see:

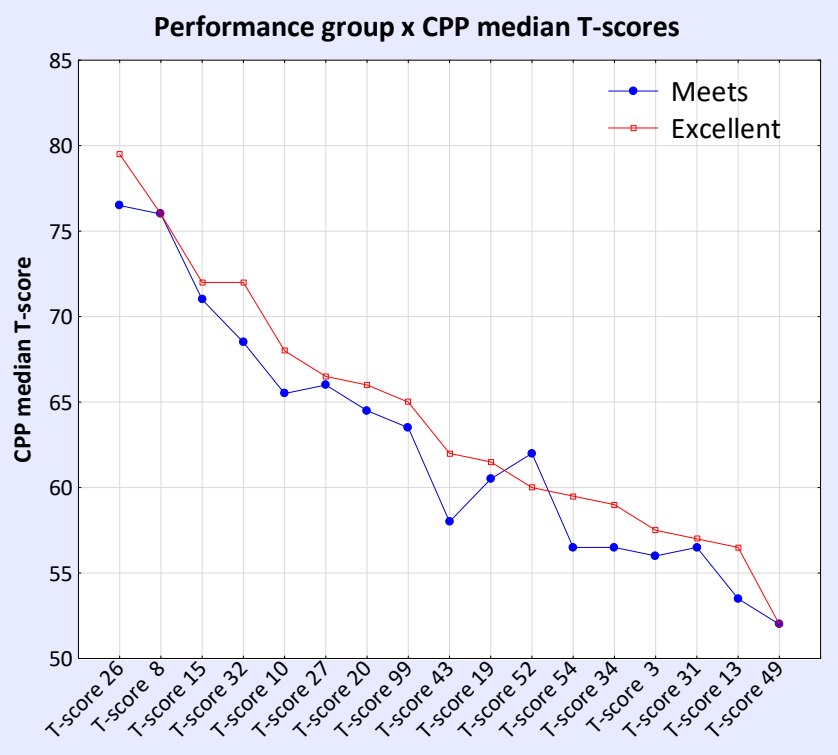
Figure 17: Study 20: Job Performance Group and median ranked CPP style linear trends



With both slope coefficients statistically significant at $p < 0.0001$.

We can do the same with the CPP cognitive processing scores. The CPP T-Score medians are ordered with respect to the size of the medians for the *Excellent Performance group*. Then we plot the medians for the *Meets Expectations* (n=60) group in that same *Excellent Performance* group order.

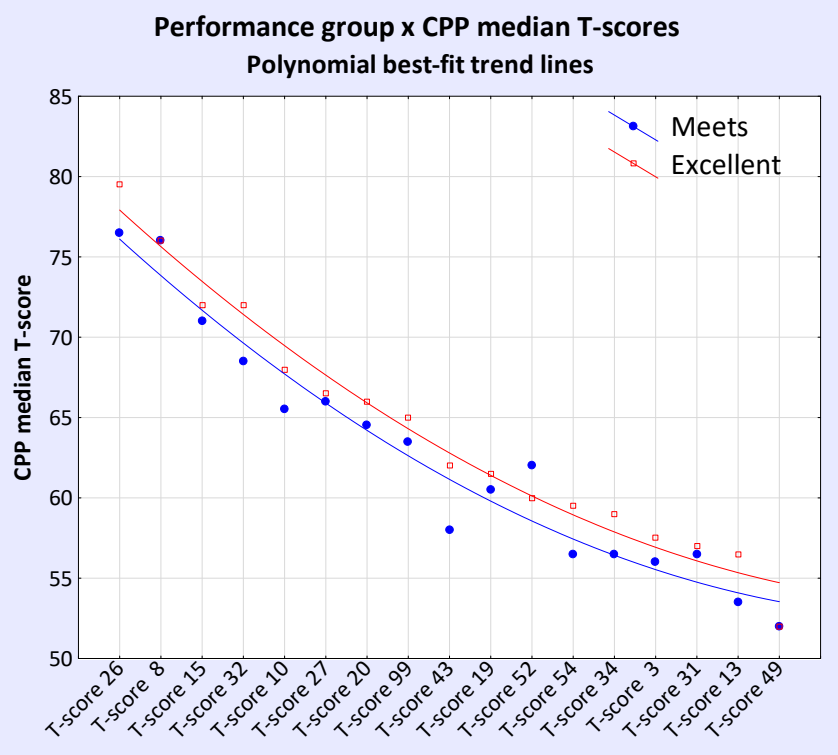
Figure 18: Study 20: Job Performance Group and median CPP cognitive processing scores



Where:
T-score 26: Follows arguments through
T-score 8: Analytical identification of relationships
T-score 15: Quick insight learning
T-score 32: Memory strategies
T-score 10: Rule orientation
T-score 27: Generating abstract concepts
T-score 20: Complexity
T-score 99: Average score
T-score 43: Exploring
T-score 19: Integrate discrepant information
T-score 52: Gradual improvement learning
T-score 54: Judgement to clarify information
T-score 34: Awareness and alertness
T-score 3: Discrimination
T-score 31: Relying on own memory
T-score 13: External ordering and categorizing
T-score 49: Elimination strategy

Both groups show a slight quadratic trend in Figure 24; which when fitted to the data appear as:

Figure 19: Study 20: Job Performance Group and median CPP cognitive processing scores; quadratic trends



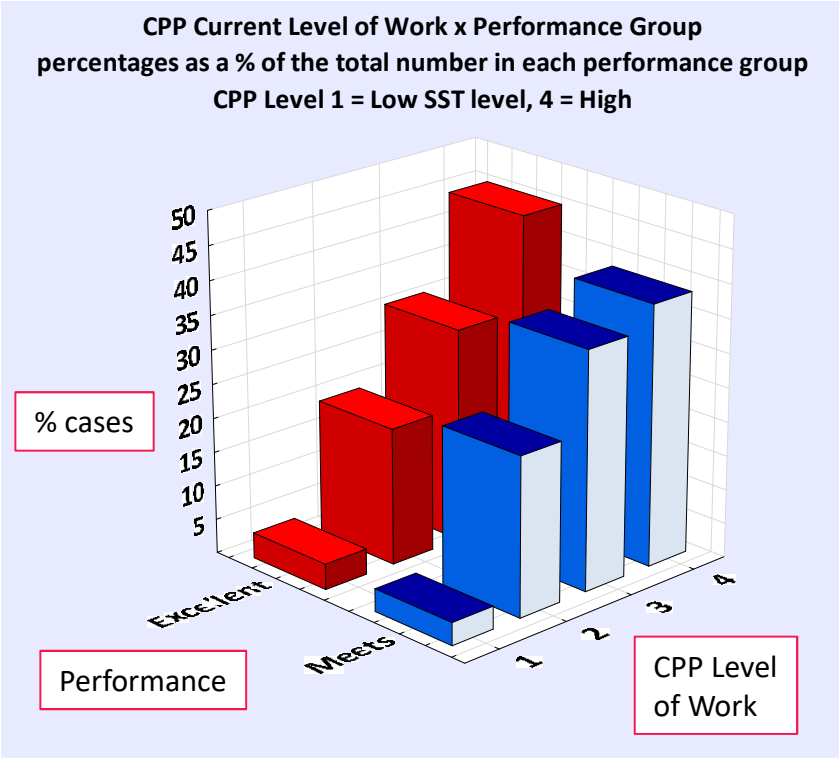
Where:
T-score 26: Follows arguments through
T-score 8: Analytical identification of relationships
T-score 15: Quick insight learning
T-score 32: Memory strategies
T-score 10: Rule orientation
T-score 27: Generating abstract concepts
T-score 20: Complexity
T-score 99: Average score
T-score 43: Exploring
T-score 19: Integrate discrepant information
T-score 52: Gradual improvement learning
T-score 54: Judgement to clarify information
T-score 34: Awareness and alertness
T-score 3: Discrimination
T-score 31: Relying on own memory
T-score 13: External ordering and categorizing
T-score 49: Elimination strategy

