Industrial and Organizational Psychology
PERSPECTIVES ON SCIENCE AND PRACTICE

I–O Psychology and Progressive Research Programs on Intelligence

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Scherbaum, Goldstein, Yusko, Ryan, and Hanges' (2012) conclusions and suggestions are partly based on two observations from extant research on intelligence in industrial–organizational (I–O) psychology. The first observation is that *g* is overwhelmingly more important in job performance than narrower cognitive abilities. The second observation is that *g* leads to higher flexibility in adapting to changes. Recent work suggests that both observations are closely linked to the use of theoretical assumptions and specific methods that are not necessarily superior to alternative assumptions and methods that lead to different conclusions (Lang & Bliese, 2009; Lang, Kersting, Hülsheger, & Lang, 2010). We suggest that studying these alternative perspectives is a promising starting point for progressive research programs on intelligence in the context of I–O psychology.

g, Narrower Cognitive Abilities, and Job Performance

Scherbaum et al. review work suggesting that narrower cognitive abilities do not have much incremental validity over *g* and propose that this finding has hampered the progress of the field. In their view, the future lies in using innovative new measurement approaches for the intelligence construct, and they suggest that I–O psychologists should contribute on studying the measurement of the construct—presumably with the idea in mind that this could potentially lead to different findings on the importance of *g* and narrower cognitive abilities in job performance.

The idea of finding a completely new measurement approach for intelligence and applying it to explain new variance in I–O criteria such as job performance is intuitively appealing. However, the research literature has shown that new conceptualizations and measures of intelligence frequently tap sources of variance that the extant intelligence literature (e.g., see Carroll, 1993, for an extensive review) has already considered in some way or are difficult to measure (e.g., Brody, 2003; Visser, Ashton, & Vernon, 2006). Intelligence research is a discipline that has investigated numerous different conceptualizations of the construct over the years (Carroll, 1993) and continues to establish new theories and approaches (e.g., Beauducel & Kersting, 2002; Johnson & Bouchard, 2005). However, these approaches are more evolutionary refinements than paradigm shifts. We accordingly believe that focusing on new approaches can improve but will not dramatically change the way I–O psychologists can predict criteria using intelligence.

Instead of trying to reconceptualize the intelligence construct and seeking to find totally new ways of measuring it, it may be more fruitful to reconsider the use

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of incremental validity analysis in studying the relationship between intelligence constructs and I–O criteria. The reoccurring finding (McHenry, Hough, Toquam, Hanson, & Ashworth, 1990; Ree, Earles, & Teachout, 1994) that the prediction of I–O criteria is dominated by *g* may be more related to the fact that I–O psychologists have largely focused on incremental validity analyses when studying the role of *g* and narrower cognitive abilities in I–O criteria than to the nature of the intelligence measures. One reason for the focus on incremental validity analysis may be that this method has long been readily available to I–O psychologists and directly corresponds to a specific theory in classic intelligence research, Spearman's (1904) original two-factor theory, and theories that build on this early conceptualization. Spearmanian theories entail the assumption that *g* (the general factor) has a causal effect on narrower cognitive abilities (the specific factors). Shared variance between *g* and narrower cognitive abilities therefore, by definition, always belongs to *g* and should automatically be assigned to *g* like in incremental validity analysis.

