




Secondary education as a predictor of aptitude: Implications for selection in the automotive sector



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Dates:

Received: 11 Oct. 2016

Accepted: 21 July 2017

Published: 22 Sept. 2017

How to cite this article:

Puchert, J.I., Dodd, N., & Viljoen, K.L. (2017). Secondary education as a predictor of aptitude: Implications for selection in the automotive sector. *SA Journal of Industrial Psychology/SA Tydskrif vir Bedryfsielkunde*, 43(0), a1416. <https://doi.org/10.4102/sajip.v43i0.1416>

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Orientation: Details of applicants' secondary education (incorporating subject choice) could be a useful screening tool when processing large applicant pools. Here, the relationships between secondary education (incorporating subject choice) and the reasoning and visual perceptual speed components of the Differential Aptitude Test are explored.

Research purpose: The objective of the study was to determine whether type of secondary education (incorporating subject choice) could be used as a substitute for reasoning (verbal and non-verbal) and/or visual perceptual speed aptitudes in the selection of operators for an automotive plant in South Africa.

Motivation for the study: The motivation for this study arose from the evident gap in academic literature as well as the selection needs of the automotive industry.

Research design, approach and method: This research adopted a quantitative approach. It involved a non-probability convenience quota sample of 2463 work-seeking applicants for an automotive operator position in South Africa. Participants completed a biographical questionnaire and three subtests from the Differential Aptitude Test battery. The Chi-square test was used to determine the relationship between type of secondary education (incorporating subject choice) and selected cognitive aptitudes.

Main findings: The study's findings revealed statistically and practically significant relationships between type of secondary education (incorporating subject choice), verbal reasoning, non-verbal reasoning and visual perceptual speed. Broad performance levels in the three aptitude subtests employed in this study were significantly associated with the type of matriculation certificate held by applicants. The findings specifically indicated that the secondary education types that included the subjects mathematics or both mathematics and science were associated with higher levels of performance in the three aptitudes. This had consequences for these applicants' success in the screening process which could lead to enhanced chances of employability.

Practical and managerial implications: Applicants' type of secondary education (incorporating subject choice) could be regarded as a key criterion in human resource selection and be instructive in the screening process. This could reduce the candidate pool prior to more costly psychometric assessments.

Contribution or value-add: The findings are specifically relevant to the South African automotive industry in terms of their human resource selection practices. The insights gained from the findings may also be used as a guide to human resource practitioners in the selection of similar level employees in other working contexts. The study makes a case for a multiple-hurdle approach to selection.

Introduction

More than any other area, the measurement of intelligence is one of psychology's most significant achievements (Deary, Strand, Smith & Fernandes, 2007; Foxcroft & Roodt, 2013; Furnham, 2008; Nisbett, 2013). General mental ability (GMA), or intelligence, is furthermore regarded as the most validated individual differentiating construct in psychology (Bertua, Anderson & Salgado, 2005; Giberson & Miklos, 2012; Schmidt, 2002). GMA is known to be the common aspect underpinning achievement on all mental ability tests (Brown, Le & Schmidt, 2006; Carretta & Ree, 2000).

In comparison to GMA, specific cognitive aptitudes, often simply called aptitudes, are narrower in focus and aim to provide a unitary assessment of a specific aptitude (Foxcroft & Roodt, 2013; Schmidt, 2002). Aptitude is broadly defined as the potential within a person to obtain a specific level of skill or ability, following a certain amount of training and/or practice (Byars & Rue, 2011;

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Coetzee & Volsoo, 2000). Cognitive ability tests (CATs) measure specific mental abilities such as verbal skills, quantitative or numerical skills and reasoning ability (Foxcroft & Roodt, 2013; Noe, Hollenbeck, Gerhart & Wright, 2011). Perceptual speed and spatial ability tests are also commonly incorporated in aptitude tests. In addition, finger dexterity, wrist-finger speed and manual dexterity are examples of the abilities analysed in psychomotor aptitude instruments (Byars & Rue, 2011). Whilst often tested individually, it is noteworthy that a combination of two or more specific aptitudes is in actual fact a measure of general cognitive ability (GCA) (Brown et al., 2006; Domino, 2002; Foxcroft & Roodt, 2013; Schmidt, 2002).

Decades of empirical research has consistently revealed the significance of CATs in predicting, amongst others, academic success, work success and significant life events (Heaven & Ciarrochi, 2012; Kuncel & Hezlett, 2010; Kuncel, Ones & Sackett, 2010; Luo, Thompson & Detterman, 2003; Macpherson & Stanovich, 2007). This proliferation of support for the use of standardised CATs has also had the unfortunate result of developing a pervasive array of flawed ideas and beliefs (Kuncel & Hezlett, 2010; Nisbett, 2013). One of these erroneous conclusions is that cognitive ability is mostly because of genetics, with the environment having little effect on it (Foxcroft & Roodt, 2013; Nisbett, 2013). Incremental theorists take a different stance and view it as malleable. Through exerting more effort, working and learning from mistakes, cognitive ability can be influenced (Malmberg, Wanner & Little, 2008). Based on this paradigm, an individual's cognitive ability is not dictated by genetic inheritance per se but rather the genetic inheritance may exert a considerable influence on how the individual's cognitive ability develops in different environments (Hunt, 2014). Cognitive test scores are hence the complex reflection of a sum of talents, learned knowledge and skills and other environmental factors such as past experience, education and training (Kuncel & Hezlett, 2010; Wicherts, Dolan & Van der Maas, 2010). These environmental factors, including secondary education, could then shape CATs, such as the three aptitudes used in this study.

Some researchers have taken the nurture viewpoint to the extreme, indicating that one of these environmental factors, namely, education, has a causal relationship with cognitive ability. The significant correlation between cognitive ability and length or quantity (i.e. the highest grade successfully completed) of schooling has been well documented. Researchers have insisted that there is a stable and robust relationship between schooling and the enhancement of cognitive skills (Ceci, 1991; Hunt, 2014; Jacobs et al., 2003; Watkins, Lei & Canivez, 2007). Studies have confirmed this relationship through the investigation of particular educational reforms, namely increased compulsory schooling. These studies have provided consistent evidence for the long-term impact of increased schooling years on cognitive ability (Brinch & Galloway, 2011; Schneeweis, Skirbekk & Winter-Ebmer, 2014). Given this, it stands to reason that education could be used as a predictor of aptitude and as a proxy for psychometric assessment.