It is interesting to note that the two group-trend-lines are virtually parallel but with the Excellent group scoring higher for every T-score attribute than the "Meets Performance Expectations" group. The linear Pearson correlation between the median T-scores magnitudes and their order on the X-axis is .96 for the "Meets Performance Expectation" group, and .97, for the "Excellent" group *(again, both correlations were negative but it is the magnitude of the coefficient, not its sign, which is important).*

Running the same analyses for the "Potential" ratings produced almost identical results for both CPP styles and information processing competencies.

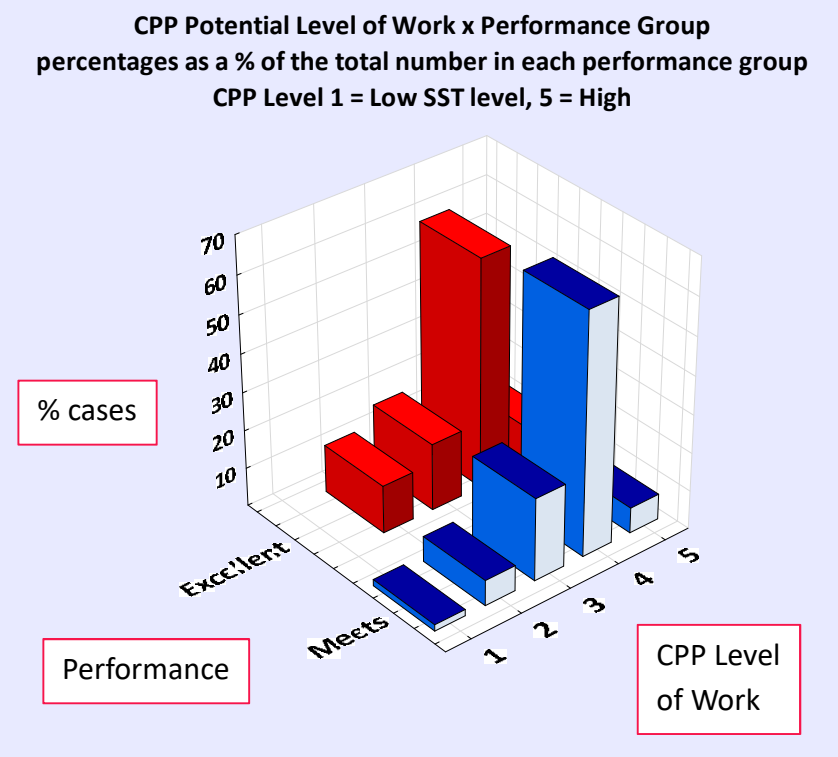
With respect to the CPP Levels of Work attributes, we computed bivariate histograms showing the frequencies of cases in each performance group for each CPP Current Level of Work (1 to 4) expressed as a percentage of the total number of cases in each performance group. Then these relative percentages were plotted side-by side.

Figure 20: Study 20: Job Performance Group x CPP Current Level of Work categories



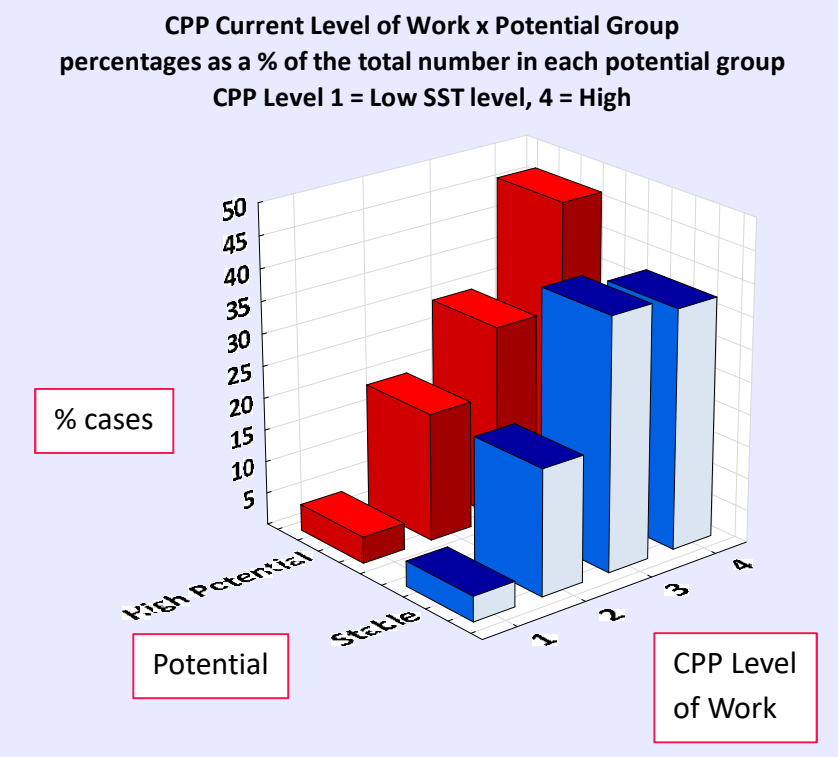
What we see here is that for CPP Level 4, as might be expected, there are a higher proportion of cases in the Excellent performance group than in the Meets Performance Expectations group

Figure 21: Study 20: Job Performance Group x CPP Potential Level of Work categories



