



# The information processing foundations of human capital resources: Leveraging insights from information processing approaches to intelligence



Joseph Fagan<sup>a</sup>, Robert E. Ployhart<sup>b,\*</sup>

<sup>a</sup> Case Western Reserve University, United States

<sup>b</sup> University of South Carolina, United States

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## ABSTRACT

This paper considers how information processing approaches to intelligence may offer implications for the study of human capital resources within organizations. We first provide a brief overview of human capital research that summarizes its evolution and current areas of emphasis. This review notes that most of the research on human capital has ignored key developments in the psychological study of intelligence. We then review contemporary approaches to studying intelligence as information processing. We conclude by proposing a broad agenda for integrating research on human capital resources with information processing approaches to intelligence.

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## 1. Introduction

Intelligence plays a vital role in the success of individuals, organizations, and societies. In various forms, intelligence has been examined within multiple disciplines (e.g., economics, psychology, sociology), levels of analysis (e.g., individual, firm), and theoretical perspectives (e.g., individual differences; firm level resources). For example, psychologists tend to emphasize the relationships between intelligence and individual outcomes (e.g., Schmidt & Hunter, 2004), economists often study proxies of intelligence and wages (e.g., Becker, 1964), and management strategy scholars tend to focus on relationships between human capital resources (aggregates of individual differences) and firm competitive advantage (e.g., Hitt, Biermant, Shimizu, & Kochhar, 2001). Such breadth speaks to the importance of intelligence in science and practice. These different disciplinary perspectives each offer unique insights, but the research has tended to be more *multidisciplinary* than *interdisciplinary* (Ployhart & Hale, 2014). That is, intelligence is not conceptualized, operationalized, or understood the same way within psychology, economics, and strategic management, and each field remains fairly independent of the others (Ployhart, Nyberg, Reilly, & Maltrich, 2014). This is particularly troubling because research on human capital has the opportunity to illuminate how individual differences such as intelligence influence the performance of firms and even societies.

The purpose of this article is to consider how recent findings based on an information processing approach to intelligence can inform the study of human capital resources in organizations. We focus primarily on how theory and research in cognition and psychometrics can enhance understanding human capital and talent management. The article will focus on what human capital and management professionals need to know about what determines achievement, and emphasizes three key points. First, achievement is based, in large part, on what we know and how much we know. Second, what we know is a product of how well we process information and on the information we have been given to process. Third, some of the information that we process that is important for achievement has to do with what we believe about our ability to achieve our goals by our own efforts. That belief is called

\* Corresponding author at: Management Department, Darla Moore School of Business, University of South Carolina, Columbia, SC 29208.  
E-mail address: [ployhart@moore.sc.edu](mailto:ployhart@moore.sc.edu) (R.E. Ployhart).

self-control. Thus, understanding the information processing foundations of intelligence may offer insight into how firms can use intelligence as a valuable human capital resource for generating competitive advantage in a globally diverse world.

In the section that follows, we first provide a brief summary and review of human capital within organizations. Our focus is mainly on human capital resources at the firm level, although we do occasionally consider human capital from the perspective of economics. We then turn to a consideration of information processing perspectives on intelligence, and finally summarize an empirical study that illustrates the flavor of this kind of research. A summary of key implications of the information processing view of intelligence is provided, and we conclude with a broader research agenda for connecting human capital research with information processing research on intelligence.

## 2. Intelligence, human capital, and competitive advantage

Early civilizations such as the Chinese and Greeks realized that intelligence, along with other individual difference constructs, could be leveraged to enhance performance on tasks and jobs. Yet it was not until Adam Smith's (1776) treatise on "the wealth of nations" that such intellectual capacities became a more prominent part of economic thought. It would then take another 175 years before these intellectual capacities were more formally integrated into economics via the introduction of human capital theory (Becker, 1964; Schultz, 1961). The contemporary study of human capital originated in economics during the late 1950s, with an early emphasis on understanding individual wage differentials due to differences in education and tenure. Although many of the early economists who developed human capital theory would ultimately receive Nobel Prizes, at the time it was a fairly radical idea to conceptualize human intellectual capabilities as a form of capital.

Strategic management interest in human capital became more widespread in the 1990s because it appeared that human capital could be a firm-level resource capable of enhancing competitive advantage. This research proceeded to conceptualize human capital within the lens of resource-based theory (RBT; Barney, 1991; Barney & Wright, 1998; Wernerfelt, 1984). RBT holds that firms are heterogeneous in their endowment of resources, and these resource endowments contribute to variability in organizational performance and competitive advantage. For our purposes, competitive advantage is generally defined in terms of achieving above-normal returns relative to competitors (Peteraf & Barney, 2003). Competitive advantage is thus an issue of differentiation, not simply "more is better." Resources that contribute to competitive advantage are valuable and rare, and such advantages may be sustainable if the resources are also inimitable and nonsubstitutable (Barney, 1991). From even the beginning of RBT, it was suspected that human capital resources have the potential to underlie sustained competitive advantage because they have these four characteristics. Human capital is not something that can be "owned" by the organization (Coff, 1997), and hence firms must deploy Human Resource (HR) policies and practices that can accumulate (through employee selection) and develop (through training) it. The accumulation and development processes are socially complex, causally ambiguous, and path dependent, thus making human capital difficult to imitate.