It certainly cannot be disputed that in educational settings, cognitive ability plays an essential role in learning and academic performance as the two variables are significantly associated with one another (Soares, Lemos, Primi & Almeida, 2015). However, the direction and scope of this potential causal relationship between education and CAT scores remains elusive and drawing clear conclusions thereon is highly controversial (Deary et al., 2007; Lynn & Mikk, 2007; Rohde & Thompson, 2007). When prior academic achievement and cognitive ability are simultaneously considered, researchers have concluded that the only meaningful predictor of final academic achievement is prior academic achievement (Brinch & Galloway, 2011; Soares et al., 2015).

Nevertheless, research into the relationship between educational factors and CAT scores reveals that something is happening but they are not yet able to specify just how it is happening (Hunt, 2014). Scores on cognitive tests and schooling are positively associated, but it is difficult to determine if the relationship is unilaterally causal or if a reverse influence exists (Carlsson, Dahl, Öckert & Rooth, 2015). It is plausible that the association between schooling and cognitive ability involves reciprocal causation. One postulated reason for this reciprocal relationship is the adaptive plasticity of the developing brain (Ariës, Groot & Van den Brink, 2015; Baker et al., 2015; Baker, Salinas & Eslinger, 2012; Howard-Jones, Washbrook & Meadows, 2012; Stevens & Bavelier, 2012). Other researchers have indicated that because of increased environmental complexity and the significant emphasis on extended education at secondary level, there have been enhanced levels of academic aptitude (Barber, 2005; Howell & Wolff, 1991).

The tipping point in this highly emotive topic could be the distinction between quantity and quality of education. Even when samples have been matched in terms of educational level or quantity, research has highlighted quality of education as an important factor in CAT test scores (Barro & Lee, 2001; Donnelly, 2001). South African research has also confirmed the significant effect of the quality of education on intelligence scores (Nell, 1999; Shuttleworth-Edwards et al., 2004; Van Tonder, 2007). One of the current challenges facing the South African educational system is the improvement of the quality of education in all schools (Mayer et al., 2011; Ramdass, 2009; Smith, 2011; Spaull, 2013). This is a fundamental prerequisite in order for the educational system to effectively fulfil its primary task of preparing youth for the world of work as well as optimising knowledge and skills production within these students (Van de Werfhorst, 2014).

It is incontestable that this world of work cannot effectively function without human resources. Through the consistent application of their knowledge, skills and wisdom, the workforce increases the quality and quantity of labour output. Human resources are essential in achieving overall strategic business objectives (Breugh, 2013; Naude & O'Neill, 2011; Shatouri, Omar & Igusa, 2012). The selection of this workforce is therefore a fundamental aspect of an organisation's strategic planning initiatives. Organisations

need to tactically engineer a methodology to match talent supply with the current and future talent demand (Grobler, Wärmich, Carrell, Elbert & Hatfield, 2011; Mehok, 2009; Nel et al., 2011; Noe et al., 2011). There is specifically a need for human resource selection processes to indicate the incumbents that have a realistic possibility to be successful. Failure to do so can have dire consequences for the organisation. Various methods and techniques are thus employed in human resource selection to increase the organisation's productivity and competitiveness (Grobler et al., 2011; Nel et al., 2011; Noe et al., 2011). Education and skills development is a priority in South Africa where unskilled, inexperienced jobseekers are viewed as a risky investment in a faltering local economy (Mahembe, 2012; Nzimande & Patel, 2012; Peo, 2013). In light of this, it is noteworthy that research papers on the range of selection techniques employed in South African organisations have indicated the increasing trend towards using psychological assessments (see Louw, 2013; Van der Merwe, 2002).

The background for this study has elucidated an important issue for consideration within the South African human resource management field. That is, understanding the relationship between type of secondary education (incorporating subject choice), reasoning and visual perceptual aptitudes in the selection of personnel.

Research purpose and objectives

Cognitive ability is the result of interaction between genetic endowment and the environment. Current research highlights that education can be a central factor in the environment's influence on cognitive ability (Baker et al., 2012, 2015; Barber, 2005; Downey, von Hippel & Broh, 2004; Ostrosky, Ardilia, Rosselli, Lopez-Arango & Uriel-Mendoza, 1998). Regardless of the specific content area being taught, what happens at school has an impact on neurocognitive development. Learning basic literacy, numeracy and other academic subjects, even only for a few years under basic conditions, leads to a number of cognitive enhancements resulting in schooled children thinking and reasoning in a significantly different manner in comparison to unschooled children. Immersed in an environment that prioritises cognitive abilities, whilst learning a specific set of skills at school, children's scope and depth of cognition and aspects of their executive functioning are also fundamentally enhanced (Baker et al., 2012; Downey et al., 2004; Howard-Jones et al., 2012; Ostrosky et al., 1998; Schneeweis et al., 2014; Stevens & Bavelier, 2012).

Within this dynamic, studies have identified the impact of educational quality on cognitive ability and have specified that this aspect needs additional investigation (Donnelly, 2001; Luo et al., 2003). Furthermore, it is evident that there is significant investigation and debate surrounding educational attainment level and cognitive ability, but scant exploration on the relationship between type of secondary education (incorporating subject choice) accomplished and level of GCA (Kuncel et al., 2010). There is specifically a lack of

research into the reasoning skills of adolescents and the role of subject-based content at the secondary educational level on the youth's reasoning achievements (Ari s et al., 2015). A need has been identified for research into what it is about prior learning at school that enhances subsequent cognitive abilities. Specifically, there is a call to investigate whether syllabi or different subjects employed at schools have a distinguishing impact on neurocognitive development, specifically the executive intelligence functions (Baker et al., 2012). Researchers have called for their findings into the relationship between mathematical achievement and GCA in young adults should be replicated in a large more diverse sample to further explore the extent of this association (Rohde & Thompson, 2007).