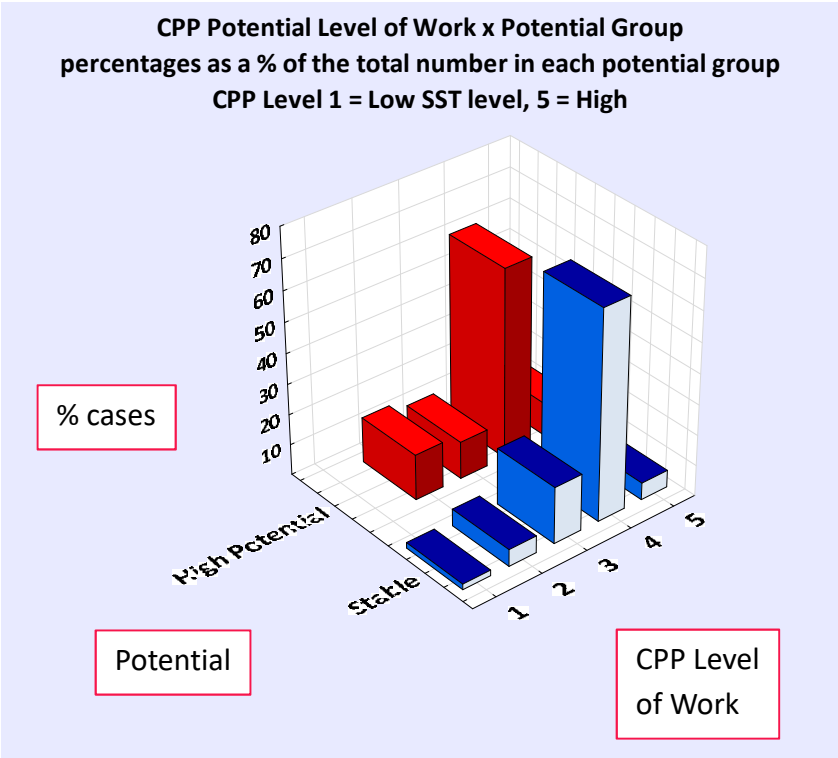
There is a clear monotonic relationship between the percentages of cases in a performance group and increasing CPP Potential Level of Work rankings., except for Level 5. This may reflect that fact that Level 5 on the CPP is a qualitative step beyond Level 4 in terms of how the organization assesses employee performance expectations. Level 4, Parallel Processing requirements are associated with executive functioning within this organization.

Figure 22: Study 20: Employee Potential Group x CPP Current Level of Work categories



What we see here is that for CPP Level 4, as might be expected, there are a higher proportion of cases in the High Potential group than in the Stable Potential group. However, the opposite is the case for the Stable Potential group whose members have been assigned a CPP current level of work rank of 3, and whose percent frequency exceeds that of the High Potential group with the same "3" rank.

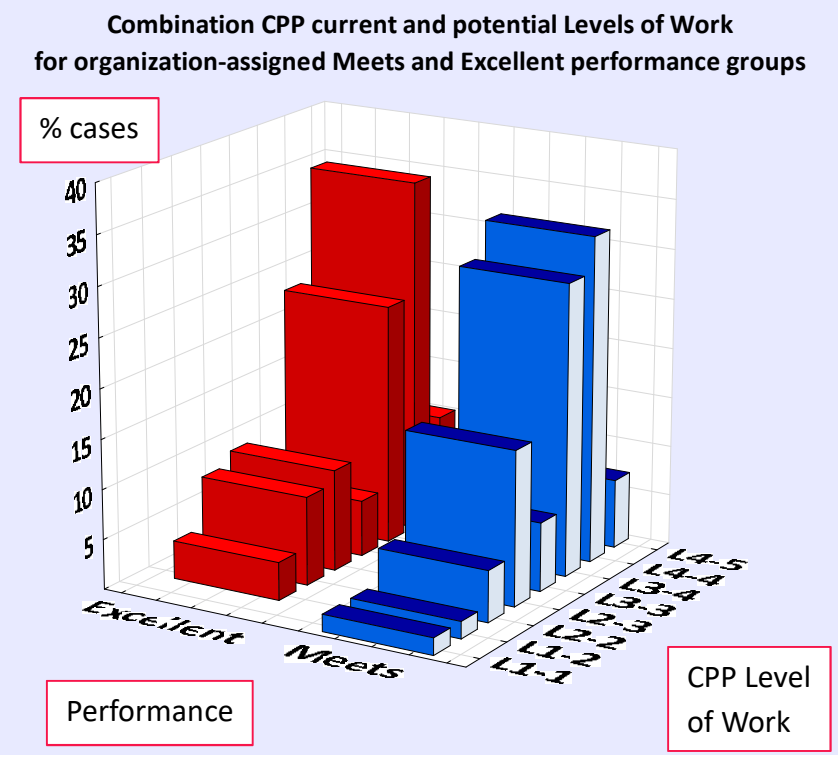
Figure 23: Study 20: Employee Potential Group x CPP Potential Level of Work categories



There is less of a monotonic relationship here, with the bulk of Stable and High Potential cases being assigned a Potential Level of Work SST level of 4.

In the final two bivariate histogram graphs, the CPP Current and Potential Levels of work rankings were combined into a new ordered-class categorisation. The frequency of new combination codes for the organization-assigned performance groups are expressed as a percentage of the total number of cases in each *performance* group. Then these relative percentages are plotted side-by side. Likewise for the *potential* groups.

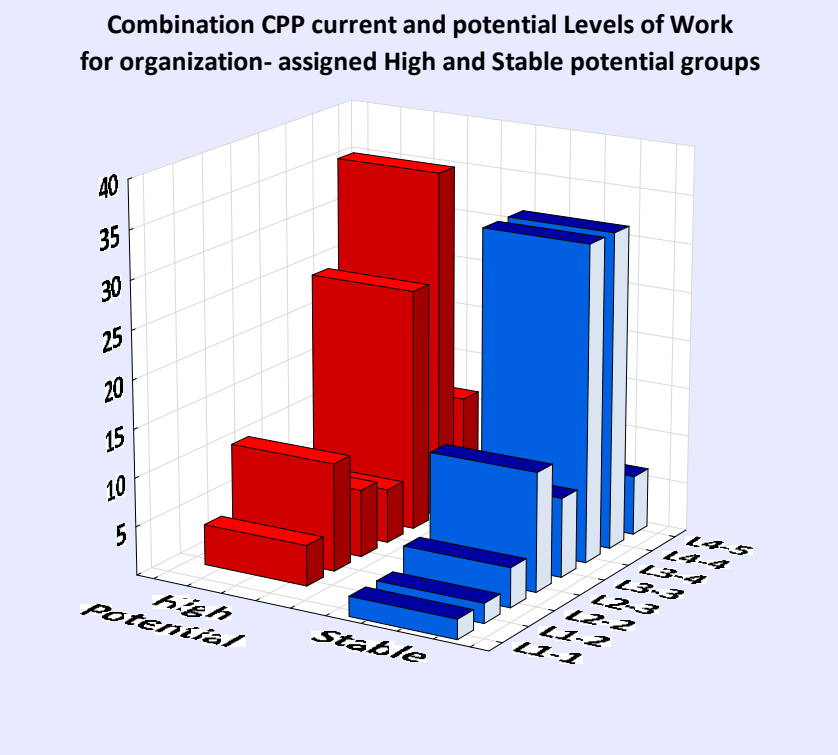
Figure 24: Study 20: Performance Group x CPP combined current & potential Level of Work categories



Legend:

L1-1 = Current LOW = 1, Potential = 2
L1-2 = Current LOW = 1, Potential = 2
L2-2 = Current LOW = 2, Potential = 2
L2-3 = Current LOW = 2, Potential = 3
L3-3 = Current LOW = 3, Potential = 3
L3-4 = Current LOW = 3, Potential = 4
L4-4 = Current LOW = 4, Potential = 4
L4-5 = Current LOW = 4, Potential = 5

Figure 25: Study 20: Employee Potential x CPP combined current & potential Level of Work categories



Legend:
L1-1 = Current LOW = 1, Potential = 2
L1-2 = Current LOW = 1, Potential = 2
L2-2 = Current LOW = 2, Potential = 2
L2-3 = Current LOW = 2, Potential = 3
L3-3 = Current LOW = 3, Potential = 3
L3-4 = Current LOW = 3, Potential = 4
L4-4 = Current LOW = 4, Potential = 4
L4-5 = Current LOW = 4, Potential = 5

In both figures 30 and 31, we see a similar monotonic trend for both High and Stable potential employees. As the combined current and potential Level of Work composite scores increase, so do we see more and more frequencies of cases. But, reflecting the data in Figures 27 and 29, the highest level CPP combined Level of Work frequencies are much lower than expected given a monotonic trend, reflecting a slight dissonance between the meaning of the CPP Level 5 potential category and how employees are being rated for performance and potential within the organization.