The economic human capital theory (Becker, 1964) is primarily focused on the individual level, while RBT is primarily focused on the firm level. Yet both of these theoretical frameworks emphasized individual difference constructs among people. What is surprising, however, is that the RBT-based research on human capital was derived from the economics approach. In turn, the economics approach emphasized the study of education and experience to examine how these characteristics helped explain wage differentials over time (see Becker, 2011). Human capital theory further focused on two main types of individual characteristics that were important for the purposes of the theory: generic human capital that could be applied to any firm and context, and specific human capital which was only applicable to a particular firm. This distinction was important for explaining wage differentials within the lens of human capital theory, but strategy scholars took this distinction and applied it to competitive advantage. Specifically, generic human capital resources could not be a source of competitive advantage because the value that they produce corresponds to the costs of acquiring them (they were also imitable and mobile); specific human capital resources could be a source of competitive advantage because there is no corresponding labor market where they can be acquired (Barney, 1986).

Clearly, the prior research on human capital theory and human capital resources ignored the nearly 100 years of research on individual differences in psychology. It is perhaps no surprise, then, that the predictions from those fields collide with the scholarship in psychology and individual differences. In psychology, "generic" individual differences such as intelligence, personality, and values, have been shown to be related to the most important occupational and personal outcomes (Jensen, 1998; Schmidt & Hunter, 1998, 2004). What one might call "specific" individual differences are those that are more contextually-bound, such as specific forms of knowledge and skill. The fascination of individual differences within the psychological research has been on "generic" individual differences precisely because they are important across multiple contexts.

Of the various generic individual difference constructs that exist, intelligence is one of the most enduring. This is not surprising given that intelligence predicts nearly all major life and work outcomes, at least at the individual level. Those with greater intelligence have greater individual job performance (Schmidt & Hunter, 2004), and the importance of intelligence increases as the complexity of the job increases (see Schmidt, 2002). Intelligence is positively related to a number of other important individual outcomes, including educational attainment, educational performance, income, occupation, psychological adjustment, and health; and negatively related to workplace accidents, delinquency, and disciplinary problems (see Gottfredson, 1997; Herrnstein & Murray, 1994; Jensen, 1998; Lubinski & Humphreys, 1997; Schmidt, 2002). Yet notice that this research is nearly universally conducted at the individual level and linked to individual level outcomes. It is less clear whether intelligence contributes to the formation of human capital resources that contribute to competitive advantage.

More contemporary human capital research is starting to recognize the psychological "microfoundations" of human capital resources (see Barney & Felin, 2013; Coff & Kryscynski, 2011; Wright & McMahan, 2011). That is, rather than relying on human capital theory conceptualizations of individual differences, the emphasis is becoming more of one that connects RBT to psychology (Ployhart & Hale, 2014).

This, in turn, is creating an appreciation for individual differences widely studied within psychology (e.g., intelligence, personality), which historically were not treated as forms of human capital. Ployhart and Moliterno (2011) developed a theoretical framework that connects strategic resources to psychological-based individual differences. They define human capital resources as “a unit-level resource that is created from the emergence of individuals' knowledge, skills, abilities, and other characteristics (KSAOs)” (p. 128). Emergence refers to the contextual and social factors that lead to individual differences becoming manifested unit-level phenomena (Kozlowski & Klein, 2000). Human capital resources are transformed into collective constructs from individual KSAOs as a result of an emergence enabling process. The first part of this process involves the complexity of the task environment. The more a unit's tasks require coordination and interaction, the more likely the collective human capital resource will differ from its lower-level origins. The second part of this process involves emergence enabling states that create a social context supportive of emergence. These emergence enabling states are cognitive (e.g., transactive memory), affective (e.g., trust, cohesion), and behavioral (e.g., coordination patterns).

Thus, individual differences in intelligence may transform into unit-level collective human capital resources based on the manner in which members interact and the social context that surrounds such interactions. The next evolution of this research is to more strongly connect the strategic research on human capital resources to the current research on individual difference KSAOs. In this article we focus on intelligence because of its central place within both the basic and applied psychology literatures and its applicability to the workplace. The following section therefore considers what intelligence is by offering a new perspective on how intelligence contributes to achievement. This perspective is important because it may offer new insights into the formation and leveraging of human capital resources for competitive advantage.

### 3. Intelligence as information processing

Two theoretical approaches regarding the nature of intelligence are currently prevalent. The psychometric approach focuses upon analyses within and among intelligence tests to provide clues as to the nature of intelligence. The psychometric approach has led some theorists to conclude that there is a single intelligence (Jensen, 1998) and other theorists to conclude that there are multiple intelligences (Sternberg, 1997a,b). The second approach (Ackerman, 1996; Fagan, 1992, 2000) recognizes the aspects of both psychometric approaches and emphasizes information processing ability as the definition of intelligence. Theories equating intelligence with information processing assume that knowledge is the result of information processing ability while pointing to additional influences on achievement per se. A common thread running through all the theories noted above is the sense that some basic cognitive abilities, however defined, underlie intelligent functioning. Jensen holds that there is a general factor in intelligence explainable, in part, as the speed or efficiency of information processing. Sternberg (1997a,b, 2000a,b) emphasizes, as fundamental, elementary learning abilities underlying intelligence, abilities which remain the same across cultural contexts. Ackerman's (1996) theory posits intelligence as information processing ability interacting with personality and with interests to result in intelligence as knowledge. Fagan (1992, 2000) assumes that a set of mental activities underlying information processing which are influenced by genetic mechanisms and by biophysical influences on the brain operate on information provided by the culture to result in knowledge. These mental activities would include sensing and perceiving, association of new information to what is already known and selective attention to new aspects of received information which results in changes in and growth in knowledge. The theoretical approach guiding our further discussion defines intelligence as information processing ability and the intelligence quotient (IQ score) as a measure of knowledge, knowledge resulting from processing ability and from the information provided by the culture for processing (Fagan, 1992, 2000).