Taking into consideration the background and motivation for this study, there were four primary research questions underpinning the project:

- Is there a significant relationship between the type of secondary education (incorporating subject choice) obtained and verbal reasoning ability?
- Is there a significant relationship between the type of secondary education (incorporating subject choice) obtained and non-verbal reasoning ability?
- Is there a significant relationship between the type of secondary education (incorporating subject choice) obtained and visual perceptual speed?
- Is there a significant relationship between applicants' type of secondary education (incorporating subject choice) and selection outcomes?

One of the most critical management decisions is the appropriate selection of a candidate for a vacant position (Azar, Sebt, Ahmadi & Rajaeian, 2013; Grobler et al., 2011). Recruitment and selection are, however, costly human resource management exercises and errors in judgement can be extensive in terms of time, energy and money (Grobler et al., 2011; Lough & Ryan, 2010; Moore, 2006; Paterson & Uys, 2005). There is no set, typical and/or generally accepted human resource selection process and no two organisations conduct selection in the same manner (Louw, 2013; Van der Merwe, 2002). A widely used technique, the multiple-hurdle (or successive-hurdle) approach, results in the candidate pool becoming increasingly smaller after each stage in the selection process (Grobler et al., 2011; Nel et al., 2011; Noe et al., 2011). To assist in this decision-making process, various tools are used to assist recruitment and selection practitioners, including the initial screening of candidates' curricula vitae, reviewing application forms, conducting interviews, carrying out assessment and testing, as well as doing medical and reference checks (Chan & Kuok, 2011; Grobler et al., 2011; Louw, 2013).

General cognitive ability is regarded as a valid predictor of both educational and vocational performance, providing valuable appraisals of creativity and career potential (Kuncel, Hezlett & Ones, 2004; Ng & Feldman, 2010). The reason for the first broad test of cognitive ability, developed by Binet in

1905, was to be able to predict individual differences in educational outcomes and research continues to underpin a moderate to strong association between cognitive ability and educational achievement (Deary et al., 2007). The use of psychometric tests as educational and occupational selection tools is hence justified on the basis of firm evidence that their scores accurately predict real-world success and have considerable value at both practical and theoretical levels (Deary et al., 2007; Foxcroft & Roodt, 2013). Given their usefulness in making employment decisions, GCA tests have been used in human resource selection for over 80 years (Outtz, 2002). Aptitude testing can denote the future performance of job applicants accurately. Psychological tests are considered as valuable instruments for two reasons. They can predict what the person is able to do currently as they reflect existing skills and knowledge, plus they are able to provide insight into how well an individual is likely to benefit from training and develop in the future (Kuncel & Hezlett, 2010). In a meta-analysis into the validity of GMA and specific cognitive abilities (i.e. verbal, numerical, perceptual and spatial) for predicting job performance and training success, both were found to be valid predictors of the two criteria across a wide variety of occupational groups (Bertua et al., 2005). Through the use of a multi-intelligence aptitude test battery, Tao, Chen and Chen (2009) concluded that an organisation can evaluate whether a job respondent has the required aptitude rapidly and effectively and use this as an important selection technique.

Psychological assessment in South Africa has come under close scrutiny over the past few decades, resulting in national labour legislation and regulations being passed by various stakeholder bodies after the 1994 elections (Nel et al., 2011; Nzama, De Beer & Visser, 2008; Paterson & Uys, 2005). The Employment Equity Amendment Act (EEAA) (2013) particularly indicates that employers may not reject candidates on the basis of a lack of skills or experience. Furthermore, this Act requires potential, the ability to acquire the required skills and experience within a reasonable time period, to be acknowledged in selection practices. Educationally disadvantaged learners are not a homogeneous group and psychological testing therefore needs to assist in accurately identifying between those who have potential but have been disadvantaged and those, although disadvantaged, who do not have potential (Murphy & Maree, 2006; Theron, 2007; Van der Merwe & de Beer, 2006).

Applicants undergoing psychological assessments are also protected by specific regulations governing the administration thereof. All assessment practitioners using psychological assessment procedures in the workplace must be registered with the Professional Board of Psychology and are required to adhere to a code of practice (Health Professions Council of South Africa, 2010; Mauer, 2000; SIOPSA, 2006). Adhering to these rules and regulations is of major concern to South African organisations using psychometric testing (Van der Merwe, 2002). The cost of using psychological assessments in the selection process is also a significant deciding factor (Bartram, 2004; Louw, 2013; Zibarras & Woods, 2010).

Another convenient measure used to assist managers in selection decisions is secondary education, including grade obtained, overall marks achieved and per subject, as well as the type of institution the secondary education was obtained at and the subjects included therein (Grobler et al., 2011; Louw, 2013; Sackett & Lievens, 2008). Certain professions or vocations show preference for certain types of secondary education. For example, artisans are traditionally selected from applicants who have a technical-type secondary education, which is obtained through a technical high school or a technical vocational education and training (TVET) institution (Schafmeister, 2013). A study researching the effectiveness and fairness of using matriculation and aptitude test results as predictors of further academic performance found that both have predictive validity (Van der Flier, Thijs & Zaaiman, 2003).

This study will assist human resource managers, recruitment and selection practitioners, or any individual involved in personnel selection to make informed decisions regarding potential employees with regard to their cognitive abilities and secondary education. The next section offers a literature review of the theoretical frameworks underpinning the study, incorporating a review of the empirical literature in the research field.

