Cognadev Technical Report Series

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CPP Information Processing Competency Trends as a function of Levels of Education and Age

This investigation examines the variation in scores on the 14 CPP Information processing competencies (IPCs) as a function of various current employment categories, age at CPP completion, and highest attained educational level, using a sample of the most recently acquired 60,572 cases of CPP data,

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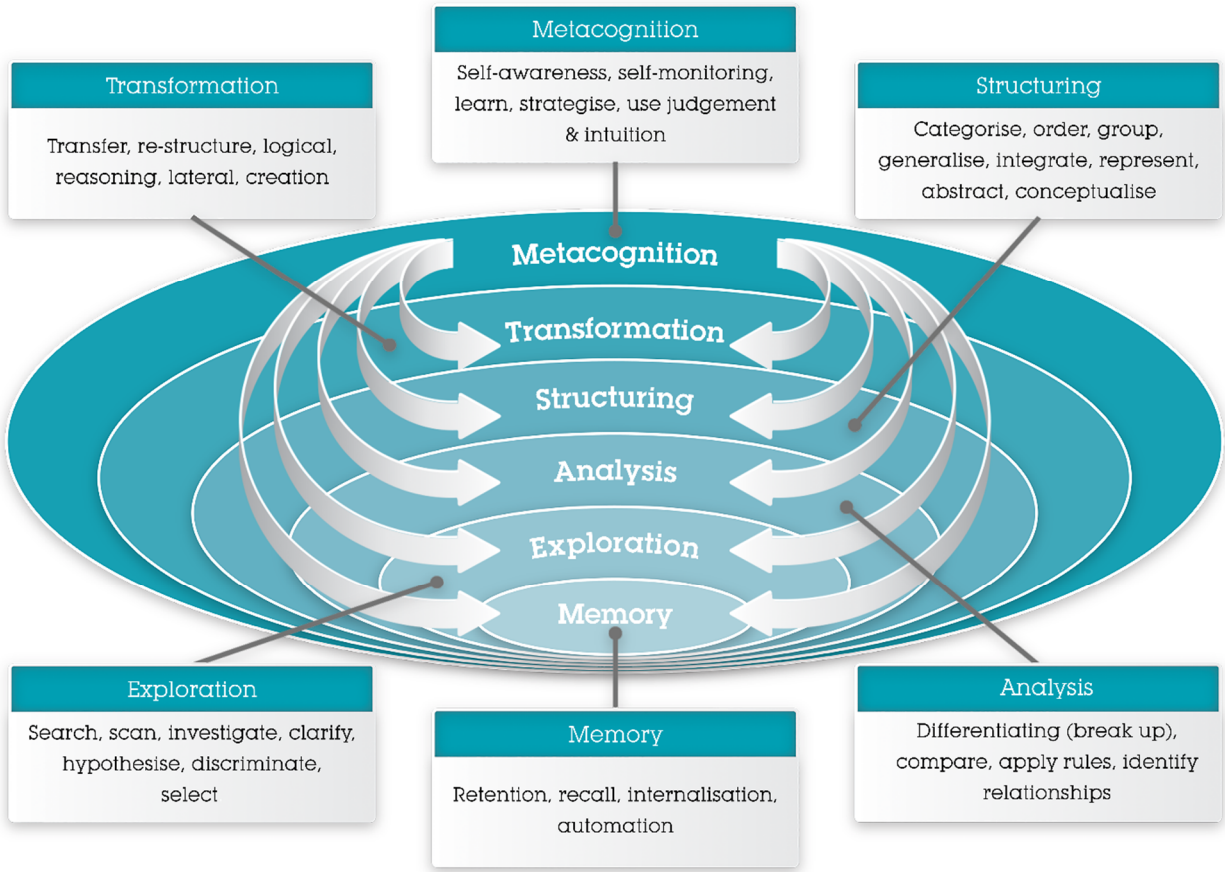
1. The Cognitive Process Profile (CPP) assessment

The CPP measures a person's cognitive preferences and capabilities by means of a simulation exercise which was designed to externalise and track thinking processes according to thousands of measurement points. The results are analysed by an expert system and automated reports are generated. The CPP primarily measures the following constructs: information processing competencies, cognitive styles, units of information, learning potential, a suitable working environment, as well as cognitive strengths and development areas.

1.1 The theoretical model of thinking processes

The CPP is based on a self-contained theoretical model of thinking processes. The Cognadev Information Processing model is holonically organised in that the various thinking processes are represented as a "soft hierarchy" of increasingly complex and inclusive operations. A *holon* refers to a system which consists of various subsystems, each of which incorporates and transcends underlying subsystems. The thinking processes incorporated in the CPP model can be regarded as functional information processing categories. The theoretical model of thinking processes on which the CPP is based, can be depicted graphically, as shown in Figure 1.

Figure 1: Cognadev Information Processing model: The holonic structure of the model



1.1.1 Information processing constructs

Each of these information processing constructs consists of a number of sub-constructs, all of which are guided by the application of metacognitive criteria. For example, the processing construct of Exploration consists of sub-processes including scanning, searching, focusing, hypothesising, investigating, discriminating, selecting and eliminating information. The metacognitive criteria that guide exploration activities are those of clarity, relevance and depth. A high score on the information processing construct of Exploration, indicates the effectiveness by which a person investigates unfamiliar information.

Not all the information processing constructs measured, indicate effectiveness in thinking, though. Some processes such as Quick closure and Assumptions amongst others, may actually indicate ineffective thinking strategies or an absence of metacognitive awareness.
The various metacognitive criteria responsible for the effective application of each of the processes are shown below in Figure 2.

Figure 2: Cognadev Information Processing model: The metacognitive criteria that guide thinking processes