In addition to intellectual ability, there is a further determinant of achievement in complex situations. That factor is one's sense of self-control. Ackerman (1996) noted aspects of personality as additional determinants of achievement on the part of adults. A review by O'Connor and Paunonen (2007) of research based on McCrae and Costa's (1997) Five-Factor Model of personality showed that one aspect of personality, self-discipline, predicts the academic performance of young adults. A study by Beier, Campbell, and Crook (2010) and a review by von Stumm, Hell, and Chamorro-Premuzic (2011) reinforce O'Connor and Paunonen's conclusions. Sternberg, Grigorenko, and Bundy (2001) and Zimmerman and Kitsantas (2005) also point to peoples' beliefs in their own control as important in achieving success. Tangney, Baumeister, and Boone (2004) developed a brief, easily administered self-report measure of self-control and found it to be predictive of both academic and interpersonal success. The Tangney et al. scale was also employed in a study by Duckworth and Seligman (2005) who found that self-control accounted for more variance in the prediction of grades among adolescents than did IQ scores.

With regard to occupational success, it is well known that the extent of one's current knowledge (as indexed by IQ) is predictive of occupational success (Schmidt & Hunter, 2004) and of income (Zagorsky, 2007). There is also some evidence that personality factors indicative of self-control such as conscientiousness (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007; Schmidt & Hunter, 2004) and locus of control (Zagorsky, 2007) may also contribute to occupational success. While the results of these studies are impressive as to the importance of self-control in success in various situations, the generality of their findings is limited by the question of whether self-control contributes variance to the prediction of achievement which is independent of that contributed by intellectual ability (von Stumm et al., 2011). Nisbett et al. (2012) note in a recent review of findings in the field of intelligence that motivational factors such as self-control may be influencing achievement in academic pursuits as well as in other life outcomes in addition to the influence of intelligence on achievement.

The question of whether self-control influences occupational success independently of the contribution made by information processing ability in populations where there is a wide range of intellectual functioning is illustrated in a recent empirical study conducted by Fagan (2012). This study was intended to discover how information processing ability, extent of past knowledge, self-control and racial-ethnic status interrelate to determine occupational achievement. Specifically, a set of three studies including 487 employed adults, representative of the general population as to race, with a mean age of 43.6 years (*SD* 9.0), 190 males and 297 females, were

tested for their ability to process new information as to the meanings and uses of words, for the extent of their existing knowledge of word uses and meanings, and for their responses to questions about their sense of self-control. The general approach was to give the participants multiple choice tests of their ability to process new information concerning word meanings. Following a brief training, the participants received a set of multiple choice tests on the newly learned material. They were also tested for their existing general knowledge of word meanings. The tasks used in the present studies to estimate either the ability to process new information or to gauge the extent of past knowledge were representative of complex, verbal tasks commonly used on standard IQ tests. Achievement was estimated by ratings of occupational status based on norms for socioeconomic indices for detailed categories within occupational classifications. Self-control, independent of the tendency to give socially desirable answers, was measured by using various self-report scales. The analyses showed that greater occupational status was associated, independently, with better information processing ability, more past knowledge, greater self-control and to membership in the racial–ethnic majority. The extent of a person's knowledge was due (in large part) to their information processing ability and was greater on the part of the racial majority. Self-control did not vary with processing ability or with knowledge and was, in fact, somewhat stronger for minorities.

In summary, information processing ability, extent of past knowledge, self-control and racial ethnic membership each influence occupational success. The fact that self-control contributes independent variance to the prediction of achievement is in accord with present thoughts about self-control as an influence on achievement independent of cognitive ability. Salthouse (2004) notes that intelligence is only one contributor to success during a lifetime, noting motivation and persistence as related to variance in achievement over age. Dweck (2008) assumes that acquired beliefs about one's self with regard to one's ability to achieve play an important role in achievement. Sternberg, Grigorenko, and Zhang (2008) assume that there are both ability and personality bases underlying learning. They note that personality bases are acquired in social situations and can be modified. Hunt (2008) agrees with Sternberg et al. (2008) in the need to combine intelligence and personality to predict achievement and points to conscientiousness, self-management and the ability to withstand delays in reward as examples of aspects of personality contributing to achievement. Kuncel and Hezlett (2010) note that the prediction of occupational achievement is increased by taking into account personality traits that have little or no correlation with cognitive ability.

The present results answer the further questions posed by von Stumm et al. (2011) and by Nisbett et al. (2012) as to whether personality factors such as self-control are predictors of achievement, independent of the variance in prediction due to intelligence. Self-control is such an independent predictor. The present results also tell us that racial differences in occupational success might not be sought in differences in self-control or in differences in basic information processing ability. They are to be sought in cultural differences in access to information relevant for occupational success. The criteria for acceptance and advancement in occupational pursuits are likely to be based on conventional tests of general knowledge, tests favoring the racial majority. Minority members achieving the same level of competence as majority members on those conventional tests are likely minority members whose information processing abilities and self-control are greater, allowing them to make up for a cultural disadvantage in access to relevant information.

