To cite this article: Yu, C., Beckmann, J. F., & Birney, D. P. (2019). Cognitive Flexibility as a Meta-Competency / Flexibilidad cognitiva como meta-competencia. *Estudios de Psicología*, 1-22.

# Cognitive Flexibility as a Meta-Competency

Calvin Yu[1]

Jens F. Beckmann[2]

&

Damian P. Birney[1*]

1. University of Sydney
2. Durham University

* Contact Author:

Damian P. Birney

School of Psychology

University of Sydney

damian.birney@sydney.edu.au

## Synopsis

There exists a large body of research that has studied cognitive flexibility as an executive function assessed through shifting and set-switching tasks. This approach has been criticised as overly narrow and reductionist (Ionescu, 2012; 2017), thereby undermining the relevance of cognitive flexibility beyond tightly controlled cognitive tasks. In light of such limitations, we review the extant literature and reflect on the understanding of cognitive flexibility as (1) an cognitive approach to novelty processing and (2) as a conative disposition toward novelty. We present a theoretical model of cognitive flexibility as a meta-competency reflected in adaptive performance which emerges as a strategic response to novelty in dynamic environments. This meta-competency draws on a confluence of cognitive and conative variables that are actively and adaptively harnessed by an individual under specific circumstances.

## Cognitive Flexibility as a Meta-Competency

As the information era marches on, it has become clear that the demands for innovation, premised on individual creativity and flexibility in the 21st century workplace have shifted substantially from what they were a few mere decades ago, in both their nature and their extent. Research on these constructs, as well as related abilities and dispositions, must evolve to keep pace with this change. Our overarching goal for this paper is to reflect on the notion of cognitive flexibility, which we (and others) see as a prerequisite for creativity, and as a moderator of the creative process. To achieve this, we recognise that while cognitive flexibility has an obvious cognitive character, its conative and *meta*-cognitive nature is often overlooked when it is operationalised as a unidimensional, individual differences variable. Thus our second aim is to briefly review the extant literature and reflect on the understanding of the term cognitive flexibility as (1) a cognitive approach to novelty processing, as it is sometimes linked in conceptual definitions of fluid intelligence, and (2) as a conative disposition toward novelty. We conclude by surmising that there is a case for considering cognitive flexibility as a meta-competency to unify cognitive, conative, and situational dependencies, rather than thinking of cognitive flexibility simply as a component of a broader flexibility, as it is frequently conceived.

### *Cognitive Flexibility in Concepts of Intelligence*

The traditional construct of general intelligence has largely failed to meet the contemporary empirical and theoretical challenges pitted against it to sufficiently explain successes and failures in everyday function (Sternberg, 2011). For example, while intelligence traditionally conceived (e.g. as *g,* Spearman, 1923) has served as an effective predictor of workplace performance (Schmidt and Hunter, 1998; Gotfredson, 2018), meta-analyses have routinely highlighted how conative and metacognitive variables (e.g. degree of reflective self-assessment, creative and practical intelligence, and "grit") routinely account for a significant amount of unique variance in workplace performance beyond IQ (e.g., Sitzmann & Ely, 2011; Credé, Tynan, & Harms, 2017; Colquitt, 2000). Scherbaum et al. (2012) argue that theories of 'pure intelligence' are ill-equipped to explain variation in actual dynamic performances across a range of workplace demands, which are better understood through notions of flexibility, adaptation, and learning on the job. One reason for this misalignment is that

despite conceptual definitions of "intelligence" suggesting otherwise, psychometric tests of intelligence, such as Raven's Progressive Matrices (RPM, Raven 1941), were never designed as indicators of flexibility. Furthermore, the way test performance was subsequently translated into a score (i.e., operationalised), was always going to be incapable of measuring the dynamic aspects of such constructs, in spite of them being routinely interpreted to do so (cf Beckmann, 2014; Birney, Beckmann, Beckmann, in press). While psychometric tools such as the RPM purportedly predict test takers' propensity to direct actual learning and flexibility in criterion tasks, such tests do not explicitly provide opportunities to assess these competencies directly (Bui & Birney, 2014). We argue (as have others in other contexts, Beckmann, 2006), that the most important aspect of theoretical definitions of intelligence (especially fluid intelligence) — the propensity for flexibility of thought in novel contexts — which affords its broad relevance, is better operationalised in other ways.