Literature review

There have been numerous theories and definitions of GMA and GCA over the decades. The underpinning theory supported in this study is Carroll's (1993) two-factor theory of intelligence, namely, fluid intelligence (*G_f*) and crystallised intelligence (*G_c*). Carroll revised and extended Cattell and Horn's fluid-crystallised model, which is currently regarded as the most expedient model in both educational and business contexts (Hunt, 2014; Nisbett, 2013; Thorsen, Gustafsson & Cliffordson, 2014). Crystallised intelligence is defined as 'consolidated knowledge ... built out of the knowledge of the culture and out of the education of a subject' (Ter Laak, Gokhale & Desai, 2013, p. 341). Fluid intelligence, in contrast, relies significantly less on stored knowledge, depends more on working memory and is involved in solving new problems (Nisbett, 2013; Ter Laak et al., 2013). According to Cattell's investment theory, there is a causal relationship between *G_f* and *G_c*, with *G_f* being a broad knowledge acquiring ability and hence involved in all tasks related to knowledge attainment. Working memory, abstract reasoning and perceptual or processing speed are regarded as *G_f* measures (Colom, Escorial, Shih & Privado, 2007), whilst general knowledge, vocabulary and comprehension are instruments of crystallised intelligence (Furnham, 2010). This study explores three forms of *G_f*, namely verbal reasoning, non-verbal reasoning and visual perceptual speed.

There is voluminous literature supporting the extensive importance of GCA testing (Kuncel et al., 2004). The measurements of GMA and GCA are regarded as extremely useful instruments as they are reasonably effective predictors of school grades, occupational performance and several other

aspects of achievement in life (Kuncel & Hezlett, 2010; Nisbett, 2013). It is purported that GCA is more than likely the single measurable human characteristic that impacts on almost every practical aspect of an individual's life, from education to occupation, economic and social consequences (Furnham, 2008). CATs have revealed strong predictability of success in military and civilian occupational training, overall job performance, effectiveness in leadership positions, various indices of academic achievement as well as creativity assessments (Kuncel & Hezlett, 2010).

Whilst GCA has an impact on an array of outcomes, it is also influenced by many factors. Studies have found it challenging to clearly separate the relative importance of each of these factors as they are deemed interrelated and possibly even have a reciprocal impact on one another. Amongst other factors, GCA as measured through CAT performance is affected by age, gender, genetics, parental intelligence, personality, prenatal and immediate postnatal care, race and socio-economic status factors (Colom et al., 2007; Furnham & Monsen, 2009; Leeson, Ciarrochi & Heaven, 2008; Nisbett, 2013). In the transformation of potential (G_f) into fulfilled potential (G_c), several elements are influential, including personal factors (i.e. interests, motivation and persistence) as well as the availability and quality of both formal (e.g. school) and informal (e.g. family and community) learning experiences (Soares et al., 2015; Thorsen et al., 2014).

Rather than being a static, predetermined construct endowed on individuals by virtue of their heredity and genetics, GCA is understood to be a malleable individual trait (Malmberg et al., 2008; Nisbett, 2013; Thorsen et al., 2014). Research has confidently exposed two contributing factors to the malleability of GCA: increased schooling and improvements to the curriculum (Hunt, 2014; Nisbett, 2013). Substantial research into the impact of schooling on cognitive functioning has confirmed that this environmental factor has shown an ontogenetic effect on individual cognition 'making schooling into a neurocognitive developmental institution' (Baker et al., 2012, p. 8). Education and academic training appear to modify the brain's size and organisation. These changes may be either structural or the result of the redeployment of neural networks, which implies neural plasticity (Howard-Jones et al., 2012; Hunt, 2014). There is evidence of training causing changes in brain anatomy, such as the enlarged splenium of the corpus callosum and increased tissue volumes in multiple cortical regions during academic tasks such as reading, writing and language comprehension (Baker et al., 2015). A study revealed that, in the auditory and language processing areas, the white matter of the corpus callosum is thinner in illiterate people than in literate people (Ardila et al., 2010). Researchers established that targeted academic training for schooled children and adolescents can meaningfully alter the brain's patterns of activity, and hence expertise in specific cognitive spheres. Following arithmetic training and the consequent heightened activation of the students' brains, the attention and executive processing-rich zones of the frontoparietal areas became more automatic and

efficient knowledge retrieval zones (Ischebeck, Laura, Karl, Michael & Margarete, 2007).

Whilst the neurobiological plasticity underpinning human cognitive development is certainly robust enough, there is growing evidence that its development is consistently tethered to the surrounding context. Environmental exposures and demands, such as education and academic training, are intervening and restraining variables that can influence neurocognitive growth (Baker et al., 2012). This is compounded by the appreciation that the number of years of schooling as well as the quality of education fulfils a substantial role in determining an individual's intellectual capacity (Van Tonder, 2007). Within South Africa, this is a particular challenge as a weight of evidence supports the contention that there is an ongoing crisis within the country's educational system. The South African educational system is noted as being exceptionally inefficient, severely underperforming and grossly unfair (Ramdass, 2009; Spaul, 2013). However, the focal undertaking of any educational system is to prepare the country's young people effectively for the world of work (Van de Werfhorst, 2014).

It is clear from the literature review that there is evidence to support a link between cognitive abilities and education. The exact nature of that link and the implications thereof are less clear. In order to shed some light on this area, this research study aimed to investigate whether there is a relationship between the type of secondary education (incorporating subject choice) obtained and the applicants' specific cognitive aptitudes and hence their selection for potential employment. The research sought to explore whether certain types of secondary education (incorporating subject choice) better prepared individuals for the world of work as seen in the results obtained through a selection process. It was believed that this could assist human resource practitioners to overcome some of the challenges inherent in implementing psychological assessment, specifically the EEAA (2013) stipulations.

Within this study, secondary education refers collectively to technical high schools, academic high schools and TVET institutions. The terminology 'secondary education', 'Grade 12 qualification' and 'matriculation' are therefore used interchangeably. Specifically, this study denotes five types of secondary education (incorporating subject choice) named and defined as follows:

- A secondary education with mathematics and science as subjects is a Grade 12 qualification obtained through an academic high school.
- A secondary education inclusive of mathematics as a subject is a matriculation qualification achieved at an academic high school.
- A secondary education with science as a subject is a Grade 12 qualification acquired at an academic high school.
- A technical-type secondary education, inclusive of mathematics and science as subjects, is obtained through a technical high school or TVET institution.