The problem with focusing only on Spearmanian theories is that they do not necessarily represent a majority view in the intelligence literature. There is a second class of theories—nested-factors theories—in intelligence research, which does not support the use of incremental validity analysis (Gustafsson & Balke, 1993; Holzinger & Swineford, 1937; Humphreys, 1981; Yung, Thissen, & McLeod, 1999). Modern Spearmanian theories that include latent narrower cognitive abilities and the nested-factors model are all hierarchical in the sense that there are narrower cognitive abilities that are lower in the hierarchy than an overarching *g* factor (Yung et al., 1999). However, Spearmanian theories define hierarchy in terms of subordination, whereby the higher order ability (*g*) causally influences the lower order abilities. In contrast, nested-factors conceptualizations define hierarchy in terms of breadth not subordination such that *g* and other abilities are only correlated and directly related to the measurement indicators. Nested-factors conceptualizations are consequently neutral regarding the debate on whether *g* causes lower order abilities or whether lower order abilities interact such that a positive manifold emerges (positive correlations between intelligence tests). Fundamental research and theory is currently and has long been divided on this major question and finds some support for both the idea that the narrower cognitive abilities can cause *g* (Bartholomew, Deary, & Martin, 2009; Dickens, 2007; van der Maas et al., 2006) and the alternative view (Spearman, 1904) that a single latent *g* factor causes the positive manifold phenomenon and that this *g* factor has a biological (Duncan et al., 2000) or cognitive basis (Deary, 2002). In using the nested-factors model, I–O psychologists can avoid relying on a theoretical assumption (that *g* causes the narrower cognitive abilities) that is not necessarily unanimously supported by research.

The nested-factors model has likely long been disregarded by researchers because a method that allows one to investigate the relationship between predictors and criteria in correspondence with the nested-factors conceptualization has long not been readily available. Recently, I–O psychologists have contributed to the development of an approach—relative importance analysis (Johnson & LeBreton, 2004)—that can be used to analyze the relationship between hierarchical ability structures and criteria in correspondence with the nested-factors model (Lang et al., 2010). In relative importance analysis, the shared variance between narrower cognitive abilities and *g* is not automatically assigned to *g*. Instead, the method empirically distributes shared variance among predictors such that ability factors do not need to be orthogonalized like in earlier approaches (Gustafsson & Balke, 1993) for research studying relationships between nested-factors conceptualizations and criteria.

A recent meta-analytic study suggests that the use of nested-factor theory and relative importance analysis instead

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of Spearmanian theories and incremental validity analysis leads to dramatically different conclusions regarding the importance of *g* and narrower cognitive abilities in job performance (Lang et al., 2010). The study applied both methods on a matrix linking *g*, Thurstone's (1938) seven primary mental abilities, and job performance. Results revealed that *g* accounted for 10.9–28.6% of the total explained variance in the relative importance analyses. Depending on the complexity of the jobs and the relative importance analysis method employed, *g* was also not consistently the most important predictor. In some situations, narrower cognitive abilities such as verbal comprehension or word fluency explained more of the total explained variance than *g*. These findings contrasted with the results of incremental validity analyses of the same data, suggesting that the majority of the total explained variance (more than 50% in all analyses conducted) belonged to *g*.

Although the described analyses focused on Thurstone's seven primary abilities and *g*, the findings are likely not restricted to intelligence as defined in the primary mental abilities. To illustrate this point, we conducted a similar analysis using the data of Project A (McHenry et al., 1990). In our reanalysis, we focused on the core technical performance (CTP), the general soldiering proficiency (GSP), and the effort and leadership (EL) criteria, and we included the verbal, the quantitative, the speed, the spatial, and the psychomotor composite as the narrower cognitive abilities. In addition, we built a *g* composite out of these narrower cognitive ability composites and one additional ability composite, the technical ability composite. We then calculated relative weights using a script written by Johnson (2000). Results revealed that *g* was an important explanatory variable but not an overwhelmingly dominant one (5.2%, 7.1%, and 1.8% of explained criterion variance for CTP, GPS, and EL, respectively). For two job-performance criteria, spatial ability was equally or more important (CTP: 5.5%; GSP: 8.7%). In contrast, incremental validity analyses on the same data suggested that *g* was very important (like in the original publication). Nearly all explained criterion variance was assigned to *g* in these analyses (CTP: 17.9% of 19.4%; GPS: 24.9 of 27.7; EL: 3.4% of 4.8%). As described earlier, the incremental-validity results are based on the preliminary theoretical assumption that shared variance between *g* and the narrower cognitive abilities belongs to *g*.