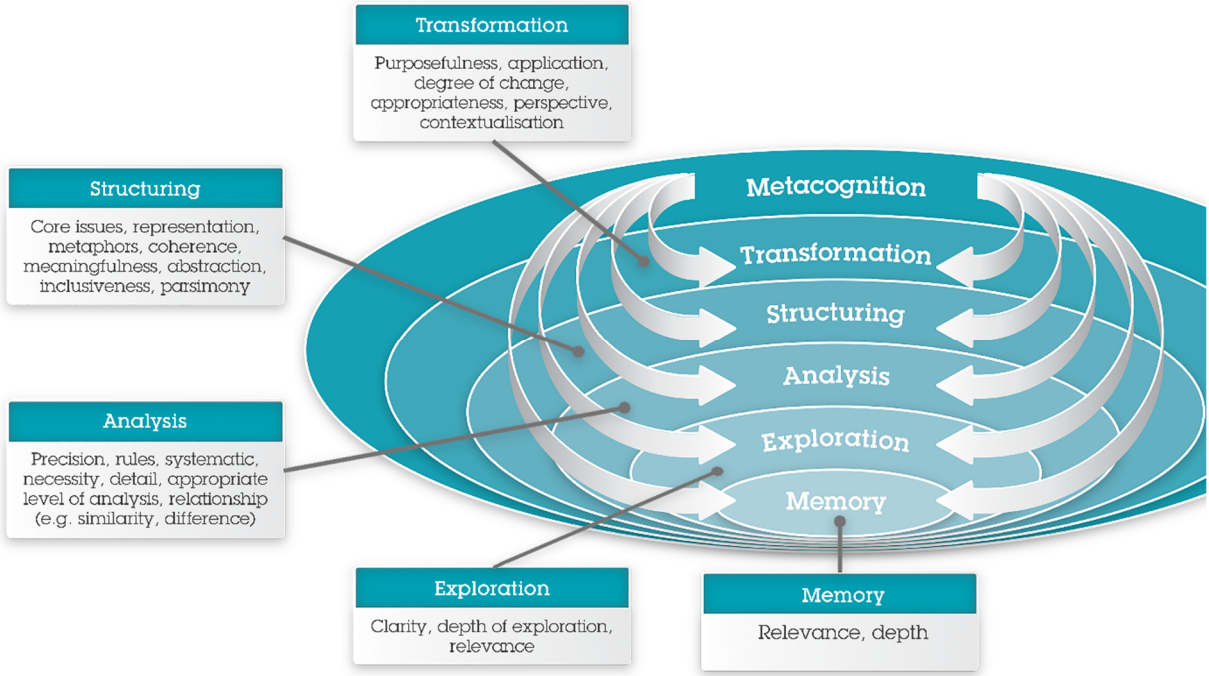


Table 1 lists the competencies and their descriptions.

Table 1: The Information Processing Competencies assessed within the CPP

Competency	Description
Use of memory	Reliance on memory
Memory strategies	Effectiveness of memory strategies
Pragmatic	Practical orientation (clarification of tangible information)
Exploration	The effectiveness, depth and width of exploration
Analysis	Working in a detailed and systematic manner to subdivide information and determine interrelationships between elements
Rules	A focus on rules
Categorisation	Creating external order, categories and reminders
Integration	Synthesis of ambiguous / discrepant / fragmented information
Complexity	The preferred level of complexity and unit of information
Logical reasoning	The disciplined, logical deployment and following through of reasoning processes
Verbal conceptualisation	Unusual / flowery / creative and / or abstract verbalisation and conceptualisation
Judgement	Capitalising on intuitive insights to clarify unstructured and vague information
Quick insight learning	Grasping new concepts and acquiring knowledge and understanding relatively quickly
Gradual improvement learning	A preference for practical or experiential learning

The CPP estimates the magnitude of these competencies as integers varying between 0 and 100; these are actually T-scores assigned to a raw competency score using the general CPP norm-based lookup-table.

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2. The Study

In this investigation, we look at how the scores on the 14 Information processing competencies (IPCs) which are graphically represented in the CPP reports vary over various current employment categories, as a function of age at CPP completion, and highest attained educational level. It should be noted that while the graphs reveal average trends and tendencies, a wide distribution of scores can be found within each demographic category.

2.1 Sample Information and Graphics

The dataset we used is a sample of the most recently acquired 60,572 cases of CPP data, where a subset of cases provided a current employment position which we subsequently coded into 9 categories. This was achieved using a computer rule-based coding scheme on a partial free-response field containing 195 unique entries, with 188 recode-rules subsequently generated, and 36,770 recodes implemented. Table 2 provides the frequencies in each category within the total sample.

Table 2: The frequencies of cases with a Current Employment Position

	Frequency table: Current Employment Position			
Category	Count	Cumulative Count	Percent	Cumulative Percent
Department / Unit Manager	11049	11049	21.00	21.00
Trainee	3244	14293	6.17	27.17
Administrative / Clerical	2550	16843	4.85	32.01
Specialist	8192	25035	15.57	47.58
Professional / Technical Consultant	9108	34143	17.31	64.89
General Manager / Senior Executive / Director	5913	40056	11.24	76.13
Managing Director / Chief Executive Officer	4110	44166	7.81	83.94
Divisional / Functional Head	4819	48985	9.16	93.10
Supervisor / Foreman	3630	52615	6.90	100.00

Some categories are not entirely discrete and are clearly broad in terms of the industry sectors represented by cases within a category. However, for the purposes of analysis, they might still be considered 'informative'.

Three levels of education were created from five fixed-response categories:

- 10-12 year of schooling.
- Diploma/Certificates
- A single degree, or multiple degrees, including postgraduate degrees

In these analyses, age is reported in years (nearest integer); computed from a respondent's date of birth and assessment completion date. Only cases between 20 and 70 are analysed.

We created 27 graphs, three for each current employment position category (one for each educational level), displaying LOWESS smoothed trend lines for all 14 IPCs. LOWESS (locally weighted scatterplot smoothing) is a robust non-parametric technique used to calculate the underlying trend within a 2-dimensional scatterplot. A local regression model is fit to each point and the points close to it. Rather than predefine a formal function fit (as say with linear or non-linear regression), the LOWESS process determines the trend function incrementally by calculating it over 'local' sequential clusters of data points across the range of the x-y pairs. The smoothness of the trend is controlled by a 'stiffness' parameter which allows the user to control the number of 'cluster' points used in each of the local regressions. By varying that parameter, the trend can be made more, or less sensitive, to local variations in data trends. The smoothed data provides a clearer picture of the overall shape of the relationship between the x and y variables. For all LOWESS figures below, we use a stiffness parameter of 0.25, which provides a smooth overall trend.

Figure 3: IPC T-Scores for Department/Unit Managers x 3 educational levels

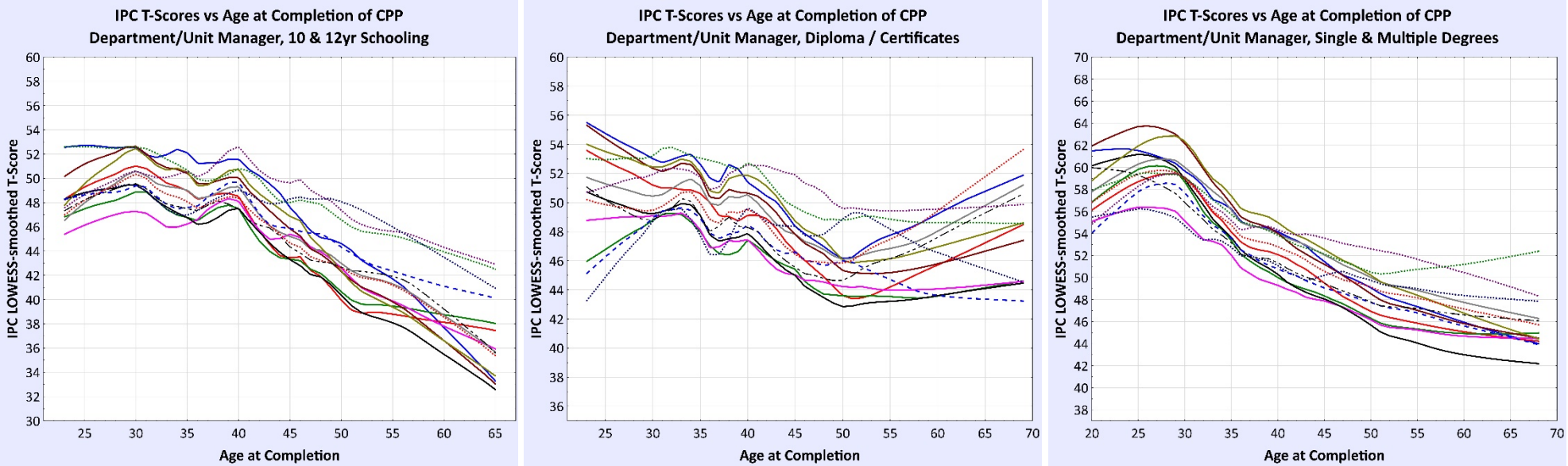


Table 3: Numbers of cases for Department/Unit Managers, filtered on Age and Educational Attainment