- The fifth type of secondary education does not include mathematics and science as Grade 12 subjects and is attained at an academic high school. For the purposes of this study, this type of secondary education is referred to as the general type of secondary education.

The literature review leads to the study's four hypotheses:

Hypothesis 1: There is a significant relationship between levels of verbal reasoning and type of secondary education (incorporating subject choice).

Hypothesis 2: There is a significant relationship between levels of non-verbal reasoning and type of secondary education (incorporating subject choice).

Hypothesis 3: There is a significant relationship between levels of visual perceptual speed and type of secondary education (incorporating subject choice).

Hypothesis 4: There is a significant relationship between types of secondary education (incorporating subject choice) and success in the screening process.

The quantitative research design and methodology employed in this study will subsequently be explained, followed by a presentation of the study's findings.

Research design

Research approach

The underpinning research philosophy for this research project was a positivist perspective. A descriptive quantitative approach was adopted as hard data, in the form of numbers, were collected and statistically analysed in this study (Blanche, Durrheim & Painter, 2006; Neuman, 2012). A cross-sectional convenience survey design, which involved standardised questionnaires, was implemented this data.

Research method

Research participants

The study assessed 2463 conveniently sampled prescreened work-seeking candidates for an automotive operator position in South Africa. This is because of the project being part of a large recruitment process at a South African automobile plant. The target population was screened on the basis of the type of Grade 12 qualification obtained, with a need for representation across the five types of secondary education delineated in this study. Other key internal criteria were a 60–40 ratio between male and female applicants and a minimum overall aggregate score of 60% in their Grade 12 education. In order to improve the accuracy of the study's findings, the complete prescreened sampling frame constituted the sample size.

The majority (45.3%) of the study's respondents were between 25 and 29 years old, with the second largest group (22.8%) of applicants within the 30–34 year age category. Over 80% of the respondents surveyed were black people, 16.8% mixed race, 0.5% Indians and 0.9% were white people. The majority (65.7%) of the study's sample were males.

A large portion (44.4%) of the sample achieved a secondary education with mathematics and science as subjects. The second highest category (25.1%) was the general type of matriculation, with neither mathematics nor science as subjects in Grade 12. Respondents who completed their Grade 12 qualification with mathematics as a Grade 12 subject were the third highest category at 19.2%. A technical N3, a Grade 12 equivalent, was completed by 7.3% of the sample. The remaining 3.9% of the candidates completed a Grade 12 with science as a subject.

Measuring instruments

Differential Aptitude Test battery: The overall purpose of the Differential Aptitude Test (DAT) battery is for counselling or to assist in producing the best match between individuals in certain jobs or in any postschool training centre (Coetzee & Vosloo, 2000). In this research study, the DAT-K version was used, which is the standard form applicable to individuals who have completed Grades 10–12. A job analysis of the operator position was conducted at this particular automotive plant. This job analysis indicated that three aptitude skills, namely verbal reasoning, non-verbal reasoning and attention to detail, were potentially predictive of operator job performance. Three subtests from the DAT-K test battery were therefore used to collect data in this study. The key differences with regard to purpose, items per instrument and timing of these subtests are discussed.

- *The verbal reasoning subtest:* The intention of this instrument is to establish an aspect of general reasoning on the basis of verbal material. The tool is based on the supposition that the skill of identifying relationships, being able to conduct word similarities and to decipher broad problems utilising rational thought, as well as a person's vocabulary experience is a valid indication of an aspect of general reasoning. The subtest consists of 25 multiple choice type questions with a 25-min test completion time (Coetzee & Vosloo, 2000).
- *The non-verbal reasoning subtest:* The aim of this tool is to determine an aspect of general reasoning on the basis of non-verbal items. The instrument comprises two sections. The first section rests on the postulation that the capacity to identify the association between figures and thereby select the correct matching missing figure is a valid sign of an aspect of non-verbal reasoning ability. In the second section, a series of modified figures is presented. The correct identification and application of the underlying principle informing the modification is regarded as a valid sign of an aspect of non-verbal reasoning ability. The subtest has a 25-min completion time in which 25 multiple choice type questions need to be attempted (Coetzee & Vosloo, 2000).
- *The visual perceptual speed subtest:* This instrument seeks to ascertain the candidate's visual perceptual speed, which is the ability to make swift and precise discernments of the similarities and dissimilarities between visual arrangements. The rationale of this technique is that the ability to identify the one grouping of characters (numerical, alphabetical or diagrammatical) that is not

consistent with the other four groupings is a valid indication of visual perceptual speed. In this subtest, 25 multiple choice type questions need to be answered within 4 min (Coetzee & Vosloo, 2000).

The reliability of the three DAT-K subtests used in this study was established with the aid of the Kuder–Richardson formula 14. The reliability coefficients of the three DAT-K subtests in respect of Grade 12 candidates are moderately consistent with those obtained for the Grade 10 and 11 groups (Coetzee & Vosloo, 2000). The predictive validity of the DAT-K subtests is also confirmed. This was ascertained by the significant Pearson product moment correlation coefficients realised between the subtests and year-end school subject results obtained. For the verbal and non-verbal reasoning subtests, correlations with a p -value ≤ 0.01 were established for both English and mathematics school subjects, whilst p -values of ≤ 0.05 were obtained for the visual perceptual tool (Coetzee & Vosloo, 2000). Furthermore, the content validity of the DAT-K battery was established by a committee of specialists independent of the test developers. The construct validity of the subtests was examined through subjecting the norm group's data to confirmatory factor analysis. Given that the subtests correlate highly with one another, two meaningful factors were established and hence construct validity was confirmed (Coetzee & Vosloo, 2000).

Research procedure

The assessment process was conducted over several months during working hours. Two groups were assessed per weekday of scheduled assessment. The participants' anonymity and confidentiality was maintained and assurance was provided that the research findings would not jeopardise either the participant or the organisation. Information on the use of the results was provided at the commencement of the assessment process, and permission was obtained from the respondents through a consent form. Answer sheets were manually scored using a scoring stencil. In adherence to standard psychometric assessment practice, raw scores were converted to stanines, using the appropriate norm table.