4.3.7 Study 21: Comparing externally assigned SST levels of Work with CPP-assigned Levels

This study is aimed at answering the question of whether the CPP results of individuals tend to match the complexity requirements of their work as indicated by the Stratified Systems Theory (SST).

A perfect match between people and jobs is not expected as employees are not always carefully matched or suited to their positions. An overall comparison of job levels and people capabilities will, however, be useful given the impact of natural selection processes on job promotion – especially at managerial and executive levels.

The CPP and CCM measure 5 levels of work complexity whereas the SST specifies 7 levels. The CPP and CCM Level 5 include the requirements and capabilities associated with the SST Level 5, 6 and 7.

In this study, the jobs in question were largely analysed by HR practitioners in terms of a number of criteria linked to the Stratified Systems Theory (SST) which describes the complexity of work. These criteria are provided systematically by the Contextualised Competency Mapping (CCM) job analysis tool, which was provided to the companies involved. However, in the majority of cases, not all the positions were analysed in detail by using the CCM, but the SST levels of certain positions were merely indicated by professionally trained and CCM-accredited practitioners. The so-called CCM levels of the positions as indicated here, may therefore lack accuracy. The job levels are indicated in this study as CCM levels whereas the complexity levels of the people involved, are indicated as CPP levels.

In some cases, positions were also slotted into 9 SST categories (Level 1, Level 1 for 2, Level 2, Level 2 for 3, Level 3, Level 3 for 4, L4, Level 4 for 5, and Level 5) and at other organisations jobs were merely slotted into 5 categories (Level 1, Level 2, Level 3, Level 4, Level 5). To resolve this discrepancy in the categorisation of the positions, those job categories that spanned 2 different SST levels were "rounded lower" *(e.g. Level 1-for-2 becomes a Level 1 job)* or higher *(Level 1-for-2 becomes a Level 2 job).*

It can be expected that the CPP current level will best map onto the "rounded lower" level of the job, and the CPP potential level will be best suited to the "rounded higher" level of the position.

The normal work population is roughly estimated to function at the following SST levels:

- A good 80% of work roles represent operational work at the SST Pure Operations and Diagnostic Accumulation levels. It can also be expected that the majority of people feel most comfortable in these structured and relatively routinised and/or technical environments where they can rely on previously acquired knowledge and experience.

- Approximately 15% of roles can be regarded as representative of the Tactical Strategy level. These include most professional and business management roles where a job incumbent has to deal with tangible systems and/or the application of professional knowledge.
- A much smaller percentage, an estimated 4% of roles, can be regarded as reflecting Parallel Processing complexity where the focus is on the integration of complex, dynamic and fuzzy information, innovation, model building and considering the viability of complex systems.
- A mere fraction of a percentage point of roles in the work environment, require dealing with the chaos and emerging patterns on which Pure Strategic roles focus. These roles are normally associated with determining the strategic intent of an organisation, the long term viability and sustainability of an industry, realising emerging philosophical trends in the industry and capitalising on the offerings of alternative industries.

These estimated percentages are merely meant to contextualise the CPP scores of people in the work environment.

In the samples analysed as part of this study, employees from the mining, manufacturing and retail industries from 3 organisations were included. A large number of roles were involved which primarily span Pure Operational to Parallel Processing work complexity. A fair proportion of the roles from the manufacturing and mining industries in particular represent managerial and executive functioning.

As can be expected, the samples largely show a preference for Diagnostic (level 2) and Tactical (Level 3) work. This can be expected as normal SST level distributions which peak at Levels 1 and 2, differ from the nature of the samples included in this study where a fair proportion of the roles involve Level 3 and Level 3 for 4 functioning. The largest of the samples included here, does however, reflect mostly operational work.

Table 75: Study 21 Details: External SST levels with CPP-SST Levels of Work

Study 21: External SST levels of work compared to CPP-SST assigned levels	
Date:	2017
Authored by:	Barrett & Prinsloo
Sample Size:	4 discrete samples, N=1157 total sample size
Age:	No information available
Gender:	No information available
Ethnicity:	No information available
Language Groups:	No information available
Education:	Many possessed tertiary degrees in various subjects.
Source:	Employees from the mining, manufacturing and retail industries from 3 organisations. A fair proportion of the roles from the manufacturing and mining industries in particular represent managerial and executive functioning.
Notes:	Stratified Systems Theory (SST) job levels assigned by HR practitioners and/or using the Cognadev Contextualised Competency Mapping (CCM) job analysis tool.

The following samples (Samples 1, 2, 3, 4) were analysed:

Table 76: Study 21 The four constituent files, and numbers of cases in the combined sample global file

	Frequency table: Sample			
Category	Count	Cumulative Count	Percent	Cumulative Percent
Sample 1	36	36	3.11	3.11
Sample 2	202	238	17.46	20.57
Sample 3	185	423	15.99	36.56
Sample 4	734	1157	63.44	100.00
Missing	0	1157	0.00	100.00

Table 77: Study 21 The global file structure containing the four samples of data

	Multiple file SST dataset	
	1 Variable Name	2 Long Name -Description
1	Sample	
2	CCM Rounded Lower LOW	CCM Job Level - Rounded Lower
3	CCM Rounded Higher LOW	CCM Job Level - Rounded Higher
4	CPP Current LOW	
5	CPP Potential LOW	

- Each Level of Work (LOW) variable ranges between {1 and 5}.

- For the CCM, the dual category rating (e.g. L1-2) was "rounded down" into the CCM Rounded Lower LOW variable (so L1-2 would be coded as L1) and "rounded up" into the CCM Rounded Higher LOW variable (so L1-2 would be coded as L2).

- For the Sample 4 data, where only a single "Actual Job Rating" code was provided {1-5}, the same value was used in both the CCM Rounded Lower LOW and CCM Rounded Higher LOW variables.