	Department/Unit Managers		
Variable	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	1376	2567	6621
Analytical	1376	2567	6621
Rule-Oriented	1376	2567	6621
Categorisation	1376	2567	6621
Quick Insight Learning	1376	2567	6621
Integration	1376	2567	6621
Complexity	1376	2567	6621
Logical Reasoning	1376	2567	6621
Verbal Conceptualisation	1376	2567	6621
Use of Memory	1376	2567	6621
Memory Strategies	1376	2567	6621
Exploration	1376	2567	6621
Gradual Improvement Learning	1376	2567	6621
Judgement	1376	2567	6621

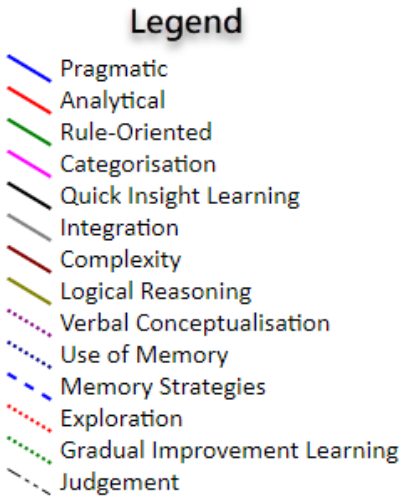


Figure 4: IPC T-Scores for Trainees x 3 educational levels

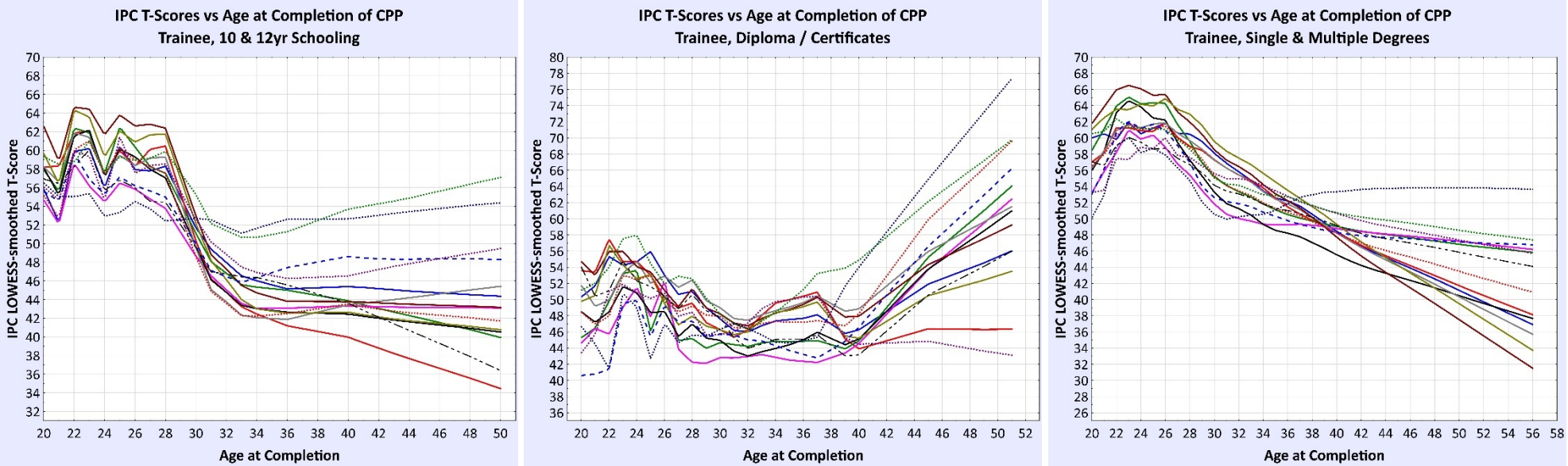


Table 4: Numbers of cases for Trainees, filtered on Age and Educational Attainment

Variable	Trainees		
	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	199	214	2692
Analytical	199	214	2692
Rule-Oriented	199	214	2692
Categorisation	199	214	2692
Quick Insight Learning	199	214	2692
Integration	199	214	2692
Complexity	199	214	2692
Logical Reasoning	199	214	2692
Verbal Conceptualisation	199	214	2692
Use of Memory	199	214	2692
Memory Strategies	199	214	2692
Exploration	199	214	2692
Gradual Improvement Learning	199	214	2692
Judgement	199	214	2692

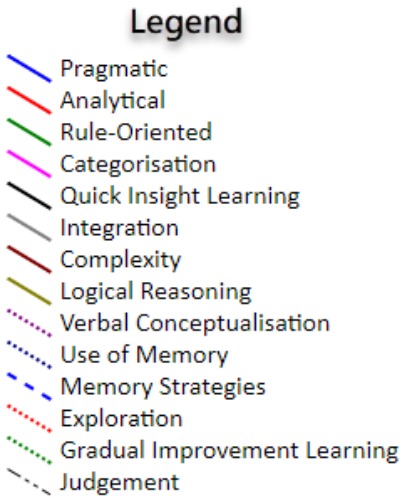


Figure 5: IPC T-Scores for Administrative/Clerical Positions x 3 educational levels

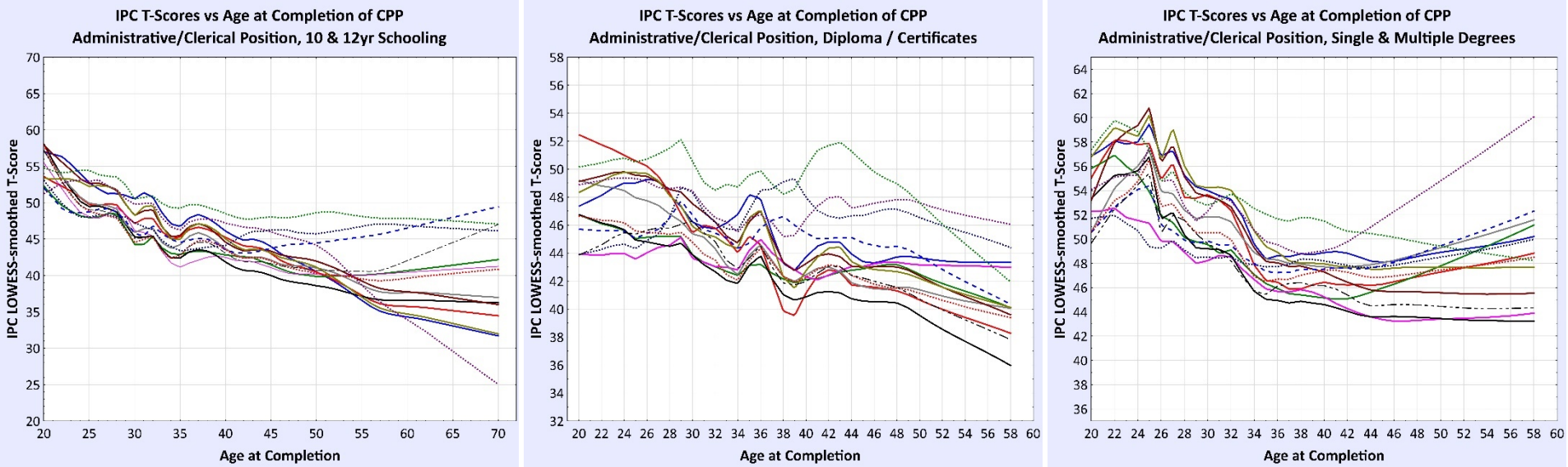


Table 5: Numbers of cases for Administrative/Clerical Positions, filtered on Age and Educational Attainment