These findings may be used to understand how and why intelligence could contribute to human capital resources and thus competitive advantage. For example, it appears that information processing ability, knowledge, and self-control all contribute to individual achievement. If these same characteristics also underlie competitive advantage at the firm level, then a firm would need to accumulate or develop all three to create a competitive advantage. Further, the pattern of interrelationships among these three characteristics may also create complementarities that result in a firm-level human capital resource being highly organization specific and thus not obtainable in strategic factor markets (Ployhart et al., 2014). This, in turn, could make the competitive advantage sustainable because it would be difficult for a competitor to duplicate all three resources and their interrelationships (Dierickx & Cool, 1989). Focusing on only one characteristic would likely obscure these relationships and seriously underestimate the extent to which intelligence underlies competitive advantage.

Alternatively, information processing, knowledge, and self-control could have different relationships to firm performance outcomes than those observed at the individual level. For example, generic human capital resources may be more valuable in times of organizational adaptation or environmental change than firm-specific human capital resources (e.g., Kim & Ployhart, 2014). This means information processing or self-control resources could be more strongly related to firm performance when adapting to changing task or environmental demands than knowledge resources. In contrast, knowledge resources may be more valuable under times of stable economic conditions. Thus, the relative effects of information processing, knowledge, and self-control on performance may be moderated by broader task or economic conditions, and this occurs at both individual (Lang & Bliese, 2009) and organizational (Kim & Ployhart, 2014) levels.

It is also worth considering that the multilevel view of human capital resources realizes that firm resources emerge from individual level KSAOs (Coff & Kryscynski, 2011; Ployhart & Moliterno, 2011; Wright & McMahan, 2011). Understanding the nature of the task context and emergence enabling states will be vital for understanding how information processing, knowledge, and self-control transform into unit-level resources. For example, those with greater information processing may attend to different types of HR practices or react to different types of task demands than those with less effective information processing. Similarly, those with greater self-control may show different types of social interactions than those with less self-control. In either case, the nature of emergence processes for intelligence may differ as a function of the information processing or self-control of members within the unit, and thus the likelihood that intelligence contributes to human capital resources and competitive advantage.

#### 4. An agenda for future human capital research

Researches on intelligence and human capital are similar in that they seek to understand how variability in human characteristics contributes to variability in performance outcomes. They differ primarily in their level of analysis and the nature of the performance

outcomes. Intelligence research tends to focus on individual level outcomes such as achievement, job performance, or educational performance. Human capital research tends to focus on individual earnings (in economics) or firm competitive advantage (in strategy). Despite these differences in level and outcome, intelligence plays a fundamental role. The recent research on psychological microfoundations of human capital resources explicitly recognizes the need for a better understanding of intelligence across all levels, and for multiple types of performance outcomes (Ployhart & Hale, 2014). Toward this end, we conclude by leveraging the insights of information processing approaches to intelligence, to develop an agenda for future human capital research.

#### 4.1. Study intelligence

The first suggestion is the simplest but also the most profound. We suggest that whenever possible, human capital research move away from proxies of intelligence, such as GPA or educational level, and study intelligence directly. Proxies such as GPA are imperfect indicators of intelligence and contain a host of sources of contamination and deficiency (e.g., socioeconomic status; motivation). Intelligence is just one type of individual difference that may comprise human capital, but it is perhaps the most important one because it is the latent construct that underlies most of the proxies used in past research: education, GPA, and even some measures of *g*. In fact, despite decades of research on the consequences of intelligence, we know almost nothing about whether organizations that are comprised of more intelligent employees outperform those that do not (Ployhart, 2012). We know that intelligence is a strong determinant of job performance, and utility analysis models estimate greater economic returns from using more valid tests, but the fact is that we have yet to see studies linking intelligence as a firm-level human capital resource to operational, financial, accounting, or market-based performance metrics (Schneider, Smith, & Sipe, 2000). Despite many claims, the linkage between individual differences—including intelligence—and firm performance is based more on estimates and hope than data.

If human capital research is going to connect to the psychological study of intelligence, then it will have to adopt the latter's theories and measurement methods. Measures of employees' information processing abilities will be required, as well as measures of their knowledge and self-control. It will be important that these measures capture the breadth of intelligence and include the various individual difference constructs that contribute to achievement. Failing to measure intelligence in its multifaceted nature will lead to misspecified relationships and likely weaker effect size estimates for performance and competitive advantage. Current intelligence research highlights the importance of looking at these constructs and processes in combination (e.g., Ackerman, 1996; Fagan, 2012; Sternberg et al., 2008). While incorporating information processing measures of intelligence will be a dramatic break from past research, it is worth noting that the issues with measuring intelligence in this manner are no greater than administering measures of psychometric *g*.