Table 78: Study 21: Descriptive statistics for the Aggregate Sample data file

Variable	Descriptive Statistics: Aggregate Sample Data File						
	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
CCM Rounded Lower LOW	1157	2.1	2	1	4	1	3
CCM Rounded Higher LOW	1157	2.2	2	1	5	1	3
CPP Current LOW	1157	2.4	2	1	4	2	3
CPP Potential LOW	1157	3.1	3	1	5	2	4

Table 79: Study 21: Descriptive statistics for Sample 1 data

Variable	Descriptive Statistics: Sample 1						
	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
CCM Rounded Lower LOW	36	3.1	3	2	4	3	3
CCM Rounded Higher LOW	36	3.6	4	3	4	3	4
CPP Current LOW	36	2.7	3	1	4	2	3
CPP Potential LOW	36	3.5	3	2	5	3	4

Table 80: Study 21: Descriptive statistics for Sample 2 data

Variable	Descriptive Statistics: Sample 2						
	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
CCM Rounded Lower LOW	202	2.9	3	2	4	3	3
CCM Rounded Higher LOW	202	3.3	3	2	5	3	4
CPP Current LOW	202	2.7	3	1	4	2	3
CPP Potential LOW	202	3.4	4	2	5	3	4

Table 81: Study 21: Descriptive statistics for Sample 3 data

Variable	Descriptive Statistics: Sample 3						
	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
CCM Rounded Lower LOW	185	3.0	3	2	4	3	3
CCM Rounded Higher LOW	185	3.3	3	2	4	3	4
CPP Current LOW	185	2.8	3	1	4	2	4
CPP Potential LOW	185	3.4	4	1	4	3	4

Table 82: Study 21: Descriptive statistics for Sample 4 data

Variable	Descriptive Statistics: Sample 4						
	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
CCM Rounded Lower LOW	734	1.6	1	1	4	1	2
CCM Rounded Higher LOW	734	1.6	1	1	4	1	2
CPP Current LOW	734	2.2	2	1	4	2	3
CPP Potential LOW	734	2.9	3	1	5	2	4

It is suggested that the Current CPP levels of people be compared to the "rounded lower" estimates of the CCM levels, whereas the CPP Potential levels be compared to the "rounded higher" CCM levels.

CPP Current Level of Work

Table 83: Study 21: Aggregate Sample data file - using CCM Rounded Lower Level of Work

Summary Frequency Table: Aggregate Sample Data FIle Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Lower LOW	CPP Current LOW 1	CPP Current LOW 2	CPP Current LOW 3	CPP Current LOW 4	Row Totals
1	140	192	62	31	425
2	43	107	57	30	237
3	20	170	167	106	463
4	1	4	5	22	32
All Grps	204	473	291	189	1157

Gamma correlation = **0.52, % classification accuracy = 38%** *(sum of diagonal/total number of cases)*

For the Aggregate Sample data file - using CCM Rounded Lower Level of Work x CPP Potential Level of Work, the gamma correlation was 0.471.

In this combined sample it seems that many employees with current Level 2 CPP results are employed in Level 1, 2 and 3 jobs. In the case of inexperienced employees with a CPP Level 2 capacity, employment at operational Level 1 is common, from where employees can progress further as they gain more knowledge and experience. The majority of those with current CPP Level 4 capacity, are employed at Levels 3 seeing that the majority of the roles reflected Level 3 as opposed to Level 4 complexity.

Those employees with a current level 2 CPP result, that are employed at CCM level 3 positions, are likely to approach their work in a linear, rule-based manner, without adequately focusing on the entire functional system, the interaction between systems elements and the longer term goal achievement of the functional system. In other words, these individuals can be expected to experience difficulty in planning and monitoring tactical strategies, thereby reducing the effectiveness of managerial functioning.

Table 84: Study 21: Sample 1 - using CCM Rounded Lower Level of Work

Summary Frequency Table: Sample 1 Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Lower LOW	CPP Current LOW 1	CPP Current LOW 2	CPP Current LOW 3	CPP Current LOW 4	Row Totals
2	0	2	0	0	2
3	1	14	11	3	29
4	0	0	0	5	5
All Grps	1	16	11	8	36

Gamma correlation = **0.98, % classification accuracy = 50%**

This sample largely consisted of managers and executives within the mining and production environments. Most of the roles represented a CCM Level 3. The majority of the employees showed current CPP Level 2 and 3 capacity although a good proportion also showed a current CPP Level 4 capability. The majority of people with Level 2 and Level 3 capacity were employed in Level 3 roles. Most of those that showed a current Level 4 capacity were employed in Level 4 roles.

Table 85: Study 21: Sample 2 - using CCM Rounded Lower Level of Work

Summary Frequency Table: Sample 2 Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Lower LOW	CPP Current LOW 1	CPP Current LOW 2	CPP Current LOW 3	CPP Current LOW 4	Row Totals
2	4	20	2	0	26
3	3	62	66	40	171
4	0	0	0	5	5
All Grps	7	82	68	45	202

Gamma correlation = **0.90, % classification accuracy = 45%**

In this sample of managers and executives too, most individuals showed a current Level 2 and 3 capability and most were employed in CCM level 3 roles. Most of those currently capable of Level 4 functioning, were slotted into Level 3 roles. The distribution of the capability levels of this managerial / executive sample does, however, look very different from broad estimates of the normal working population where 80% show Level 1 and 2 capacity.

Table 86: Study 21: Sample 3 - using CCM Rounded Lower Level of Work

Summary Frequency Table: Sample 3 Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Lower LOW	CPP Current LOW 1	CPP Current LOW 2	CPP Current LOW 3	CPP Current LOW 4	Row Totals
2	5	2	0	0	7
3	13	56	60	43	172
4	0	0	0	6	6
All Grps	18	58	60	49	185

Gamma correlation = **0.97, % classification accuracy = 37%**

In this sample of managers and executives from a global manufacturing company, the majority of positions were classified as Level 3 work and individuals showing level 2, 3 and 4 capacity were

in Tactical Strategy work. In this sample it is interesting to note that only people with a current Level 4 capacity were found in Level 4 roles, but many others with current Level 4 capacity were employed in Level 3 positions. Again this sample of executives and managers show a completely different distribution in terms of capability levels than the normal working population.

Table 87: Study 21: Sample 4 - using CCM Rounded Lower Level of Work

Summary Frequency Table: Sample 4 Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Lower LOW	CPP Current LOW 1	CPP Current LOW 2	CPP Current LOW 3	CPP Current LOW 4	Row Totals
1	140	192	62	31	425
2	34	83	55	30	202
3	3	38	30	20	91
4	1	4	5	6	16
All Grps	178	317	152	87	734

Gamma correlation = **0.44, % classification accuracy = 35%**

Roles within this Retail organisation represent SST Levels 1 to 4 complexity, but a large majority of the roles are of an operational nature. In fact, 85% of roles reflect SST Levels 1 and 2. The employees also showed primarily Operational capacity with a good 67% of employees showing current Level 1 and Level 2 preferences and capabilities. Given the large proportion of young and inexperienced employees as well as people who have not had access to higher education, a majority of the employees in this organisation who show current Level 3 capacity are employed at Levels 1 and 2. The majority of those with current Level 1 and 2 capacity are also employed in Level 1 roles.