	Administrative/Clerical Positions		
Variable	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	702	884	871
Analytical	702	884	871
Rule-Oriented	702	884	871
Categorisation	702	884	871
Quick Insight Learning	702	884	871
Integration	702	884	871
Complexity	702	884	871
Logical Reasoning	702	884	871
Verbal Conceptualisation	702	884	871
Use of Memory	702	884	871
Memory Strategies	702	884	871
Exploration	702	884	871
Gradual Improvement Learning	702	884	871
Judgement	702	884	871

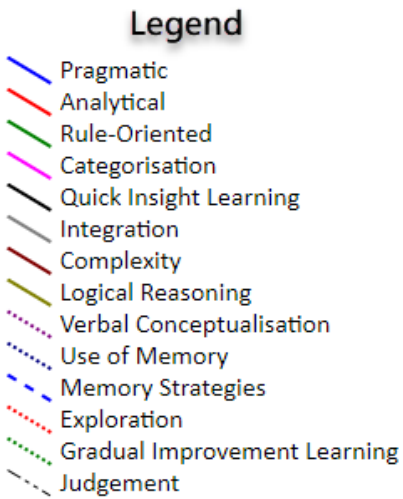


Figure 6: IPC T-Scores for Specialists x 3 educational levels

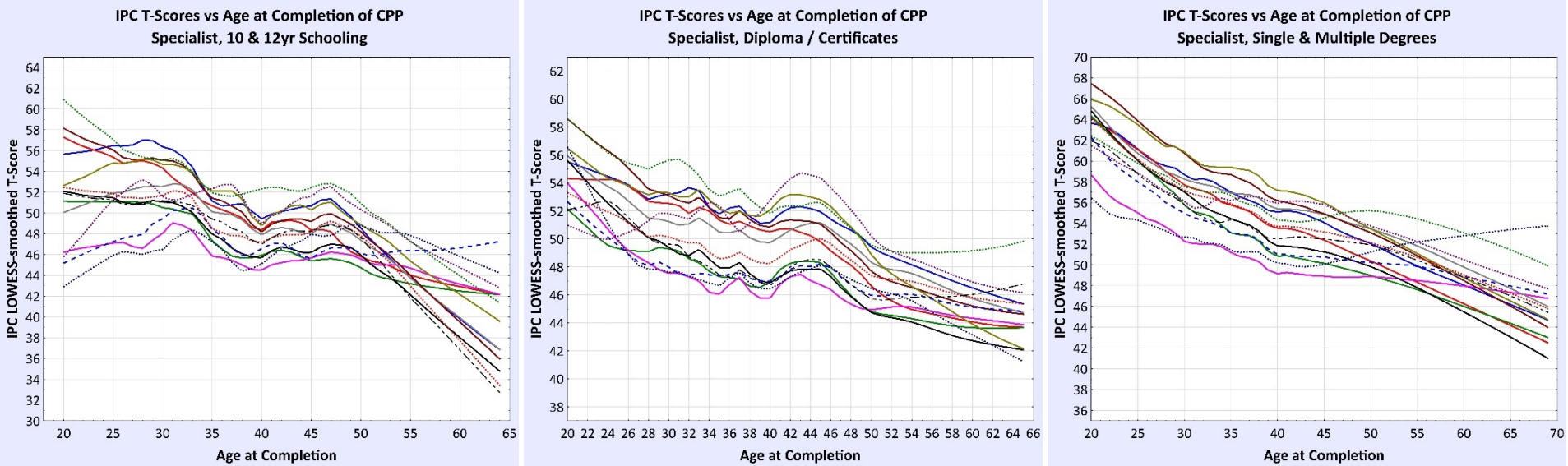


Table 6: Numbers of cases for Specialists, filtered on Age and Educational Attainment

Variable	Specialists		
	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	844	2045	5033
Analytical	844	2045	5033
Rule-Oriented	844	2045	5033
Categorisation	844	2045	5033
Quick Insight Learning	844	2045	5033
Integration	844	2045	5033
Complexity	844	2045	5033
Logical Reasoning	844	2045	5033
Verbal Conceptualisation	844	2045	5033
Use of Memory	844	2045	5033
Memory Strategies	844	2045	5033
Exploration	844	2045	5033
Gradual Improvement Learning	844	2045	5033
Judgement	844	2045	5033

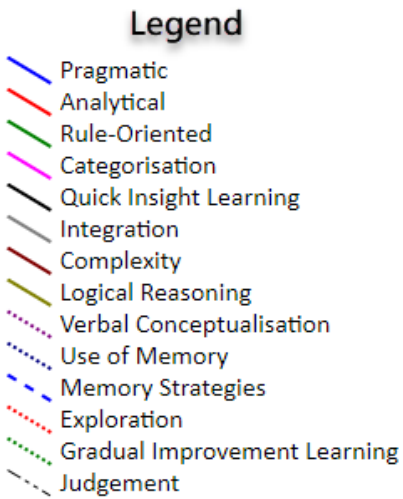


Figure 7: IPC T-Scores for Professional/Technical Consultants x 3 educational levels

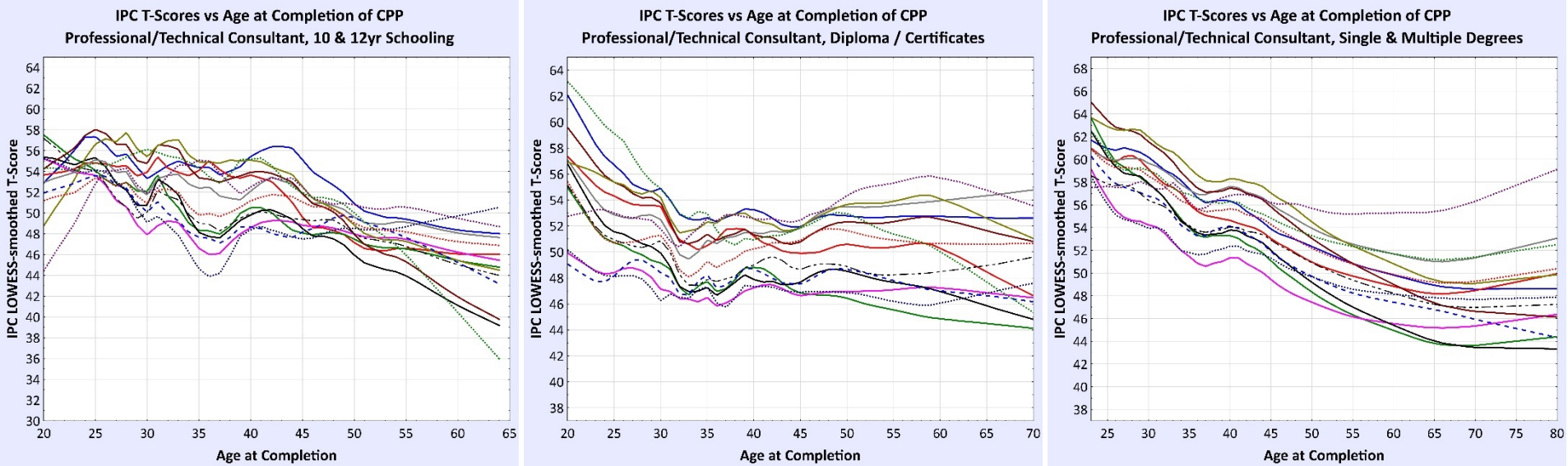


Table 7: Numbers of cases for Professional/Technical Consultants, filtered on Age and Educational Attainment