#### 4.2. Examine personality and self-control

The study of human capital tends to focus on one "type," by which we mean that only a single individual difference is expected to represent human capital. Studies tend to conceptualize human capital in terms of a single (but broad and multidimensional) knowledge, skill, or ability (see Nyberg, Moliterno, Hale, & Lepak, 2014). For example, Ployhart, Weekley, and Ramsey (2009) operationalized human capital in terms of service orientation that was comprised of personality and basic numerical ability. If the study of human capital is to incorporate the research on intelligence as information processing, then it will need to also examine self-control and the personality characteristics that may contribute to self-control. This will obviously require looking at multiple resources, which is something that the human capital literature has typically not done (Ployhart et al., 2014). Interestingly, much of the contemporary HR research promotes HR policies and practices that offer autonomy, build trust, and increase involvement (Becker & Huselid, 2006). These practices essentially offer more discretion to employees, but one may suggest that such discretion is likely to be helpful only to the extent that employees have sufficient levels of self-control. If correct, then many interesting questions come to mind. For example, can HR policies or practices take the place of self-control by guiding and constraining employee behavior? Does self-control matter more in the absence of appropriate HR policies or practices? Might self-control and HR policies and practices operate in a synergistic manner?

#### 4.3. Complementarities

Intelligence research by Fagan (2012) clearly shows that there are interrelationships among information processing, knowledge, and self-control, and these constructs jointly influence achievement. The multi-faceted perspective is also found in other models of intelligence, such as Ackerman (1996), Cronbach and Snow (1969) and Sternberg et al. (2008). We need to know more about how these constructs combine to influence each other, which requires a more dynamic and process-oriented view. For example, it would be helpful to know how levels of one characteristic of intelligence contribute to levels of another characteristic. Hunter (1983) (see also Schmidt & Hunter, 2004) suggests that cognitive ability contributes to the formation of job knowledge, and it is for this reason that cognitive ability predicts job performance. However, all of this research is conducted at the individual level. We don't know whether these interrelationships also exist at the firm level or if firm-level human capital resources are a composite of individual level relationships. Understanding these causal interrelationships is vital yet surprisingly consistent with the strategy research on resource complementarities. Complementarities are simply combinations of resources that jointly create a synergistic effect on outcomes (Adegbesan, 2009). Combinations of resources may create a competitive advantage because they are more immobile, inimitable, and have less well-defined strategic factor markets than "stand-alone" resources (Denrell, Fang, & Winter, 2003; Schmidt & Keil, 2013). In this manner, research needs to consider how the interrelationships observed at the individual level

among information processing, knowledge, and self-control, may be manifested at the firm level to influence performance and competitive advantage. These resource complementarities may result in human capital being a strong determinant of competitive advantage because they are socially complex, causally ambiguous, and path-dependent (e.g., Ployhart et al., 2014).

#### 4.4. How to build intelligence-based human capital resources

It would be interesting to study how HR policies and practices can be used to build human capital resources based on intelligence. Existing research certainly suggests that it is possible (e.g., Lepak, Liao, Chung, & Harden, 2006; Ployhart & Moliterno, 2011; Schneider, 1987), but most of the past research has examined the direct link between HR policies and practices to firm performance, neglecting the intermediate processes (Becker & Huselid, 2006). It will be important for future research to focus on cross-level and mediated relationships (e.g., Felin & Hesterly, 2007). HR policies and practices first produce a cross-level influence on employee behavior, affect, and cognition. Then, if these policies and practices are understood by employees and applied consistently (Bowen & Ostroff, 2004), firm-level resources will emerge from the individual level behavior, affect, and cognition. It is the firm-level resources that directly relate to performance. Thus, the key is to understand how HR policies and practices influence human capital resource emergence. For example, how might tests of information processing be used to better screen applicants, relative to existing psychometric measures of *g*? Would using information processing measures contribute to the emergence of an intelligence-based human capital resource more quickly than existing approaches? Can training be developed to improve information processing ability, and what types of incentives may be necessary to ensure that it is maintained on the job?

Similarly, research should examine how HR policies and practices can influence self-control directly. Applicants could be hired by screening on self-control. Training could then be implemented to help foster and develop greater self-control. Compensation systems could ensure that self-control was being manifested appropriately and encouraged. In this manner, there could be a “self-control HR system” created similar to those that emphasize high commitment, involvement, or performance.

#### 4.5. Capabilities

The strategic management literature gives considerable attention to capabilities, which are the mechanisms and processes through which a firm may bundle, deploy, or divest of resources (Sirmon, Hitt, & Ireland, 2007; Teece, Pisano, & Shuen, 1997). For our purposes, capabilities reference the extent to which a firm can manage or leverage its resources. These capabilities are often based on managerial competencies, for example, a manager's ability to appropriately value resources acquired within strategic factor markets (Schmidt & Keil, 2013). Likewise, the management team's cognitive endowments and teamwork processes will have a fundamental influence on the management and use of resources (Helfat & Peteraf, 2003). Thus, managerial cognition can be conceptualized as an intelligence and can be as important as the resources themselves.

Future research should build from existing work and incorporate information processing models of managerial cognition (Hodgkinson & Healey, 2011). There is no reason to expect that managers are different in their basic information processing than any other groups of people. However, the *context* within which these processes may occur is likely to be quite distinct. Managers are challenged by environments that require collaboration and teamwork, involve poorly-defined problem spaces, and have a lack of necessary resources (including time). Basic research based on controlled simulations of these environments could be conducted to understand the degree to which information processing ability, specific product knowledge, time, degree of collaboration required, attitudes toward teamwork, and variations in problem space contribute to or determine managerial success.