In response to these foundational limitations, over the course of his career, Sternberg has presented a theoretical framework of intelligence defined as a competency which dictates an individual's ability to perform optimally across a range of problem states within a given domain (Sternberg, 1997), the ability to deal with novelty (Sternberg, 1987), to succeed through overcoming a range of novel challenges (one is reminded of the adage 'it's not just what you know, it's how you use it'), and to be both wise and creative (Sternberg, 2003). Aligned with this interactionist approach (see Todd & Gigerenzer, 2007 for a related perspective on decision making), there has been a reinvigorated research effort focused specifically on the "cognitive flexibility" construct, as evinced by a 2019 search of the term in literature databases yielding more than 3000 results on PsycINFO, with approximately 1500 in the last 5 years alone. In the remaining sections, we aim to map out and elaborate on theoretical connections between the often-disparate research areas of cognitive flexibility, creativity and the broader framework of modern intelligence research. In doing so, we hope to flesh out the latter by elucidating how specific cognitive processes broadly linked to flexibility in the literature (i.e., set-switching, self-monitoring, and transfer of learning) interact in their causal contribution towards adaptive performance.

***Assessment of Cognitive Flexibility and Creativity***

Firstly, what creativity and cognitive flexibility have in common is how both are positioned in contrast to intelligence in the way they are operationalised. Psychometric tests of general cognitive ability (be it fluid or crystallized) feature almost exclusively convergent problem-solving within a consistent and well-defined task paradigm of knowledge acquisition and application (often within an abstract context). On the other hand, cognitive flexibility is concerned with how individuals shift their cognition to effectively respond to novelty in problem states (Beckmann, 2014), and creativity centres on how people generate (multiple) novel solutions to a single problem. The paradigm for such assessments is distinctly 'divergent'. Secondly, while flexibility and creativity are intuitively related (in that novel problem states often require novel strategies), it is important to recognise that they are not the same. Despite an observed overlap in measures, the early literature on cognitive flexibility attempted to differentiate it from creativity by defining the former as the "ability to vary one's mode of approach" (Cosden, Ellis, & Feeney, 1979, p. 386) and a "superordinate ability" which involved "[choosing] an optimal control process and [implementing] it effectively" (Macleod, 1979, p. 535). This distinction was later expanded upon by Sternberg (2007), who contrasted creativity with a competency he called "practical intelligence". While Sternberg's view aligns with previous research, in that creativity involves the generation of solutions that are novel and original (Torrance, 1988; Nickerson, 1999), he describes practical intelligence as "the set of skills and dispositions used to solve everyday problems by applying knowledge… to purposefully adapt to, shape, and select environments" (p. 39) [1]. This is a set of adaptive skills which intrinsically encapsulates the situational evaluation of available strategies (which are often *creatively* generated by the individual themselves) and executing them effectively, skills which underpin the intuitive conceptualisation of cognitive flexibility.

[1] We do not wish to suggest here that creativity involves the purely non-normative 'anything goes' generation of ideas, as there must logically exist a baseline of marginal acceptability, which incorporates the criteria of usefulness and appropriateness (Torrance, 1988; Runco & Smith, 1982) against which responses are evaluated. Rather, the purpose of this comparison was simply to show that there are indeed conceptual differences between the two constructs. More specifically, we speculate that their relationship may be analogous to the System 1/System 2 distinction in Stanovich and West (2000) in which the semi-automatic System 1 (creativity in this case) generates workable solutions which are passed on to System 2 (the 'slow' deliberate and adaptive awareness in cognitive flexibility) to evaluate in terms of its situational suitability for the current problem state.

Acknowledging basic differences between creativity and cognitive flexibility, we now consider the defining features of cognitive flexibility that justify it as a necessary topic to study in tandem with intellect. While there exist many approaches to studying cognitive flexibility, the two most common and relevant perspectives to the current discussion are the set-switching/shifting view and the meta-theoretical approach.

***Cognitive flexibility as a distinct ability: too broad or too narrow?***

The logic of the set-switching view is perhaps best illustrated through a methodological outline of one of its common tools: the Wisconsin Card Sorting Task (WCST; originally proposed by Grant and Berg, 1948). In this task, participants are instructed to sort a deck of cards into different piles according to a set of basic rules (e.g. shape or colour of the stimuli). At an unannounced point during the task, these sorting rules change, and participants must deduce the new sorting rule through feedback obtained through trial-and-error and update responses to be congruent with the current requirements. The fewer perseverative errors an individual makes following a rule change (i.e. the faster they adapt to the new task demands), the higher their 'cognitive flexibility score'. Moreover, this tacit assumption that cognitive flexibility can be cleanly separated from other cognitive processes also plays out in neuroscience research which attempts to localise set-switching competencies to specific parts of the brain (see Kehagia, Murray, & Robbins, 2010 for a review). This 'cognitive-flexibility-as-distinct-ability' was subsequently formalised in Diamond (2013), in which the summary of cognitive flexibility research was largely framed under the label of 'shifting' within the tripartite model of executive functions, alongside inhibition and updating (Miyake et al., 2000).