Ethical consideration

Ethical clearance to conduct the study was obtained from the University of Fort Hare's Research and Ethics Committee. Permission was then obtained from the Human Resource Management Department of an automotive plant to collect data in the organisation.

Statistical analysis

Data analysis was conducted by means of the SPSS programme, version 20. Descriptive statistics, in the form of two types of central tendency measures, namely the median and mode, were employed for the stanine results obtained for the three aptitude subtests.

Based on a previously conducted job analysis, a stanine 3 cut-off requirement was set for each of the three aptitude subtests as qualifying screening criterion to progress to the next

screening phase. In preparation for the execution of the inferential statistics, the aptitude subtests' results were tabulated into three categories: a low, moderate and high scoring. The low category included stanine scores ranging from one to three and captured the lower 23% percentile range described as far below average to below average. The moderate category comprised the fourth to sixth stanine scores and described the low average to high average percentile ranges. The seventh to ninth stanine scores were designated to the high scoring category. This category portrayed applicants who scored in the top 23% percentile range and are described as being above average to superior in the aptitude assessed. These three scoring categories were created as they ensured equal variance in each group and statistically it made sense. Inferential statistics were then performed on these three scoring categories. Bivariate statistical analysis was carried out on the two variables to establish either covariance or independence between the dependent and independent variables (Bryman & Bell, 2011). In this study, the dependent variables were the three aptitudes assessed and the independent variable was the type of secondary education (incorporating subject choice) obtained. To test the significance of the relationship between the variables for hypotheses 1–4, the Chi-square test of independence was used. An alpha level of 0.05 was used for each statistical test. In order to elucidate the magnitude of the relationship between the variables, effect size statistics were employed and interpreted. Informed judgements of the study's practical significance were thus made possible (Sun, Pan & Wang, 2010). The Cramér's V statistic was reported in the analyses of the hypotheses and interpreted according to the eta-squared guidelines.

Results

Descriptive statistics

Descriptive statistics for the three aptitude subtests are displayed in Table 1. The medians for all three subtests were in the moderate (stanines 4–6) range with the verbal reasoning subtest's median being slightly higher than that obtained for both the non-verbal reasoning and visual perceptual speed subtests. Table 1 also depicts that modes of seven, in the high range, were achieved for each of the three aptitude subtests.

Inferential statistics

Chi-square tests of independence were performed to examine the relationship between the type of secondary education (incorporating subject choice) and the stanine scores attained in the three aptitude tests, grouped according to low, moderate and high scores. Tables 2–4 summarise the applicants' ($N = 2463$) results in the three aptitude subtests

TABLE 1: Medians and modes of DAT-K subtests.

Subtests	Mdn	Mo
Verbal reasoning	6	7
Non-verbal reasoning	5	7
Visual perceptual speed	5	7

Note: The distribution of the data is recorded in stanine format. DAT-K, Differential Aptitude Test; Mdn, median; Mo, mode.

TABLE 2: Contingency table of observed frequencies for the verbal reasoning subtest.

Subtest	Stanine scores	Variable	Type of secondary education					Total
			Mathematics and science	Mathematics	Science	Technical	General	
Verbal reasoning	Low	Count	86	33	2	28	55	204
		% within group	8	7	2	16	9	8
	Moderate	Count	481	193	50	102	284	1110
		% within group	44	41	52	57	46	45
	High	Count	527	248	44	50	280	1149
		% within group	48	52	46	28	45	47
Total		Count	1094	474	96	180	619	2463
		% within group	100	100	100	100	100	100

$\chi^2(8, N = 2463) = 44.08; V = 0.0946; p < 0.001.$

TABLE 3: Contingency table of observed frequencies for the non-verbal reasoning subtest.

Subtest	Stanine scores	Variable	Type of secondary education					Total
			Mathematics and science	Mathematics	Science	Technical	General	
Non-verbal reasoning	Low	Count	310	96	39	50	290	785
		% within group	28	20	41	28	47	32
	Moderate	Count	403	202	32	88	235	960
		% within group	37	43	33	49	38	39
	High	Count	381	176	25	42	94	718
		% within group	35	37	26	23	15	29
Total		Count	1094	474	96	180	619	2463
		% within group	100	100	100	100	100	100

$\chi^2(8, N = 2463) = 145.83; V = 0.1721; p < 0.001.$

TABLE 4: Contingency table of observed frequencies for the visual perceptual speed subtest.

Subtest	Stanine scores	Variable	Type of secondary education					Total
			Mathematics and science	Mathematics	Science	Technical	General	
Visual perceptual speed	Low	Count	315	129	26	67	198	735
		% within group	29	27	27	37	32	30
	Moderate	Count	386	179	45	61	271	942
		% within group	35	38	47	34	44	38
	High	Count	393	166	25	52	150	786
		% within group	36	35	26	29	24	32
Total		Count	1094	474	96	180	619	2463
		% within group	100	100	100	100	100	100

$\chi^2(8, N = 2463) = 36.19; V = 0.085; p < 0.001.$

according to type of secondary education (incorporating subject choice) attained. Table 5 indicates the applicants' overall success in the screening process.

Hypothesis 1

There is a significant relationship between levels of verbal reasoning and type of secondary education qualification (incorporating subject choice): The verbal reasoning subtest results provided in Table 2 revealed that the relationship between the type of secondary education (incorporating subject choice) and the verbal reasoning stanine scores was statistically significant, $\chi^2(8, N = 2463) = 44.08, p < 0.001, V = 0.0946$. The relationship between these two variables was exposed as being both statistically significant ($p = 0.0001$) and practically significant ($V = 0.0946$). The effect size between the dependent and independent variables was regarded as large and hence contextualises the importance of this finding (Pallant, 2013).