Variable	Professional/Technical Consultants		
	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	490	1665	6664
Analytical	490	1665	6664
Rule-Oriented	490	1665	6664
Categorisation	490	1665	6664
Quick Insight Learning	490	1665	6664
Integration	490	1665	6664
Complexity	490	1665	6664
Logical Reasoning	490	1665	6664
Verbal Conceptualisation	490	1665	6664
Use of Memory	490	1665	6664
Memory Strategies	490	1665	6664
Exploration	490	1665	6664
Gradual Improvement Learning	490	1665	6664
Judgement	490	1665	6664

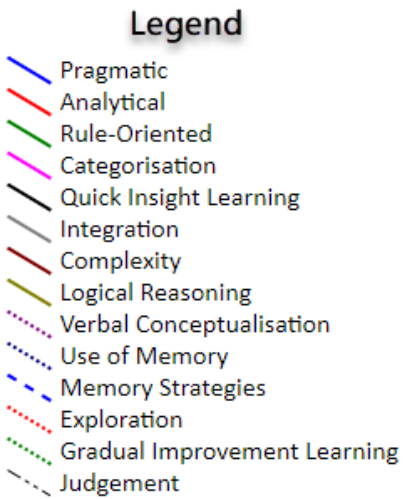


Figure 8: IPC T-Scores for General Managers/Senior Executives x 3 educational levels

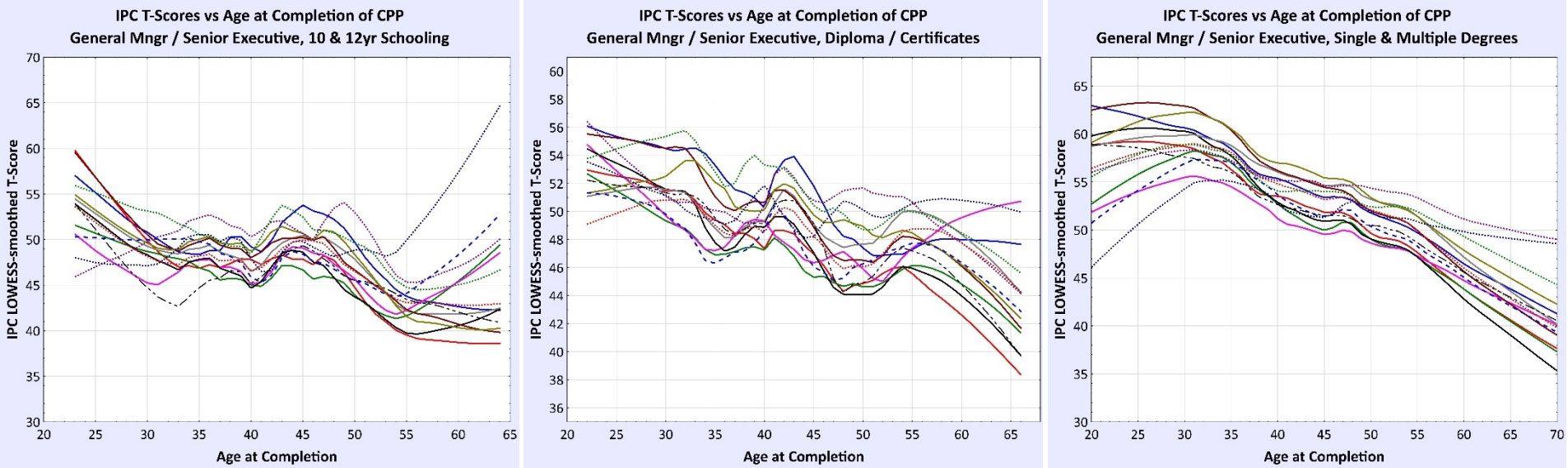


Table 8: Numbers of cases for General Managers/Senior Executives, filtered on Age and Educational Attainment

	General Managers/Senior Executives		
Variable	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	491	718	4379
Analytical	491	718	4379
Rule-Oriented	491	718	4379
Categorisation	491	718	4379
Quick Insight Learning	491	718	4379
Integration	491	718	4379
Complexity	491	718	4379
Logical Reasoning	491	718	4379
Verbal Conceptualisation	491	718	4379
Use of Memory	491	718	4379
Memory Strategies	491	718	4379
Exploration	491	718	4379
Gradual Improvement Learning	491	718	4379
Judgement	491	718	4379

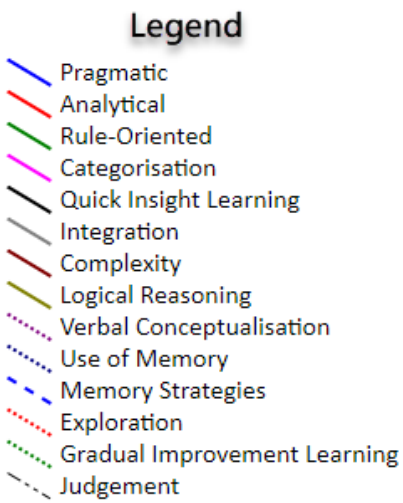


Figure 9: IPC T-Scores for Managing Directors/Chief Executive Officers x 3 educational levels