CPP Potential Level of Work

Table 88: Study 21: Global Data file - using CCM Rounded Higher Level of Work

Summary Frequency Table: Aggregate Sample Data File Marked cells have counts > 10 (Marginal summaries are not marked)						
CCM Rounded Higher LOW	CPP Potential LOW 1	CPP Potential LOW 2	CPP Potential LOW 3	CPP Potential LOW 4	CPP Potential LOW 5	Row Totals
1	36	172	119	89	9	425
2	6	50	62	78	9	205
3	1	80	139	151	11	382
4	0	4	26	100	14	144
5	0	0	0	1	0	1
All Grps	43	306	346	419	43	1157

Gamma correlation = **0.46, % classification accuracy = 28%**

For the Aggregate Sample data file - using CCM Rounded Higher Level of Work x CPP Current Level of Work, the gamma correlation was 0.502.

Interesting results here include the large proportion of individuals with a level 2 and 3 cognitive potential in level 1 positions. This may be due to the inadequate experience and educational exposure of the largest sample that was included in this study. The majority of people with a Level 3 cognitive potential are however in Level 3 positions (rounded higher) and most of those with a Level 4 cognitive potential are in Level 3 and 4 positions (rounded higher).

Only 3% of this sample showed potential for Level 5 functioning whereas 36% showed potential for Level 4; 29% show capacity for Level 3; 26% for Level 2; and 3% for Level 1. This is not reflective of the SST level distributions of the normal work population, but more an indication of the samples that were selected for this study – which included a large managerial and executive component.

Table 89: Study 21: Sample 1 - using CCM Rounded Higher Level of Work

Summary Frequency Table: Sample 1 Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Higher LOW	CPP Potential LOW 2	CPP Potential LOW 3	CPP Potential LOW 4	CPP Potential LOW 5	Row Totals
3	1	11	3	0	15
4	1	6	10	4	21
All Grps	2	17	13	4	36

Gamma correlation = **0.71, % classification accuracy = 58%**

A fair degree of overlap between the CPP levels (potential) of people and the CCM levels of positions (rounded higher) were found for this sample – although most positions reflected only levels 3 and 4 complexity.

Table 90: Study 21: Sample 2 - using CCM Rounded Higher Level of Work

Summary Frequency Table: Sample 2 Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Higher LOW	CPP Potential LOW 2	CPP Potential LOW 3	CPP Potential LOW 4	CPP Potential LOW 5	Row Totals
2	2	0	0	0	2
3	30	54	55	2	141
4	1	13	36	8	58
5	0	0	1	0	1
All Grps	33	67	92	10	202

Gamma correlation = **0.68, % classification accuracy = 46%**

In this organisation, most managerial and executive roles are of a Level 3 nature. A fair degree of overlap between the CPP profiles (potential) of people and the CCM levels of jobs (rounded higher) were found.

Table 91: Study 21: Sample 3 - using CCM Rounded Higher Level of Work

Summary Frequency Table: Sample 3 Marked cells have counts > 10 (Marginal summaries are not marked)					
CCM Rounded Higher LOW	CPP Potential LOW 1	CPP Potential LOW 2	CPP Potential LOW 3	CPP Potential LOW 4	Row Totals
2	0	1	0	0	1
3	1	34	41	59	135
4	0	1	3	45	49
All Grps	1	36	44	104	185

Gamma correlation = **0.68, % classification accuracy = 47%**

In this organisation too, most managerial and executive roles were categorised at a Level 3 (rounded higher). A fair degree of overlap between the CPP profiles (potential) of people and the CCM levels of jobs (rounded higher) were found.

Table 92: Study 21: Sample 4 - using CCM Rounded Higher Level of Work

Summary Frequency Table: Sample 4 Marked cells have counts > 10 (Marginal summaries are not marked)						
CCM Rounded Higher LOW	CPP Potential LOW 1	CPP Potential LOW 2	CPP Potential LOW 3	CPP Potential LOW 4	CPP Potential LOW 5	Row Totals
1	36	172	119	89	9	425
2	6	47	62	78	9	202
3	0	15	33	34	9	91
4	0	1	4	9	2	16
All Grps	42	235	218	210	29	734

Gamma correlation = **0.42, % classification accuracy = 17%**

No rounding off of CCM levels were required for this sample as a four-category job classification applied.

Conclusion

It was found that in the managerial and executive roles of the samples from the mining and manufacturing industries, which primarily represented SST Level 3 and Level 3 for 4 complexity, the job-incumbents largely showed current capability for SST Level 2, 3 and 4 and potential for Levels 3 and 4 as measured by the CPP.

In the Retail sector where both operational and managerial positions were analysed, the work primarily entailed SST Level 1 and 2 operational involvement and the job incumbents mostly obtained Level 1 and 2 with potential for Level 3 complexity on the CPP. The gamma correlations between CPP and CCM levels ranged from .42 to .98 and the classification accuracy mostly from 35% to 50%.

The majority of job incumbents who showed operational inclinations were thus employed in operational roles, whereas the majority of those who showed strategic orientations, were involved in strategic roles.

It should, however, be kept in mind that a large proportion of the employees in the samples analysed were not necessarily employed at the most suitable levels of complexity due to age- and experience-related, socio-political and educational factors. Selection and placement practices in general are also not necessarily ideal.

This study thus indicates a significant overlap between the SST job levels of positions and the CPP levels of job incumbents – especially at managerial and executive levels.

4.3.5 Study 22: CPP Attributes and University Degree Performance

Table 93: Study 22 Details: CPP attributes and Degree Performance

Study 22: CPP vs Degree Performance	
Date:	1998
Authored by:	Farquharson
Sample Size:	59
Age:	No information available
Gender:	51 men, 8 women
Ethnicity:	Black South Africans
Language Groups:	Several South African dialects but all English-speaking
Education:	First year university students
Source:	Engineering students from disadvantaged educational and socio-economic backgrounds in South Africa

In this study, academic achievement was correlated with three "cognitive" assessments, namely: The Cognitive Process Profile (CPP), the Neethling Brain Profile Instrument (reflecting one of four "brain quadrant" preferences as based on the work of Ned Hermann) and the Figure Classification Test. Three knowledge tests were also applied, namely the English language, Maths and Science tests. The students were, however, selected based on language proficiency. Personality test results based on the 16PF were also included. School performance was indicated by the matric results of the final exam after 12 years of schooling. The results of each of these tests were correlated with the first-year academic performances of the students in the sample.

Table 94: Study 22: CPP Information Processing Competencies and First Year Pass Rate

CPP attribute	Pearson r
Exploration: Discrimination between relevant and irrelevant info	.51
Analysis: Differentiation between subcomponents	.54
Analysis: Detail and precision	.47
Analysis: Systematic identification of relationships	.47
Logical reasoning: Following through of rule based processes	.48
Learning: cognitive modifiability	.48
Metacognition: managing complexity	.61
Impulsivity	-.56

Note: correlations equal to or greater than 0.42 are significant at $p < 0.001$, two-tail

Table 95: Study 22: Other assessments and First Year Pass Rate

CPP attribute	Pearson r
Maths Knowledge Test	.39
Science Knowledge Test	.49
Figure Classification Test	.28

Note: correlations equal to or greater than 0.28 are significant at $p < 0.05$, two-tail

The results of the customised Mathematics and Science tests, designed according to first year course-related knowledge requirements, significantly correlated with first year academic performance: for Science ($r = 0.49$) and Maths ($r = 0.39$) This finding was expected as academic first year performance in engineering reflect exactly that – Maths and Science knowledge and skills. It is interesting to note that secondary school achievements, however, did not significantly correlate with first year academic performance. Neither was there any significant correlation between personality functioning and first year academic performance. Nor any statistically significant correlation between the results of the Neethling Brain Profile and the students' academic achievements. Although the Figure Classification Test scores correlated positively with academic performance ($r = 0.28$; $p = 0.03$), the relationship between the two variables seems weak.