Table 2 highlights that over half the respondents with mathematics as a subject in their Grade 12 qualification (gained through an academic high school) obtained high

category scores in the verbal reasoning subtest, more than the applicants in any of the other four types of secondary education. High scores were also acquired by candidates with a secondary education with mathematics and science as matriculation subjects obtained through an academic high school, although at a lower percentage level (48%) than those who only had mathematics as a subject. A technical matriculation type was associated with moderate stanine scores (57%); however, this group also achieved a significantly large percentage (16%) in the low scoring category. Respondents with science as a Grade 12 qualification subject (gained through an academic high school) and those with a general type secondary education also realised scores in the moderate stanine category (52% and 46%, respectively). Nevertheless, the group with a technical Grade 12 qualification outperformed both these groupings in the moderate stanine category. Hypothesis 1 was therefore accepted.

Hypothesis 2

There is a significant relationship between levels of non-verbal reasoning and type of secondary education qualification (incorporating subject choice): Table 3 highlights that a

TABLE 5: Contingency table of observed frequencies for selection outcomes.

Type of secondary education (group)	Variable	Results		Total
		Recommended	Not recommended	
Mathematics and science	Count	754	340	1094
	% within column	46.69%	40.09%	44.42%
	% within row	68.92%	31.08%	100.00%
Mathematics	Count	342	132	474
	% within column	21.18%	15.57%	19.24%
	% within row	72.15%	27.85%	100.00%
Science	Count	60	36	96
	% within column	3.72%	4.25%	3.90%
	% within row	62.50%	37.50%	100.00%
Technical	Count	110	70	180
	% within column	6.81%	8.25%	7.31%
	% within row	61.11%	38.89%	100.00%
General	Count	349	270	619
	% within column	21.69%	31.84%	25.13%
	% within row	56.38%	43.62%	100.00%
Total	Count	1 615	848	2463
	% within column	100.00%	100%	100%
	% within row	65.57%	34.43%	100.00%

$$\chi^2(4, N = 2463) = 39.68; V = 0.1269; p < 0.001.$$

significant relationship, $\chi^2(8, N = 2463) = 145.83, p < 0.001, V = 0.1721$, was also established between the type of matriculation (incorporating subject choice) and the non-verbal reasoning subtest stanine scores. The strength of the association between the variables was statistically significant ($p = 0.0001$) and practically significant ($V = 0.1721$), highlighting the considerable practical significance of this finding (Pallant, 2013).

A significant portion (47%) of the candidates with a general type of education performed in the low stanine category and hence did not fare as well as applicants with the other four types of secondary education in this aptitude instrument. As depicted in Table 3, respondents with science as a subject in their Grade 12 qualification (gained through an academic high school) also underperformed in this instrument as over 40% of the group obtained low stanine scores. Almost half (49%) the candidates with a technical-type secondary education realised moderate stanine scores. Over 40% of the candidates with mathematics as a matriculation subject (gained through an academic high school) also achieved moderate scores in this measure; however, this group also achieved the largest percentage (37%) of candidates scoring in the high category. A secondary education (gained through an academic high school) with mathematics and science as subjects was linked to both moderate and high stanine scores. Hypothesis 2 was therefore accepted.

Hypothesis 3

There is a significant relationship between levels of visual perceptual speed and type of secondary education qualification (incorporating subject choice): Table 4 reveals that the association between the type of matriculation (incorporating subject choice) and the visual perceptual speed subtest stanine scores realised was significant: $\chi^2(8, N = 2463) = 36.19, p < 0.001, V = 0.085$. A statistically significant p -value of 0.0001 was found to exist between the types of secondary education (incorporating subject choice) and the visual

perceptual speed subtest scores, thereby indicating a low probability of the outcome being because of chance. Furthermore, the effect size for this finding, Cramér's V , indicated practical significance of 0.085. The degree to which the two variables are associated with one another therefore reveals moderate practical significance for this finding (Pallant, 2013).

The technical Grade 12 qualification group had the largest percentage (37%) of respondents scoring in the low stanine score category for this instrument. Conversely, candidates with mathematics and science or just mathematics as secondary education subjects (gained through an academic high school) achieved the largest (36% and 35%, respectively) percentage of scores in the high stanine category. Table 4 also highlights that 44% of the applicants with a general type of matriculation and almost half (47%) with a secondary education (gained through an academic high school) including science as a subject realised moderate stanine scores in this subtest. Hypothesis 3 was therefore accepted.

Hypothesis 4

There is a significant relationship between type of secondary education qualification (incorporating subject choice) and success in the screening process: A Chi-square test of independence was conducted to determine whether selection outcomes were associated with applicants' type of matric education (incorporating subject choice). A statistically significant interaction was found: $\chi^2(4, N = 2463) = 39.68, p < 0.001, V = 0.1269$. The estimated probability of accurately predicting selection outcomes from qualification type is 66%. Students with a secondary education (gained through an academic high school) including mathematics and science as subjects, and a secondary education (gained through an academic high school) including the mathematics subject were more likely to be recommended and hence successful in the assessment process. Whilst these results are statistically significant, they may have limited practical significance.

The Grade 12 qualification (gained through an academic high school) that includes the mathematics subjects had the largest percentage (72.15%) of applicants who were recommended from this phase of the selection process. The second largest grouping recommended following the aptitude testing was the Grade 12 qualification (gained through an academic high school) including both the mathematics and science subjects as 68.92% of these applicants were successful in this selection outcome. In comparison to these two types of secondary education, only 62.5% of the applicants with a matric (gained through an academic high school) that includes science were recommended and 61.11% of the technical Grade 12 qualification applicants. The general type of secondary education had less than 57% of applicants who obtained the recommended selection outcome. Hypothesis 4 was therefore accepted.

Discussion

The primary objectives of this study were to investigate the relationship between verbal, non-verbal reasoning and visual perceptual speed aptitude test scores and types of secondary education (incorporating subject choice). The initial stage of a multiple hurdles selection approach resulted in recommendation outcomes for an entry-level technical position. These selection outcome results were analysed in relation to the types of secondary education (incorporating subject choice) attained by the potential employees.

Outline of the results

The findings from the study's four hypotheses led to the generation of two conclusions. These conclusions outline the different selection outcomes achieved by matriculants with different types of secondary education.