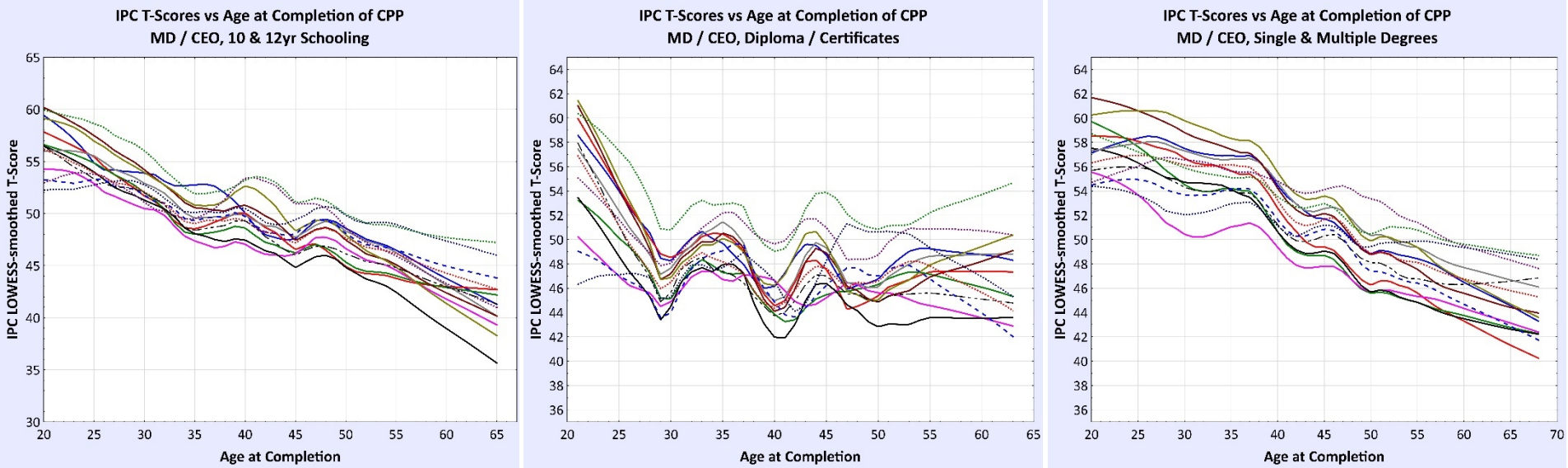


Table 9: Numbers of cases for Managing Directors/Chief Executive Officers, filtered on Age and Educational Attainment

Variable	Managing Directors/Chief Executive Officers		
	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	1054	468	2300
Analytical	1054	468	2300
Rule-Oriented	1054	468	2300
Categorisation	1054	468	2300
Quick Insight Learning	1054	468	2300
Integration	1054	468	2300
Complexity	1054	468	2300
Logical Reasoning	1054	468	2300
Verbal Conceptualisation	1054	468	2300
Use of Memory	1054	468	2300
Memory Strategies	1054	468	2300
Exploration	1054	468	2300
Gradual Improvement Learning	1054	468	2300
Judgement	1054	468	2300

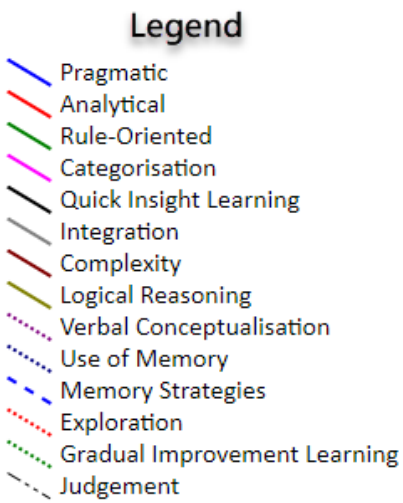


Figure 10: IPC T-Scores for Divisional/Functional Heads x 3 educational levels

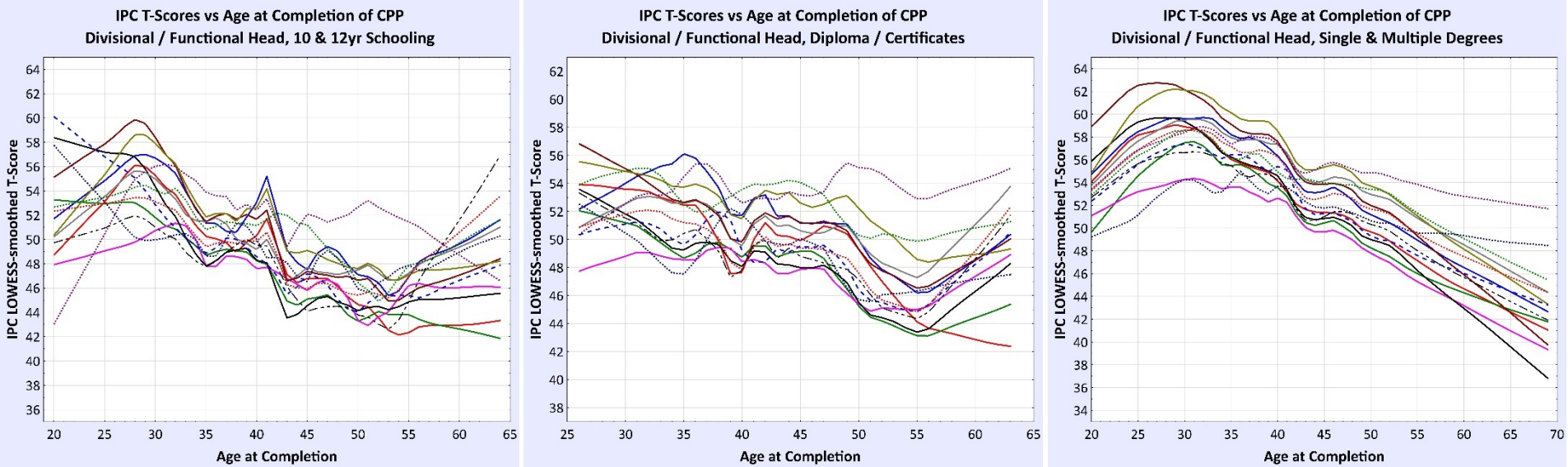


Table 10: Numbers of cases for Divisional/Functional Heads, filtered on Age and Educational Attainment

Variable	Divisional/Functional Heads		
	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	429	781	3382
Analytical	429	781	3382
Rule-Oriented	429	781	3382
Categorisation	429	781	3382
Quick Insight Learning	429	781	3382
Integration	429	781	3382
Complexity	429	781	3382
Logical Reasoning	429	781	3382
Verbal Conceptualisation	429	781	3382
Use of Memory	429	781	3382
Memory Strategies	429	781	3382
Exploration	429	781	3382
Gradual Improvement Learning	429	781	3382
Judgement	429	781	3382