The CPP dimensions of "Learning", "Logical reasoning", "Exploration", "Analysis", "Structuring" and "Integration" all correlated with first year pass rate. The score on the CPP's "strategies to manage complexity - Metacognition" showed the highest correlations with their academic performance ($r = 0.61$). It can be hypothesised that the students who performed poorly, experienced difficulty in managing the volume of work at university. In other words, they experienced difficulty in identifying core issues, and summarising and representing information.

This study points to the value of the CPP as an indication of learning potential within the context of higher education. It also indicates the crucial importance for first year or bridging students to specifically be exposed to training in metacognitive skills and methods of structuring and representing subject matter. The "how" of learning is unfortunately rarely addressed at secondary and tertiary educational levels.

Study 23: Structural Equation Modelling: Goodness of Fit RMSEA to population GFI Index calculations

The original modelling work was conducted as part of the PhD thesis research of Dr. Prinsloo (1992)[2]. For purposes of investigating the theoretical model, study tasks were analysed in terms of the required processing activities and types of task material. Test items were devised to test primarily for single processing constructs. The test tasks were complex, abstract and fairly unfamiliar. The use of unfamiliar reasoning material minimises reliance on "automatized" processing activities and thus minimises the biasing effect of previous exposure.

"Automatized" elements were, however, incorporated in the construction of the test items. This was to isolate specific processing requirements while reducing the effects of other processing activities. Task complexity was also capitalised on because, according to Larson, Merritt & Williams (1988), simple tasks are generally poorer estimates of "intelligence" than complex tasks. The type of task material was also controlled. Items with symbolic, verbal and numerical content were constructed as they are regarded in the literature as distinct areas identified in factor analytic studies.

For the purpose of theory testing, fifteen psychometric tests were constructed, each of which tested unique combinations of the three methods (symbolic, verbal and numerical) and five traits (focusing, linking, structuring, transformation and memory). The tests items were based on task analysis and are unlike existing psychometric tests. No time limits were set for the completion of the items.

The confirmatory analysis was based on standardised scores contained in a correlation matrix rather than in a variance-covariance matrix. Structural equation modelling in the form of the RAMONA and MUTMUM, as based on the LISREL V programme (Jöreskog & Sörbom, 1981c) programs were applied. 15 models, some nested versions of other models were fitted and compared to one another.

The final accepted model possessed an RMSEA of 0.046, with a population discrepancy function of 0.135, a χ^2 of 80.70 with 65 degrees of freedom (df), and p = .091 n.s. The model would be considered as fitting the data given the non-significant chi-square and with an approximate fit index (the RMSEA) of < 0.05.

However, in order to express the results in a form indexing the magnitude of goodness of fit, based upon the fundamental discrepancy function computed from the model-implied population and observed input matrices, we used the derivation of Steiger's gamma index from the population noncentrality index as the population equivalent to Joreskog's sample-based Goodness of Fit Index (the GFI). The population GFI is estimated as (taken from the Statistica SEPATH technical manual):

[2] Prinsloo, M.S.(1992). A theoretical model and empirical technique for the study of problem solving processes. PhD thesis. RAU. Johannesburg.

Noncentrality-Based Indices of Fit - Population *Gamma* Index

Tanaka and Huba (1985, 1989) have provided a general framework for conceptualizing certain fit indices in covariance structure analysis. In their first paper, Tanaka and Huba (1985, their Equation 19) gave a general form for the *sample* fit index for covariance structure models under arbitrary generalized least squares estimation.

In the Tanaka-Huba treatment, it is assumed that a covariance structure model has been fit by minimizing an arbitrary GLS discrepancy function of the form

$$F\left(\mathbf{S}, \boldsymbol{\Sigma}(\boldsymbol{\theta})\middle|\mathbf{V}\right) = \tfrac{1}{2}\mathrm{Tr}\left[\left(\mathbf{S} - \boldsymbol{\Sigma}(\boldsymbol{\theta})\right)\mathbf{V}\right]^2 \quad (93)$$

or, equivalently (see Browne, 1974)

$$F\left(\mathbf{s}, \boldsymbol{\sigma}\middle|\mathbf{W}\right) = \left(\mathbf{s} - \boldsymbol{\sigma}\right)' \mathbf{W}\left(\mathbf{s} - \boldsymbol{\sigma}\right) \quad (94)$$

where $\mathbf{s} = \mathrm{vecs}(\mathbf{S})$, and $\mathbf{s} = \mathrm{vecs}(\mathbf{S}(\mathbf{q}))$. **V** in Equation 93 and **W** in Equation 94 are arbitrary matrices. Appropriate choice of **V** or **W** can yield GLS or IRGLS estimators. For example, minimization of Equation 93 with $\mathbf{V} = \mathbf{S}^{-1}$ if **S** has a Wishart distribution yields the well-known GLS estimators (Browne, 1974). Setting $\mathbf{V}=[\boldsymbol{\Sigma}(\boldsymbol{\theta})]^{-1}$ yields IRGLS estimators. Bentler (1989, page 216), citing Lee & Jennrich, 1979, states that IRGLS estimators are equivalent to ML estimators. Setting

$$\mathbf{V} = \left[\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{ML}\right)\right]^{-1} \quad (95)$$

yields a discrepancy function which, according to Browne (1974), is usually minimized by the same **q** that minimizes the maximum likelihood discrepancy function.

The Tanaka-Huba fit index can be written as

$$\gamma = 1 - \left[\boldsymbol{\varepsilon}'\mathbf{W}\boldsymbol{\varepsilon}/\mathbf{s}'\mathbf{W}\mathbf{s}\right] \quad (96)$$

In their more recent paper, Tanaka and Huba (1989) demonstrate a deceptively simple but important result that holds for models that are invariant under a constant scaling function (ICSF). A covariance structure model is ICSF if multiplication of any covariance matrix that fits the model by a positive scalar yields another covariance matrix which also satisfies the model exactly (though possibly with different free parameter values).

If a model which is ICSF has been estimated by minimizing a discrepancy function of the form given in Equations 93 and 94, then

$$\mathbf{e}'\,\mathbf{W}\mathbf{s} = 0 \quad (97)$$

i.e., **e** and **s** are orthogonal "in the metric of **W**," and, consequently,

$$\mathbf{s}'\,\mathbf{W}\mathbf{s} = \mathbf{s}'\,\mathbf{W}\mathbf{s} + \mathbf{e}'\,\mathbf{W}\mathbf{e} \quad (98)$$

If Equation 98 holds, then *g* may be written

$$g = \mathbf{s}'\,\mathbf{W}\mathbf{s}/\mathbf{s}'\,\mathbf{W}\mathbf{s} = 1 - \mathbf{e}'\,\mathbf{W}\mathbf{e}/\mathbf{s}'\,\mathbf{W}\mathbf{s} \quad (99)$$

where, as in Equation 64, $\boldsymbol{\varepsilon} = \mathbf{s} - \boldsymbol{\sigma}$. In this form, *g* defines a weighted coefficient of determination.