#### 4.6. Diversity and intelligence

The applied psychology literature has long observed a trade-off between intelligence and racial/ethnic diversity. Specifically, Whites and Asians tend to score higher on intelligence tests than Blacks and Hispanics, and these differences are large enough to result in disproportionately lower hiring rates (adverse impact) for the minority group members (Sackett & Wilk, 1994). This tradeoff creates a difficult dilemma for those who wish to use intelligence tests in a manner that will also not affect diversity. This dilemma is not trivial because many firms have enhancing diversity as one of their strategic goals. For example, in many industries, the customer base has become more diverse and so firms are trying to structure their workforce in a way that mirrors the customer base.

To date, most of the research on resolving the diversity–intelligence dilemma has taken tests of psychometric *g* as a given, and focused on tactics that can be used to reduce or diminish the subgroup differences *after* the scores have been obtained (Ployhart & Holtz, 2008). It should come as no surprise that these attempts can reduce the subgroup differences, but they are not easy or inexpensive to implement. For example, one alternative is to use work simulations instead of measures of *g*, but these simulations can be expensive and may themselves have sizeable subgroup differences to the extent that intelligence is needed to perform them.

In contrast, the approach proposed here puts the emphasis much farther upstream, where the intelligence scores are obtained in the first place. The information processing approach of Fagan rejects the assumption held by the developers of all conventional intelligence tests that each person taking the test has had equal opportunity for exposure to the information upon which the test is based. Data from the information processing approach has shown that differences between racial–ethnic groups for items tested on an intelligence test can be reduced when equal opportunity for exposure to the information to be tested is experimentally assured. The data are consistent with the view that cultural differences in the provision of relevant information account for racial–ethnic differences in IQ (Fagan & Holland, 2007). Reducing the subgroup differences at the stage of access to relevant information is possibly key to resolving the dilemma between diversity and use of intelligence tests. Further, recognizing that other constructs such as self-control are also

important for achievement actually mirrors some of the existing suggestions for reducing subgroup differences (e.g., including personality assessments with tests of intelligence). Future research needs to consider whether the information processing approach to intelligence can be applied in the workplace with the same levels of validity and efficiency as the existing (psychometric *g*-loaded) measures, but with smaller racial–ethnic subgroup differences. Further, it would be interesting to extend this research into human capital. For example, is there an intelligence–diversity tradeoff at the firm level, or are they complementary? Are firms that are more racially diverse more innovative or adaptive, and how does intelligence influence these relationships? Just as there are potential fallacies in generalizing the individual level research on intelligence and job performance to the firm level, there may be fallacies in generalizing the individual level research on intelligence and diversity to the firm level as well.

Valid and accurate estimates of intelligence are needed to meet the challenges of the modern global workplace. Firms can now access talent wherever it exists, and the supply of talent is not distributed evenly around the world. The competitive advantage of global firms is often dependent on their ability to acquire and accumulate the desired kinds of human capital resources. And with knowledge-based work becoming more prevalent (e.g., Felin, Zenger, & Tomsik, 2009), being able to acquire and develop human capital resources based on intelligence will require the use of intelligence tests that do not negatively impact diversity. Indeed, being able to accumulate and develop a workforce with high levels of human capital resources that are based on intelligence, in a diversity-friendly manner, may be the most valuable, rare, inimitable, and non-substitutable resource of them all—the very factors necessary for creating a sustainable competitive advantage.

## 5. Conclusion

Information processing approaches to intelligence offer many implications for the understanding of human capital in organizations. At the same time, the study of information processing approaches within dynamic organizational contexts may contribute to a better understanding of intelligence. The strategy literature's examination of human capital as a source of competitive advantage has led it to search for the microfoundations of human capital resources. The intelligence of employees offers one of the most valuable psychologically-based microfoundations because it has the potential to be valuable, rare, inimitable, and non-substitutable. We suggest that future research seek to more fully integrate intelligence and human capital research, since such an integration is likely necessary to provide a complete understanding of intelligence in the workplace.

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Regrettably, Professor Fagan passed away while this manuscript was under review. We are all sorry about his loss and dedicate this article to his memory.

## References

- Ackerman, P.L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence*, 22, 227–257.
- Adegbesan, J.A. (2009). On the origins of competitive advantage: Strategic factor markets and heterogeneous resource complementarity. *Academy of Management Review*, 34, 463–475.
- Barney, J.B. (1986). Strategic factor markets: Expectations, luck, and business strategy. *Management Science*, 32, 1231–1241.
- Barney, J.B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17, 99–120.
- Barney, J., & Felin, T. (2013). What are microfoundations? *The Academy of Management Perspectives*, 27(2), 138–155.
- Barney, J.B., & Wright, P.M. (1998). On becoming a strategic partner: The role of human resources in gaining competitive advantage. *Human Resource Management*, 37, 31–46.
- Becker, G.S. (1964). *Human capital* (3rd ed.). Chicago: The University of Chicago Press.
- Becker, G.S. (2011). Forward. In A. Burton-Jones, & J.C. Spender (Eds.), *The Oxford handbook of human capital* (pp. xiii–xvi). Oxford: Oxford University Press.
- Becker, B.E., & Huselid, M.A. (2006). Strategic human resource management: Where do we go from here? *Journal of Management*, 32, 898–925.
- Beier, M.E., Campbell, M., & Crook, A.E. (2010). Developing and demonstrating knowledge: Ability and non-ability determinants of learning and performance. *Intelligence*, 38, 179–186.
- Bowen, D.E., & Ostroff, C. (2004). Understanding HRM–firm performance linkages: The role of the strength of the HRM system. *Academy of Management Review*, 29, 203–221.
- Coff, R.W. (1997). Human assets and management dilemmas: Coping with hazards on the road to resource-based theory. *Academy of Management Review*, 22, 374–402.
- Coff, R.W., & Kryscynski, D. (2011). Drilling for micro-foundations of human capital-based competitive advantages. *Journal of Management*, 37, 1429–1443.
- Cronbach, L.J., & Snow, R.E. (1969). *Individual differences in learning ability as a function of instructional variables*. Final report.
- Denrell, J., Fang, C., & Winter, S.G. (2003). The economics of strategic opportunity. *Strategic Management Journal*, 24, 977–990.
- Dierckx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science*, 35, 1504–1511.
- Duckworth, A.L., & Seligman, M.E.P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science*, 16, 939–944.
- Dweck (2008). Can personality be changed? The role of beliefs in personality and change. *Current Directions in Psychological Science*, 17, 391–394.
- Fagan, J.F. (1992). Intelligence: A theoretical viewpoint. *Current Directions in Psychological Science*, 1, 82–86.
- Fagan, J.F. (2000). A theory of intelligence as processing: Implications for society. *Psychology, Public Policy, and Law*, 6, 168–179.
- Fagan, J.F. (2012). *Additional culture-fair tests predictive of achievement*. Final report. United States Army Research Institute, Foundational Research Unit.