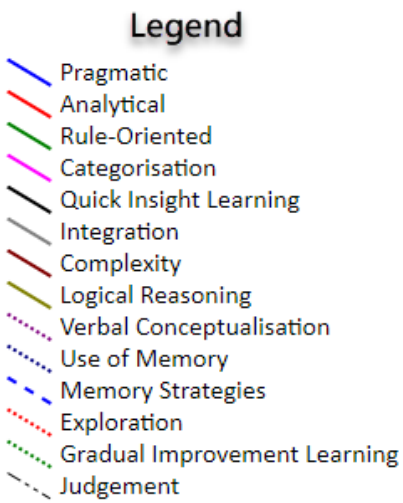


Figure 11: IPC T-Scores for Supervisor/Foreman x 3 educational levels

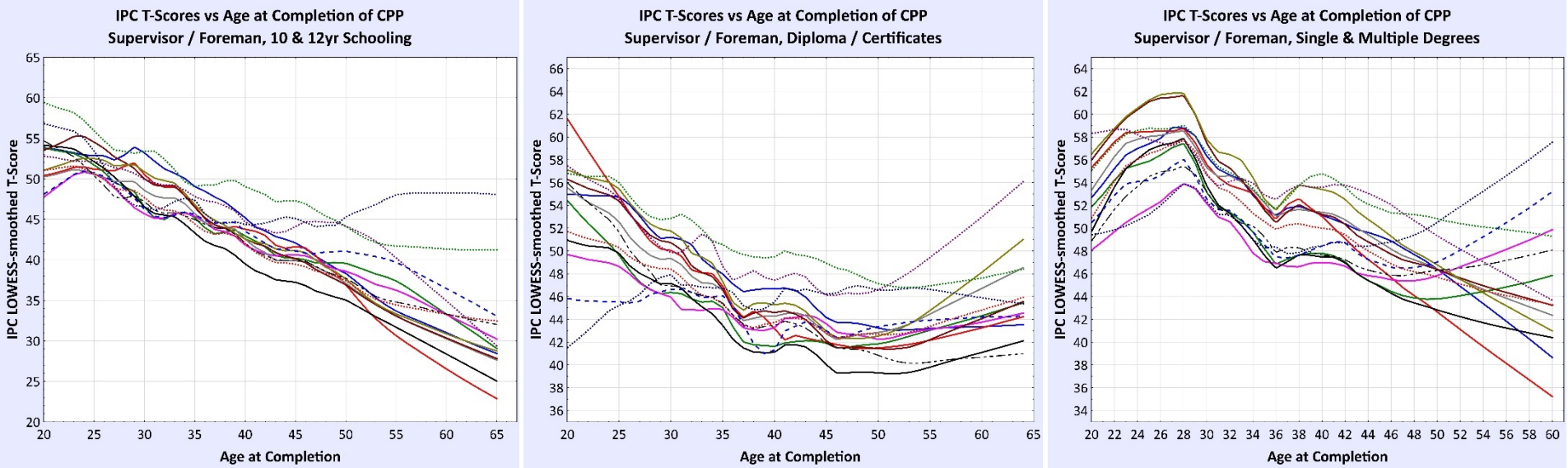
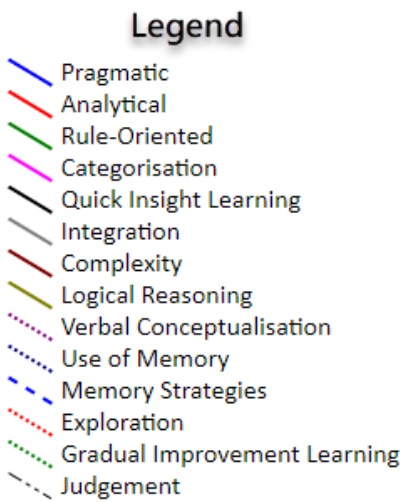


Table 11: Numbers of cases for Supervisor/Foreman, filtered on Age and Educational Attainment

Variable	Supervisor/Foreman		
	10-12yr schooling	Diploma/Certificates	Single & Multiple Degrees (incl. Postgraduate)
Pragmatic	692	1218	1556
Analytical	692	1218	1556
Rule-Oriented	692	1218	1556
Categorisation	692	1218	1556
Quick Insight Learning	692	1218	1556
Integration	692	1218	1556
Complexity	692	1218	1556
Logical Reasoning	692	1218	1556
Verbal Conceptualisation	692	1218	1556
Use of Memory	692	1218	1556
Memory Strategies	692	1218	1556
Exploration	692	1218	1556
Gradual Improvement Learning	692	1218	1556
Judgement	692	1218	1556



3. Some Observations

The age-related graphs for the various career and educational groups are briefly described below. These interpretations are based upon the LOWESS trend scores at each age.

Please note that while the graphs reveal average trends and tendencies, a wide distribution of scores can be found within each demographic category.

The possible impact of operational work (clerical and administrative roles) on the cognitive competence of the 10 – 12 year schooling versus the graduate groups, is first described in detail below.

This is followed by a brief summary of the information processing trends for the 10 – 12 year schooling, the diploma/certificate and the graduate samples, for various roles including supervisory, management, general management and executive roles.

3.1 Operational work (Clerical and Administrative roles)

3.1.1 For those with only a secondary school qualification (10 – 12 years schooling)

- At entry level (ages around 20) into operational roles, this group seems highly diverse / heterogeneous in terms of cognitive skills. Their reasons for employment in administrative and clerical roles may thus be situational (many with good cognitive potential may enter the work environment due to personal circumstances).

- During the ages of approximately 30 – 50, IPC scores which reflect suitability for SST Diagnostic (level 2) environments are shown – thereby indicating an appropriate level of processing which is well suited to the requirements of the work.

- Those with a 10 – 12 year schooling who find themselves in administrative and clerical roles do, however, over time, show improved or stable "Memory use", "Memory strategies", "Gradual Improvement learning" and "Judgement" scores in age groups over 50. This set of processing skills are required by Diagnostic environments which implies continuous practice at work.

- There seems to be a decline in the "Verbal conceptualisation", "Pragmatic/Exploration", "Logical reasoning", "Analytical", "Quick Insight learning" and "Integration" scores in the over 50's group with 10-12 years of schooling in administrative and clerical roles. It can possibly be understood in terms of the lower level requirements of operational environments with regards to analytical, logical, integrative and learning competencies. A lack of practice and application of these processing skills may thus contribute to their decline.

- It seems that candidates with 10 – 12 year schooling, who remain in operational roles for decades, show a significant decline in cognitive agility and logical-analytical as well as

integrative functioning - probably due to the lack of cognitive challenge posed by static and tangible operational environments.

The rapid age-related decline in the average IPCs of the 10 – 12 year schooling group in operational roles, thus probably indicate that those with higher level processing skills tend to:

- improve their educational qualifications with age and/or (thus no longer form part of the 10 – 12 year schooling category)
- tend to exit operational roles through promotion to supervisory and managerial roles.
- It may also indicate that operation roles fail to further contribute to the development of cognitive processing skills over time.

3.1.2 For those with a tertiary educational qualification (degree or multiple degrees)

- At entry level (ages around 20) into operational roles within the world of work, this group of graduates show less diverse cognitive skills than those with a 10 – 12 year schooling qualification.
- Overall, the cognitive skill levels of this group largely reflect a SST Diagnostic level (level 2) to Tactical Strategy level (level 3).
- Other than the 10-12 year schooling group, the graduates show a significantly improvement in terms of cognitive processing skills during their twenties. This may be related to the switch from educational to work demands and the cognitive challenge of applying educationally acquired knowledge. There seems to be a peak in cognitive effectiveness around their late twenties.
- Other than the 10-12 year schooling group, the graduates at 20 also achieved the highest average processing scores on “Gradual improvement learning”, “Pragmatic”, “Logical reasoning” and “Rule orientation”. These skills are all reflective of a Logical-analytical, yet somewhat operational orientation which differs from the somewhat strategic orientation of the diverse 10-12 year schooling group.
- During the ages of approximately 30 – 55, this group of graduates in operational roles, show IPC scores which reflect suitability for SST Diagnostic (level 2) environments, indicating an appropriate level of processing.
- Graduates in administrative and clerical roles do, however, over time, show improved or stable IPC scores on “Verbal conceptualisation”. In other words, as opposed to those with a 10 - 12 year schooling, the graduates show a tendency to rely on creative conceptualisation and verbalisation. The opposite seems to characterise non-graduates who showed a decline in terms of “Verbal conceptualisation”.

- For the graduate group there seems to be a steady decline in terms of "Quick Insight Learning", "Judgement", "Categorisation" and "Complexity" scores over time. The nature of familiar and structured operational environments seldom presents these processing challenges, resulting in a lack of practice of those skills.