In summary, the recent meta-analytic study (Lang et al., 2010) and the reanalysis of the Project A data show that the nested-factors model provides an interesting theoretical alternative to Spearmanian theories. We believe that it is important to conduct both relative importance analyses and incremental validity analyses to fully understand the role of narrower cognitive abilities and *g* in job performance criteria and to account for alternative theoretical views. In addition, relative importance analyses on the basis of the nested-factors model also may lead to practical implications by providing I–O psychologists with a theoretical basis for choosing an ability predictor out of a set of ability predictors for selection purposes that is not *g*. For instance, when *g* and verbal ability or *g* and spatial ability are equally important in an analysis, there could be practical reasons for using the narrow cognitive ability for selection instead of *g* (e.g., job-relatedness, applicant reactions, face validity, and majority–minority differences). Figuring out when and how a strategy of this type could be beneficial is an interesting research question.

Intelligence and Flexibility

Scherbaum et al. write that ''a less predictable workplace requires critical workforce competencies that are related to intelligence such as ability to learn, solving problems, in ambiguous scenarios, and integrating wide and varied sets of information'' (pp. 129–130) and that ''these arguably intelligence-based skills are required to meet the challenges of the new world of

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work, thus putting a premium on intelligence (and intellectual capital) when staffing an organization'' (p. 130).

We agree with Scherbaum et al. regarding the need to investigate the relationship between intelligence and flexible and adaptive reactions to changes. However, it is not clear that intelligence is always positively related to flexibility or adaptability.

There is evidence suggesting a positive relationship between intelligence and flexibility in response to changes, and there is also evidence suggesting the opposite—a negative relationship. The notion that intelligence is positively related to adaptation to changes is frequently based on the idea that intelligent persons have more cognitive processing capacities that allow them to implement changes and a laboratory study that found an effect of this type (LePine, Colquitt, & Erez, 2000). In contrast, findings from working memory research suggest that high-ability persons face unique problems when they need to adapt. Working memory is an individual differences variable that is related to intelligence and sometimes thought to underlie intelligence (Ackerman, Beier, & Boyle, 2005; Kane, Hambrick, & Conway, 2005; Oberauer, Schulze, Wilhelm, & Süß, 2005). Research on working memory suggests that compared with low-ability persons, those with high ability use cognitive strategies that may interfere with adaptive processes. First, high-ability persons use more complex problem-solving strategies in complex tasks that cannot be adequately executed when they are under pressure (Beilock & Carr, 2005; Beilock & DeCaro, 2007) or need to perform a second task (Kane & Engle, 2000, 2002). Second, persons with high ability devote relatively more cognitive resources to core task components and ignore unnecessary components of tasks (Ricks, Turley-Ames, & Wiley, 2007). This tendency may hamper their ability to find new solution strategies after changes.

A recent laboratory study using a complex decision-making scenario (Lang & Bliese, 2009) has documented some evidence for a negative effect of *g* on adaptive processes. This study is unique in that it separates two types of adaptive processes relative to (or controlling for) the basal task performance level and skill acquisition before the change using a discontinuous growth modeling approach (Bliese, Chan, & Ployhart, 2007; Singer & Willett, 2003). The first adaptive process—transition adaptation—is the immediate reaction to a change in a task and captures the degree to which the level of performance is robust to changes. The second adaptive process—reacquisition adaptation—captures people's ability to relearn a task over time. Interestingly, this study found a negative relationship between *g* and transition adaptation and no significant relationship between *g* and reacquisition adaptation. It is important to note, however, that because transition adaptation and reacquisition adaptation were defined relative to the basal level of task performance and skill acquisition, persons with high *g*, on average, showed higher performance during the entire measurement period. An important implication is that high-*g* individuals may show higher performance before changes but this performance advantage may decline when unforeseen changes occur. These findings suggest that one should be cautious in assuming that high-*g* people are relatively better able to perform after a change. The study suggests that high-*g* persons continue to perform better than low-*g* individuals on average after a change but that this advantage is smaller than before the change. Although laboratory findings from the individual level rarely directly translate to findings in the field and to other levels of analysis such as the team and organizational level, the findings at least question the idea that organizations with relatively more high-ability individuals are automatically better able to cope with changes. The opposite may be true such that a strong reliance on employees who use complex and highly developed problem-solving strategies leads to particularly strong performance declines after changes. Ultimately, these questions can only be answered

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by analyzing field data using methodological approaches that comprehensively capture the temporal nature of adaptive processes.