The first conclusion pertains to the recommended types of secondary education (incorporating subject choice) following the first phase of selection outcomes. Based on the results obtained, two types of secondary education (incorporating subject choice) are recommended, namely, the secondary education (gained through an academic high school) types inclusive of mathematics and science or just mathematics. Respondents with a Grade 12 qualification (gained through an academic high school) which included mathematics performed consistently better in comparison to the other four types of secondary education. Specifically, this type of secondary education inclusive of the mathematics subject outperformed the other matriculation types in non-verbal reasoning. The applicants with a secondary education (gained through an academic high school) inclusive of mathematics and science consistently performed well across the three aptitudes assessed. The common dominator in these two types of matriculation is the mathematics subject.

This conclusion is in line with the findings of several researchers who have highlighted the import of mathematical ability in academic achievement (Lubinski, Webb, Morelock & Benbow, 2001; Rohde & Thompson, 2006; Shea, Lubinski &

Benbow, 2001). Mathematics is regarded as being essential for approximately 80% of the qualifications offered at a higher education level (Ramdass, 2009). Recent neurological research has established that enhanced abilities in mathematics may well influence cognitive abilities (Baker et al., 2015; Rohde & Thompson, 2007; Schneeweis et al., 2014; Stevens & Bavelier, 2012). This study has confirmed that the common denominator for a successful selection outcome as an automotive operator is an academic-type secondary education inclusive of the mathematic subject. In order to adequately cope with the various transformations and competitive challenges being experienced, the automobile industry therefore needs to focus specifically on academic Grade 12 qualifications inclusive of mathematics as a selection criterion for automotive operators.

The second conclusion pertains to the qualification types (incorporating subject choice) that are not recommended based on the selection outcomes of the first phase of this multiple-hurdle selection process. Whilst the secondary education (gained through an academic high school) inclusive of the science subject outperformed the other matriculation types in verbal reasoning, this matriculation type did not perform well in the non-verbal reasoning subtest. Applicants with the technical and general types of secondary education consistently performed poorly in the three aptitude subtests. It is therefore concluded that these three types of matriculation are not as successful in their selection outcomes as the two matriculation types (gained through an academic high school) inclusive of the mathematics subject.

The overall results of the study revealed statistically distinct relationships between the applicants' type of secondary education and the three aptitudes assessed in this study. It is therefore concluded that the applicants' type of secondary education was as effective as a predictor of potential as the cognitive aptitude subtests' scores attained by these candidates. This conclusion highlights that secondary education can be used as a more time- and cost-efficient preliminary screening measure, specifically for entry-level technical positions. This finding is in contradiction to that of Berry, Gruys and Sackett (2006) who upheld that selection using CATs was a more efficient screening instrument than educational attainment.

Practical implications

The contribution of this research study is fourfold. Firstly, this study has confirmed the well-founded belief that standardised psychometric measures are efficient predictors of performance (Deary et al., 2007; Foxcroft & Roodt, 2013; Furnham, 2008; Kuncel & Hezlett, 2007; Rohde & Thompson, 2007; Watkins et al., 2007). Secondly, given the scant research on the relationship between the type of secondary education and cognitive abilities, this study adds to the human resource management field as the first study to successfully provide such data within a selection process for automotive operators. Thirdly, this study's findings have accentuated the need to

employ a multiple rather than a singular selection approach. This is of particular import in a context where the potential labour pool has been educated through a mass education system and where supply exceeds demand. These factors could plausibly lead to the inflation of credentials requiring employers to acquire additional information sources to discriminate between applicants (Kuncel et al., 2010; Van de Werfhorst, 2014). Fourthly, this study has highlighted that the assessment of aptitude versus using type of schooling achievements (incorporating subject choice) is a useful debate in the light of employment equity challenges. Secondary education could be instructive for human resource managers and practitioners in the screening processes they follow. The study's findings highlight that through using a multiple-hurdle selection approach, the use of type of secondary education can be successfully employed as the initial hurdle. This could add significant value to human resource managers and practitioners as they seek to optimise their allocated resources. Using type of secondary education, rather than more expensive and time-consuming psychological tests, could save time and money. This approach thereby also alleviates the practitioner from the concerns associated with psychological testing and compliance with EEAA (2013) regulations.

Limitations and recommendations

This study was conducted as part of a large recruitment process completed by a South African automotive assembly plant. The sampling frame for this study was a database of prescreened potential operators. In comparison to the 2001 census, the sample is not in line with either provincial or national data pertaining to age, race or gender (Lehohla, 2004). This means that the main shortcoming of this research is that the results cannot be generalised to either the South African or global automobile industry.

A second limitation is that the study did not explore the non-g factors that may have had a substantial influence on both educational achievement and the cognitive abilities demonstrated in the findings. These factors include, amongst others, school attendance and engagement, interest, motivation and effort, the endowment of appropriate learning experiences, teaching quality and structure. These potential relationships should be explored in future research.

A third limitation could be the way in which the five types of secondary education (incorporating subject choice) were defined for this study. Whilst these types of secondary education are not referred to in literature, they were distinct categories of selection for the automotive industry concerned. It is recommended that future research considers whether there is a relationship between the subject marks obtained by applicants and the aptitudes assessed in this study.

Conclusion

The objective of the study was to establish the relationship between the type of secondary education (incorporating

subject choice) obtained and three aptitude test scores attained by potential operators within the automotive industry. There was a statistically significant relationship between the applicants' type of secondary education (incorporating subject choice) and the three aptitudes assessed in this study. The strength of the association ranged between moderate and considerable practical significance. This has highlighted the noteworthy usefulness of using type of secondary education, rather than psychological testing, as an initial screening mechanism within a multiple-hurdle selection approach. The value for human resource managers and practitioners in implementing this technique lies in the time and cost saved, as well as not having to adhere to the EEAA (2013) rules and regulations associated with psychological testing.

Acknowledgements

This research study formed part of a large recruitment process completed within a South African automotive assembly plant. The internal Human Resource project team played a large role in the communication and administration of the project.

Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

N.D. and K.L.V. were the promoters of J.I.P. for her Master's dissertation. The article flows from her research in this regard.

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