- Fagan, J.F., & Holland, C.R. (2007). Racial equality in intelligence: Predictions from a theory of intelligence as processing. *Intelligence*, 35, 319–334.
- Felin, T., & Hesterly, W.S. (2007). The knowledge-based view, nested heterogeneity, and new value creation: Philosophical considerations on the locus of knowledge. *Academy of Management Review*, 32, 195–218.
- Felin, T., Zenger, T.R., & Tomsik, J. (2009). The knowledge economy: emerging organizational forms, missing microfoundations, and key considerations for managing human capital. *Human Resource Management*, 48, 555–570.
- Gottfredson, L.S. (1997). Why g matters: The complexity of everyday life. *Intelligence*, 24(1), 79–132.
- Helfat, C.E., & Peteraf, M.A. (2003). The dynamic resource-based view: Capability lifecycles. *Strategic Management Journal*, 24, 997–1010.
- Herrnstein, R.J., & Murray, C. (1994). *The bell curve: The reshaping of American life by differences in intelligence*. New York: Free.
- Hitt, M.A., Biermant, L., Shimizu, K., & Kochhar, R. (2001). Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective. *Academy of Management Journal*, 44, 13–28.
- Hodgkinson, G. P., & Healey, M. P. (2011). Psychological foundations of dynamic capabilities: Reflexion and reflection in strategic management. *Strategic Management Journal*, 32, 1500–1516. <http://dx.doi.org/10.1002/smj.964>.
- Hunt, E. (2008). Applying the theory of successful intelligence to education: The good, the bad, and the ogre. *Perspectives on Psychological Science*, 3, 509–515.
- Hunter, J.E. (1983). A causal analysis of cognitive ability, job knowledge, job performance, and supervisory ratings. In F. Landy, S. Zedeck, & J. Cleveland (Eds.), *Performance measurement and theory* (pp. 257–266). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Jensen, A.R. (1998). *The g factor*. Westport, CT: Praeger.
- Kim, Y., & Ployhart, R. E. (2014). The effects of staffing and training on firm productivity and profit growth before, during, and after the Great Recession. *Journal of Applied Psychology*, 99, 361–389.
- Kozlowski, S.W.J., & Klein, K.J. (2000). A multilevel approach to theory and research in organizations: Contextual, temporal, and emergent processes. In K.J. Klein, & S.W.J. Kozlowski (Eds.), *Multilevel theory, research, and methods in organizations: Foundations, extensions, and new directions* (pp. 3–90). San Francisco: Jossey-Bass.
- Kuncel, N.R., & Hezlett, S.A. (2010). Fact and fiction in cognitive ability testing for admissions and hiring decisions. *Current Directions in Psychological Science*, 19, 339–345.
- Lang, J.W., & Bliese, P.D. (2009). General mental ability and two types of adaptation to unforeseen change: Applying discontinuous growth models to the task-change paradigm. *Journal of Applied Psychology*, 94(2), 411.
- Lepak, D.P., Liao, H., Chung, Y., & Harden, E.E. (2006). A conceptual review of human resource management systems in strategic human resource management research. *Research in Personnel and Human Resources Management*, 25, 217–271.
- Lubinski, D., & Humphreys, L.G. (1997). Incorporating general intelligence into epidemiology and the social sciences. *Intelligence*, 24(1), 159–201.
- McCrae, R.R., & Costa, P.T., Jr. (1997). Personality trait structure as a human universal. *American Psychologist*, 52, 509–516.
- Nisbett, R.E., Aronson, J., Blair, C., Dickens, W., Flynn, J., Halpern, D.F., et al. (2012). Intelligence. *American Psychologist*, 67, 130–159.
- Nyberg, A. J., Moliterno, T. P., Hale, D., & Lepak, D. P. (2014). Resource-based perspectives on unit-level human capital: A review and integration. *Journal of Management*, 40, 316–346.
- O'Connor, M.C., & Paunonen, S. (2007). Big Five personality predictors of post-secondary academic performance. *Personality and Individual Differences*, 43, 971–990.
- Peteraf, M.A., & Barney, J.B. (2003). Unraveling the resource-based tangle. *Managerial & Decision Economics*, 24, 309–323.
- Ployhart, R.E. (2012). Personnel selection and the competitive advantage of firms. In G.P. Hodgkinson, & J.K. Ford (Eds.), *International Review of Industrial and Organizational Psychology*, 27. (pp. 153–196). Indianapolis, IN: Wiley.
- Ployhart, R.E., & Hale, D. Jr (2014). The fascinating psychological microfoundations of strategy and competitive advantage. *Annual Review of Organizational Psychology and Organizational Behavior*, 1, 145–172.