References

Ackerman, P. L., Beier, M. E., & Boyle, M. O. (2005). Working memory and intelligence: The same or different constructs. *Psychological Bulletin, 131*, 30–60. doi: 10.1037/0033-2909.131.1.30.

Bartholomew, D. J., Deary, I. J., & Martin, L. (2009). A new lease for Thomson's bonds model of intelligence. *Psychological Review, 116*, 567–579. doi: 10.1037/a0016262.

Beauducel, A., & Kersting, M. (2002). Fluid and crystallized intelligence and the Berlin Model of Intelligence Structure (BIS). *European Journal of Psychological Assessment, 18*, 97–112. doi: 10.1027/1015-5759.18.2.97.

Beilock, S. L., & Carr, T. H. (2005). When high-powered people fail: Working memory and ''choking'' under pressure in math. *Psychological Science, 16*, 101–105. doi: 10.1111/j.0956-7976.2005.00789.x.

Beilock, S. L., & DeCaro, M. S. (2007). From poor performance to success under stress: Working memory, strategy selection, and mathematical problem solving under pressure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, 983–998. doi: 10.1037/0278-7393.33.6.983.

Bliese, P. D., Chan, D., & Ployhart, R. (2007). Multilevel methods and statistics: Emerging issues and future directions. *Organizational Research Methods, 10*, 551–563. doi: 10.1177/1094428107301102.

Brody, N. (2003). Construct validation of the Sternberg Triarchic Abilities Test: Comment and reanalysis. *Intelligence, 31*, 319–329. doi: 10.1016/S0160-2896(01)00087-3.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies.* Cambridge, UK: Cambridge University Press.

Deary, I. J. (2002). *g* and cognitive elements of information processing: An agnostic view. In R. J. Sternberg & E. L. Grigorenko (Eds.), *The general factor of intelligence* (pp. 151–182). Mahwah, NJ: Erlbaum.

Dickens, W. T. (2007, November 19). *What is g?* Paper presented at the second Thomas S. Schelling Symposium, University of Maryland, College Park, MD. Retrieved from http://www.publicpolicy.umd.edu/symposium/speakers.htm.

Duncan, J., Seitz, R. J., Kolodny, J., Bor, D., Herzog, H., Ahmed, A., . . . Emslie, H. (2000). A neural basis for general intelligence. *Science, 289*, 457–460. doi: 10.1126/science.289.5478.457.

Gustafsson, J.-E., & Balke, G. (1993). General and specific abilities as predictors of school achievement. *Multivariate Behavioral Research, 28*, 407–434. doi: 10.1207/s15327906mbr2804_2.

Holzinger, K. J., & Swineford, F. (1937). The bi-factor method. *Psychometrika, 2*, 41–54. doi: 10.1007/BF02287965.

Humphreys, L. G. (1981). The primary mental ability. In M. P. Friedman, J. R. Das, & N. O'Connor (Eds.), *Intelligence and learning* (pp. 87–102). New York, NY: Plenum.

Johnson, J. W. (2000). A heuristic method for estimating the relative weight of predictor variables in multiple regression. *Multivariate Behavioral Research, 35*, 1–9. doi: 10.1207/S15327906MBR3501_1.

Johnson J. W., & LeBreton J. M. (2004). History and use of relative importance indices in organizational research. *Organizational Research Methods, 7*, 238–257. doi: 10.1177/1094428104266510.

Johnson, W. & Bouchard, T. J., Jr. (2005). The structure of human intelligence: It is verbal, perceptual, and image rotation (VPR), not fluid and crystallized. *Intelligence, 33*, 393–416. doi: 10.1016/j.intell.2004.12.002.