While this arguably narrow conceptualisation of cognitive flexibility boasts less generalisability outside of developmental and neuropsychological/clinical contexts (a 'normal' functioning sample will show ceiling effects after a few trials of these tasks), it nonetheless contributes to a conceptually enriched account of healthy intellectual functioning by elucidating the lower-order

cognitive/perceptual operations that necessarily enable flexible performance at a macroscopic level.[2] This being said, we (e.g., Beckmann, 2014), as have others before us (e.g., Ionescu, 2012; 2017), argue that restricting the discussion of cognitive flexibility to research on a narrow paradigm (albeit a well-established one) of set-switching needlessly limits its relevance to understanding the super-ordinate class of flexible behaviour. For an analogical example in reading research, readers' individual eye movements across words and sentences are a major determinant of the quality and speed of lexical comprehension (Veldre & Andrews, 2018; Hersch & Andrews, 2012). However, it would be a logical overstep to equate eye movements with lexical comprehension itself, or to explain higher-order reading-related phenomena purely as a function of their constituent perceptual processes (Marr, 1982).

Acknowledging these limitations of a switching-only account, Ionescu (2017) presents an alternative process-focussed framework which characterises cognitive flexibility as the culmination of an overall experiential trajectory from behavioural variability, to narrow stability, and finally to flexibility. In this model, which similarly seeks to explains flexible performance in terms of mediating cognitive (as well as essential metacognitive) processes, the initial stage of variability refers to the phase when an individual is first exposed to a novel environment and behaviour is characterised by non-systematic strategy selection and inconsistent overall task performance. If we were to map other perspectives of cognitive flexibility here, this stage is likely the one during which personality traits (e.g. openness, need for cognition) exert their strongest effect on cognitive flexibility, as individuals are motivated to seek out and experiment with a wide range of novel strategies (DeYoung, Peterson, & Higgins, 2005; Good, 2014). The intermediate stage of stability begins when individuals develop a workable strategy that is generally applicable across narrow instances of a stable task environment. This stage most closely resembles the traditional conception of expertise where outstanding performance is attributed to the consistency in executing a well-rehearsed set of behaviours achieved through a long duration of routine training. However, only when an individual is able to deliberately

[2] For the sake of brevity, we have opted to include only a bird's eye view of the set-switching perspective. For more detailed models of set-switching which further separate the 'operation' into its different cognitive/behavioural constituents, see Ravizza and Carter (2018) and De Baene, Albers, and Brass (2012).

and effectively tailor their strategic response to shifting task demands are they considered to have demonstrated genuine cognitive flexibility over and above stable performance (what Birney et al., 2012 and Ward et al. (2018) refer to as flexible expertise). At this last stage, the individual's approach has shifted from non-systematic to consistently optimal that is achieved precisely because of a considered, nuanced adaptation in strategy.

As above, much of the recent research on cognitive flexibility has investigated how it emerges from a dynamic interplay between person, task and situation factors. As such, we believe a comprehensive understanding of the construct can be best achieved through a higher-order, meta-theoretical account which integrates theory and research findings from the diversity of relevant perspectives. Given this, we present below a preliminary formulation for such a model based on a recent thematic review we conducted on how cognitive flexibility is defined in different research contexts (Birney, Beckmann & Yu, in preparation).

***Cognitive flexibility as an emergent meta-competency***

The central thesis of cognitive flexibility from a meta-competency perspective builds on two premises. First, that cognitive flexibility is a contextualised emerging property of the cognitive system, rather than a unidimensional ability that is isolated in, for instance, the aforementioned laboratory tasks (Ionescu, 2012). Second, that flexibility entails the sensitivity, capacity and inclination to detect, deliberately select and execute a specific, optimal strategy, rather than just a descriptive account of one's general tendency to switch between modes of operation in a manner which may or may not be akin to trial-and-error.