- Ployhart, R.E., & Holtz, B.C. (2008). The diversity–validity dilemma: Strategies for reducing racial/ethnic and sex subgroup differences and adverse impact in selection. *Personnel Psychology*, 61, 153–172.
- Ployhart, R.E., & Moliterno, T.P. (2011). Emergence of the human capital resource: A multilevel model. *Academy of Management Review*, 36, 127–150.
- Ployhart, R.E., Nyberg, A.J., Reilly, G., & Maltrich, M. (2014). Human capital is dead. Long live human capital resources! *Journal of Management*, 40, 371–398.
- Ployhart, R.E., Weekley, J.A., & Ramsey, J. (2009). The consequences of human resource stocks and flows: A longitudinal examination of unit service orientation and unit effectiveness. *Academy of Management Journal*, 52, 996–1015.
- Roberts, B.W., Kuncel, N.R., Shiner, R., Caspi, A., & Goldberg, L.R. (2007). The comparative validity of personality traits, socioeconomic status, and cognitive ability for predicting important life outcomes. *Perspectives on Psychological Science*, 2, 313–343.
- Sackett, P.R., & Wilk, S.L. (1994). Within-group norming and other forms of score adjustment in preemployment testing. *American Psychologist*, 49, 929–954.
- Salthouse, T.A. (2004). What and when of cognitive aging. *Current Directions in Psychological Science*, 13, 140–144.
- Schmidt, F.L. (2002). The role of general cognitive ability and job performance: Why there cannot be a debate. *Human Performance*, 15, 187–210.
- Schmidt, F., & Hunter, J. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin*, 124, 262–274.
- Schmidt, F.L., & Hunter, J. (2004). General mental ability in the world of work: Occupational attainment and job performance. *Journal of Personality and Social Psychology*, 86, 162–173.
- Schmidt, J., & Keil, T. (2013). What makes a resource valuable? Identifying the drivers of firm-idiosyncratic resource value. *Academy of Management Review*, 38, 206–228.
- Schneider, B. (1987). The people make the place. *Personnel Psychology*, 40, 437–453.
- Schneider, B., Smith, D.B., & Sipe, W.P. (2000). Personnel selection psychology: Multilevel considerations. In K.J. Klein, & S.W.J. Kozlowski (Eds.), *Multilevel theory, research, and methods in organizations: Foundations, extensions, and new directions* (pp. 91–120). San Francisco, CA: Jossey-Bass.
- Schultz, T.W. (1961). Investment in human capital. *American Economic Review*, 51, 1–17.
- Sirmon, D.G., Hitt, M.A., & Ireland, R.D. (2007). Managing firm resources in dynamic environments to create value: Looking inside the black box. *Academy of Management Review*, 32, 273–292.
- Smith, A. (1776). *An inquiry into the nature and causes of the wealth of nations* (1963 ed.). Homewood, IL: Richard D. Irwin, Inc.
- Sternberg, R.J. (1997a). The concept of intelligence and its role in lifelong learning and success. *American Psychologist*, 52, 1030–1037.
- Sternberg, R.J. (1997b). *Successful intelligence*. New York: Plume.
- Sternberg, R.J. (2000a). The concept of intelligence. In R.J. Sternberg (Ed.), *Handbook of intelligence*. New York: Cambridge University Press.
- Sternberg, R.J. (2000b). Implicit theories of intelligence as exemplar stories of success: Why intelligence test validity is in the eye of the beholder. *Psychology, Public Policy, and Law*, 6, 159–167.
- Sternberg, R.J., Grigorenko, E.L., & Bundy, D.A. (2001). The predictive value of IQ. *Merrill Palmer Quarterly*, 47, 1–41.
- Sternberg, R.J., Grigorenko, E.L., & Zhang, L. (2008). Styles of learning and thinking matter in instruction and assessment. *Perspectives on Psychological Science*, 3, 486–506.
- Tangney, J.P., Baumeister, R.F., & Boone, A.L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, 72, 271–325.
- Teece, D.J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18, 509–533.
- von Stumm, S., Hell, B., & Chamorro-Premuzic (2011). The hungry mind: Intellectual curiosity is the third pillar of intellectual performance. *Perspectives on Psychological Science*, 6, 574–588.
- Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, 5, 171–180.
- Wright, P.M., & McMahan, G.C. (2011). Exploring human capital: Putting human back into strategic human resource management. *Human Resource Management Journal*, 21, 93–104.
- Zagorsky, J.L. (2007). Do you have to be smart to be rich? The impact of IQ on wealth, income and financial distress. *Intelligence*, 35, 489–501.
- Zimmerman, B.J., & Kitsantas, A. (2005). Homework practices and academic achievement: The mediating role of self-efficacy and perceived responsibility beliefs. *Contemporary Educational Psychology*, 30, 397–417.