Kane, M. J., & Engle, R. W. (2000). Working memory capacity, proactive interference, and divided attention: Limits on long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 333–358. doi: 10.10371/0278-7393.26.2.336.

Kane, M. J., & Engle, R. W. (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic Bulletin & Review, 9*, 637–671. doi: 10.3758/BF03196323.

Kane, M. J., Hambrick, D. Z., & Conway, A. R. A. (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, and Boyle (2005). *Psychological Bulletin, 131*, 66–71. doi: 10.1037/0033-2909.131.1.66.

Lang, J. W. B., & 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*, 411–428. doi: 10.1037/a0013803.

Lang, J. W. B., Kersting, M., Hülsheger, U. R., & Lang, J. (2010). General mental ability, narrower cognitive abilities, and job performance: The perspective of the nested-factors model of cognitive abilities. *Personnel Psychology, 63*, 595–640. doi: 10.1111/j.1744-6570.2010.01182.x.

LePine, J. A., Colquitt, J. A., & Erez, A. (2000). Adaptability of changing task contexts: Effects of general cognitive ability, conscientiousness, and openness to experience. *Personnel Psychology, 53*, 563–593. doi:10.1111/j.1744-6570.2000.tb00214.x.

van der Maas, H. L. J., Dolan, C. V., Grasman, R. P. P. P., Wicherts, J. M., Huizenga, H. M., & Raijmakers, M. E. J. (2006). A dynamical model of general intelligence: The positive manifold of intelligence by mutualism. *Psychological Bulletin, 113*, 842–861. doi: 10.1037/0033-295X.113.4.842.

McHenry, J. J., Hough, L. M., Toquam, J. L., Hanson, M. A., & Ashworth, S. (1990). Project A validity results: The relationship between predictor and criterion domains. *Personnel Psychology, 43*, 335–354. doi:10.111/j.1744-6570.1990. tb01562.x.

Oberauer, K., Schulze, R., Wilhelm, O., & Süß, H.-M. (2005). Working memory and intelligence—Their correlation and their relation: Comment on Ackerman, Beier, and Boyle (2005). *Psychological Bulletin, 131*, 61–65. doi: 10.1037/0033-2909.131.1.61.

https://doi.org/10.1111/j.1754-9434.2012.01423.x Published online by Cambridge University Press

Ree, M. J., Earles, J. A., & Teachout, M. S. (1994). Predicting job performance: Not much more than *g*. *Journal of Applied Psychology*, *79*, 518–524. doi: 10.1037/0021-9010.79.4.518.

Ricks, T. R., Turley-Ames, K. J., & Wiley, J. (2007). Effects of working memory capacity on mental set due to domain knowledge. *Memory & Cognition*, *35*, 1456–1462. doi: 10.3758/BF03193615.

Scherbaum, C. A., Goldstein, H. W., Yusko, K. P., Ryan, R., & Hanges, P. J. (2012). Intelligence 2.0: Reestablishing a research program on *g* in I–O psychology. *Industrial and Organizational Psychology: Perspectives on Science and Practice*, *5*, 128–148.

Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York, NY: Oxford University Press.

Spearman, C. (1904). ''General intelligence,'' objectively determined and measured. *American Journal of Psychology*, *15*, 201–292. doi: 10.2307/1412107.

Thurstone, L. L. (1938). *Primary mental abilities*. Chicago, IL: University of Chicago Press.

Visser, B. A., Ashton, M. C., & Vernon, P. A. (2006). Beyond *g*: Putting multiple intelligences theory to the test. *Intelligence*, *34*, 487–502. doi:10.1016/j.intell.2006.02.004.

Yung, Y.-F., Thissen, D., & McLeod, L. D. (1999). On the relationship between the higher-order factor model and the hierarchical factor model. *Psychometrika*, *64*, 113–128. doi:10.1007/BF02294531.

https://doi.org/10.1111/j.1754-9434.2012.01423.x Published online by Cambridge University Press