- It seems that graduates who remain in operational roles for decades, show a significant decline in cognitive agility - probably due to the lack of cognitive challenge posed by static and tangible operational environments.

The rapid age-related decline in the average IPCs of the graduates in operational roles after the age of 30, probably indicate that:

- graduates with a SST Diagnostic cognitive orientation (level 2) tend to enter operational work environment

- graduates who enter operational roles seem significantly less prone to explore and investigate new information than those with secondary school level qualifications

Within the first 10 years there is a significant improvement of their processing skills, followed by a gradual decline.

- this decline may be due to: the inadequate cognitive challenges posed by administrative and clerical work

- those with higher levels of cognitive capability may exit operational roles through promotion to supervisory and managerial roles

It seems that graduates with SST Diagnostic level cognitive functioning, who enter into Diagnostic roles and remain there, may not develop their thinking skills sufficiently in the long term.

3.2 Management work (Unit and Departmental managers)

In the case of management roles, there seems to be a definite age-related decline in terms of cognition – but largely in the case of the 10-12 year schooling group and the graduates. Those with diploma's who end up in management roles, show significantly less decline in terms of their processing skills. It may be that those with diplomas and certificates who achieve managerial levels of employment and who maintain acceptable levels of performance in those roles, are a selected group who continually have to compete with graduates for those sought-after roles. The graduates in management roles may enter that level of employment and remain in those roles given their educational background. The graduates in management roles also seem to be a more heterogeneous group than those with diplomas in those roles. The greater homogeneity of the diploma group may be related to the fact that they rely on their performance as opposed to merely qualifications to remain in management roles.

For this group, the information competencies with the lowest level of decline are those of "Verbal conceptualisation" and "Integration". This may be due to the importance of communication in management roles as well as the natural tendency for adults to become more integrative over time as they get exposed to many diverse issues which they need to make meaning of and integrate into coherent wholes.

3.3 Specialist work/roles

Those with a 10-12 year schooling seems to be more heterogeneous as a group than the diploma and graduate groups. The 10-12 year old schooling group in specialist roles show a fair degree of age-related decline as their cognitive scores at 20 years old are distributed from 40 – 60. At retirement age the distribution ends up at 35 to 45. It is possible that those in this 10 – 12 year schooling group, who show more cognitive potential but who lack the necessary educational background, invest in obtaining educational qualifications and move out of this educational group over time. Those with a 10-12 year schooling who remain in specialist roles until the age of 60, show relatively high scores on cognitive Complexity and Learning – with scores suitable to Diagnostic Level 2 to Tactical Strategy Level 3 requirements.

Those with diplomas in Specialist roles, enter these roles with cognitive competency scores of 50 – 60. This group show less age-related decline than the 10-12 year schooling and the graduate groups. It may be understood in terms of the promotion of the best performing people with diplomas into these specialist roles.

Graduates in specialist roles, however, show a fair degree of age-related decline in terms of cognitive competence. It may be that those with higher levels of cognitive capability exit these Specialist roles and get promoted to generic Management or Executive roles.

For both those with diplomas and degrees, the least age-related decline was noticed in terms of Integrative and Memory functioning.

3.4. Professional and Technical Consulting roles

Of all the various work roles, those in General Management and Consulting roles show the lowest degree of age-related cognitive decline. This applies to all three the educational groups. The 10-12 year group show a reduction in the distribution of scores from 45 – 60 at age 20 to 40 – 50 at age 60. Those with diplomas show a decline of 50 – 65 to 45 – 55, and those with degrees show a decline from 56 – 65 to 45 – 60 over time.

The age-related patterns of the professional consulting groups also differ from those of the other career groups. For the 10-12 year schooling group in Consulting roles, highest scores are maintained in the cognitive competencies of Pragmatic and Memory. This may be linked to the importance of the

practical impact of professional and technical advice. For all the educational level groups there also is the least decline on terms of Integrative skills, which means that consulting work requires continuous practice of meaning making skills.

3.5 General Management and Executive roles

As in the case of the Consulting, General management and Executive roles also entail varied work exposure and a great degree of responsibility and accountability. The degree of age-related cognitive decline for this group is also relatively low, especially for those with Diplomas and Degrees.

In addition, it seems that for the 10-12 year schooling group, those who start off with Executive roles at a young age, show significantly higher cognitive skills that those who enter Management roles at this age. However, the age-related cognitive decline for this 10-12 year schooling group is less in Management roles than in Executive roles. The graduates who enter into Executive roles also show significantly higher cognitive skills than the graduates who enter into management roles.

An interesting finding is that the cognitive skill which shows the lowest degree of age-related decline across educational groups is once again that of Integration, whereas Complexity seems to decline with age. This may be related to the natural tendency of adults to become more integrated and intuitive with age, and to focus less on technical detail.

3.6 Trainee roles

This generally involves a diverse group of people – across educational and age groups. The various educational groups in trainee roles also show some unexpected results. The 10-12 year schooling group show score distributions at 20 years old of 52 – 65 (which covers SST level 2 and 3 capability). Those with diplomas who enter into trainee roles show lower scores than the 10-12 year schooling group, with a lower starting distribution of 40 – 58 and a higher distribution of 45 – 75 at retirement age. This group seems to be the only one of the three educational groups which actually show an age-related cognitive improvement on certain cognitive skills. Like the 10-12 year schooling group, the graduates in Trainee roles actually show a decline of 50 – 65 at 20 years old to 35 – 55 at retirement age. It could indicate that those who continually develop themselves and learn new practical skills over time, to a greater extent practice their cognitive skills.

For the trainee group the skills of Gradual Improvement Learning and Memory seem to improve with age regardless of the educational group involved.

4. Overall findings:

The results based on this analysis of 60 000 Cognitive Process Profile (CPP) sets of results, clearly indicates that cognitive skill generally declines with age. However, the patterns of decline differ for different career and educational groups.

Education generally shows a "protective" effect in that it limits age-related cognitive decline.

It is, however, the nature of work and the cognitive challenge posed by the work role, which seems to have an even more pronounced impact on the development versus decline of cognitive skills over time. This is suggested by lower decline for people who continually go for training to acquire new skills regardless of their age or educational level.

The positive impact of work challenges on cognitive skill seems even more obvious where there is greater visibility of the role – such in the case of management, executive and consulting roles where performance tends to be critically evaluated by others. This visibility of performance may well add the motivational drive to continually learn and to improve own performance. It also seems that those with cognitive potential seem to move out of lower educational categories and operational roles over time.

One of the most consistent findings, however, is that cognitive development during adulthood is characterised by greater integration, and at times intuition. There is generally a move away from a highly technical application to one where the emphasis is on making meaning in a coherent way – thus Integration. This finding does not apply to those in Specialist roles, who maintain higher scores on Complexity.

These studies also consistently show that the greatest degree of learning takes place between the ages of 20 – 30. All career and educational groups seem to significantly improve their cognitive functioning as they move from the somewhat linear, structured and knowledge driven educational context to the fuzzy, complex world of work which continually pose new challenges.

Please note that while the graphs reveal average trends and tendencies, a wide distribution of scores can be found within each demographic category.