Under the conditions of Equation 98, with maximum likelihood estimation, we immediately obtain:

$$F\left(\mathbf{S}, \boldsymbol{\Sigma}(\boldsymbol{\theta})\middle|\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{\mathrm{ML}}\right)\right) = \boldsymbol{\varepsilon}'\mathbf{W}\boldsymbol{\varepsilon}$$

$$= \tfrac{1}{2}\mathrm{Tr}\left[\left(\mathbf{S} - \boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{\mathrm{ML}}\right)\right)\left\{\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{\mathrm{ML}}\right)\right\}^{-1}\right]^2 \quad (100)$$

$$\mathbf{s}'\mathbf{W}\mathbf{s} = \tfrac{1}{2}\mathrm{Tr}\left[\mathbf{S}\left\{\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{\mathrm{ML}}\right)\right\}^{-1}\right]^2 \quad (101)$$

whence

$$\gamma_{ML} = 1 - \left\{ \frac{\mathrm{Tr}\left[\mathbf{S}\left\{\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{ML}\right)\right\}^{-1} - \mathbf{I} \right]^2}{\mathrm{Tr}\left[\mathbf{S}\left\{\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{ML}\right)\right\}^{-1} \right]^2} \right\} \quad (102)$$

which is equivalent to the Jöreskog and Sörbom (1984) GFI index.

Moreover, if the model is ICSF, then, under maximum Wishart likelihood estimation, there is the simplifying result (Browne, 1974, Proposition 8)

$$\mathrm{Tr}\left[\mathbf{S}\left\{\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{ML}\right)\right\}^{-1} \right] = p \quad (103)$$

Substituting in Equation 100, we find:

$$F\left(\mathbf{S}, \Sigma(\boldsymbol{\theta}) \middle| \boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{ML}\right)\right) =$$

$$\frac{1}{2}\left(\mathrm{Tr}\left[\mathbf{S}\left\{\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{ML}\right)\right\}^{-1} \right]^2 - p \right) \quad (104)$$

and so

$$\gamma_{ML} = \frac{p}{2s'\mathbf{W}s} = \frac{p}{\mathrm{Tr}\left[\mathbf{S}\left\{\boldsymbol{\Sigma}\left(\hat{\boldsymbol{\theta}}_{ML}\right)\right\}^{-1} \right]^2} \quad (105)$$

Tanaka and Huba (1985, 1989) based their derivation of *g* on sample quantities. However, in principle, we are interested in a sample index primarily as a vehicle for estimating the corresponding *population* index. The corresponding population quantities are obtained by substituting $\boldsymbol{\Sigma}$ for $\mathbf{S}$, and $\boldsymbol{\Sigma}(\boldsymbol{\theta})$ for $\boldsymbol{\Sigma}(\boldsymbol{\theta}_{ML})$ in Equations 104 and 105.

We obtain:

$$\Gamma_1 = \frac{p}{\mathrm{Tr}\left[\boldsymbol{\Sigma}\left\{\boldsymbol{\Sigma}(\boldsymbol{\theta})\right\}^{-1} \right]^2} \quad (106)$$

Γ_1 can be thought of as a *weighted population coefficient of determination for the multivariate (ICSF) model*. (It may also be thought of as the population equivalent of the Jöreskog-Sörbom GFI index.)

An accurate point estimate for G_1 will provide useful information about the extent to which a model reproduces the information in $\mathbf{S}$. A confidence interval, however, provides even more useful information, because it conveys not only the size of G_1, but also the precision of our estimate.

Let F* be the Population Noncentrality Index $F(\boldsymbol{\Sigma}, \boldsymbol{\Sigma}(\boldsymbol{\theta}_{ML}))$. From Equations 104 and 105, it is easy to see that

$$\Gamma_1 = \frac{p}{2F^* + p} \quad (107)$$

Equation 107 demonstrates that, under maximum likelihood estimation with ICSF models, G_1 can be expressed solely as a function of the Population Noncentrality Index and *p*, the number of manifest variables. Any consistent estimate of F* will yield a consistent estimate of G_1 when substituted in Equation 107.

Given the Population Noncentrality Index (**PNI**) is used in the computation of the RMSEA:

Noncentrality-Based Indices of Fit - Steiger-Lind RMSEA Index

The Population Noncentrality Index F^* (PNI) offers some significant virtues as a measure of badness-of-fit (see, e.g., Steiger & Lind, 1980; McDonald, 1989). First, it is a weighted sum of discrepancies. Second, unlike the Akaike information criterion, for example, it is relatively unaffected by sample size.

However, there are two obvious problems with using the population noncentrality index as an index of population badness-of-fit.

The PNI is not in the metric of the original standardized parameters, because the quadratic form squares the weighted residuals.

The PNI fails to compensate for model complexity. In general, for a given **S**, the more complex the model the better it fits. A method for assessing population fit which fails to compensate for this will inevitably lead to choosing the most complex models, even when much simpler models fit the data nearly as well. The PNI fails to compensate for the size or complexity of a model. Hence it has limited utility as a device for comparing models.

The RMS index, first proposed by Steiger and Lind (1980), takes a relatively simplistic (but not altogether unreasonable) approach to solving these problems. Since model complexity is reflected directly in the number of free parameters, and inversely in the number of degrees of freedom, the PNI is divided by degrees of freedom, then the square root is taken to return the index to the same metric as the original standardized parameters.

Hence

$$R^* = \sqrt{\frac{F^*}{v}} \quad (90)$$

The RMS index R^* can be thought of roughly as a root mean square standardized residual. Values above .10 indicate an inadequate fit, values below .05 a very good fit. Point estimates below .01 indicate an outstanding fit, and are seldom obtained.

So, by a little rearrangement of the above equation, it is possible to compute the PNI for the RAMONA model, and in turn the population gamma index as the equivalent of the *population* Goodness of Fit Index (GFI), where perfect fit is a GFI (or AGFI) of 1.0. The **A**GFI is the GFI conservatively Adjusted for the model's degrees of freedom relative to the number of observed variables.

$$RMSEA = \sqrt{\left(\frac{F'}{v}\right)} \xrightarrow{solve,F'} RMSEA^2 \cdot v$$

Given: $RMSEA := .046$

degrees of freedom = $v := 65$

no. of manifest variables = $p := 15$

then ...

$F' := RMSEA^2 \cdot v = 0.138$ the Population Noncentrality Index (PNI)

$\Gamma_1 := \frac{p}{2 \cdot F' + p} = 0.982$ which is equivalent to the population GFI

$\Gamma_{adj} := 1 - \left(\frac{\left(\frac{p \cdot (p+1)}{2}\right)}{v} \cdot (1 - \Gamma_1)\right) = 0.967$ adjusted population gamma; equivalent to the AGFI