At a meta-theoretical level, cognitive flexibility is a key capacity which underpins what Sternberg (1997) conceptualised as practical intelligence, namely the awareness and ability to adapt one's strategy to the specific situation at hand. Battig (1979) proposed that while a portfolio of suitable strategies is an important precondition for flexibility, the awareness, ability, and motivation to adaptively utilise this knowledge in a dynamic environment is the additional emergent competency that qualitatively distinguishes cognitive flexibility from the traditional construct of crystallized

intelligence. That is to say, although a strong base of explicit knowledge is necessary to be cognitively flexible (this is almost true by definition as there must exist a number of well-rehearsed strategies to switch between in the first place), it is not sufficient. Much in the same way that Fleeson's (2001) formalised the study of within-subject variability on Big-5 traits as itself a meaningful meta-trait (i.e. some individuals were more systematically variable on their expression on one or more of the Big-5 traits; consistent in their inconsistency, as it were), we have argued that the variability observed in an individual's pattern of responses on a cognitive task may reflect a considered choice on their part to match the (perceived) demands of the specific task at hand (Birney, Beckmann, & Beckmann, in press).

While Battig's (1979) model was proposed cautiously by the author at the time of publication, we believe that the four decades of research across multiple contexts conducted since have provided strong support for this integrated meta-theoretical account. It is reflected in Krampe and Baltes' (2003) notion of intelligence as adaptive resource development in the Selection-Optimization-Compensation model, Ericsson's (2003) concept of avoiding arrested development through deliberate practice beyond the automaticity of routine expertise, and intelligence-as-knowledge component of Ackerman's (1996) structural model, each of which entails strong metacognitive, motivational features.

The key distinction between the mere possession of knowledge and the flexible use of knowledge is also salient in a number of theories of adaptive functioning outside of the intelligence literature. For instance, Cognitive Flexibility Theory (Spiro et al., 1988) differentiates knowledgeable individuals from flexible individuals who harness their knowledge-in-use in a wide array of novel situations for problem solving in ill-structured domains. Laureiro-Martínez and Brusoni (2018) distinguishes between managers with a wealth of experience who are rigid in their use of the knowledge, and managers who efficiently switch between 'fast' and 'slow' modes of thinking (Kahneman, 2011) according to the situation. This adaptive functioning is similarly reflected in the distinction between individuals who can execute a single strategy well under stable conditions from those who can also

switch to a more suitable strategy when the task environment changes without warning (Cañas et al., 2003; Cañas et al., 2005; Ward et al., 2018).

Birney, Beckmann, and Wood (2012) reflected on the challenges of understanding flexible-expertise. That while component skills and abilities can be isolated,

> "… *what cannot easily be addressed is that every individual brings with them different experiences and clusters of personal characteristics and interests, various motivations and metacognitive and self-regulatory skills and processes that will play out differently in different situations. Although flexibility can be (and has been) defined behaviorally, the processes impacting on how well someone will perform in a changing situation will, inter alia, depend on their capacity to rapidly sense change, to drill down to the critical details for the problem at hand, to take into consideration the full range of competing expectations and demands, to rapidly and effectively change tact if implemented solutions are not working, and any other number of skills that various researchers have proposed*." (p 573)

Following on from this, the utility of this meta-competency model of cognitive flexibility to the individual differences approach is derived from its *intrinsically meta-theoretical conceptualisation* which can accommodate the influence of conative factors and reflective awareness, variables which have been shown to empirically predict flexible performance over and above classic notions of intelligence. To this point, we believe that this account is an improvement from a model which equates a latent construct of cognitive flexibility with the manifest behaviour of set-switching, as it provides a psychological explanation for observed changes in performance that occur as a function of learning, rather than resorting to a non-comital redescription of the psychometric data. Additionally, by elaborating on the antecedents of cognitive flexibility (see Birney et al., 2012), this approach also facilitates research which tackles questions of what learning conditions foster the development of this meta-competency. This is a pertinent question because it is proving to be increasingly important in dynamic work environments defined by the need to constantly adapt to different, novel, and

unfamiliar task demands rather than the reapplication of a narrow portfolio of pre-packaged strategies (Gruber, MacMillan, & Thompson, 2012; Laureiro-Martínez & Brusoni, 2018).

***A naturalistic way to measure cognitive flexibility***

To further assist in setting the research agenda, we conclude by analysing the implications of our meta-theoretical model for the measurement of cognitive flexibility. Given that cognitive flexibility is multifaceted in much the same way as Ackerman and Beier's (2003) notion of trait-complexes, in that it emerges from a particular profile of cognitive and conative dispositions that coalesce around an environmental cue, we acknowledge that it is unlikely to be well-measured in whole by any single task.

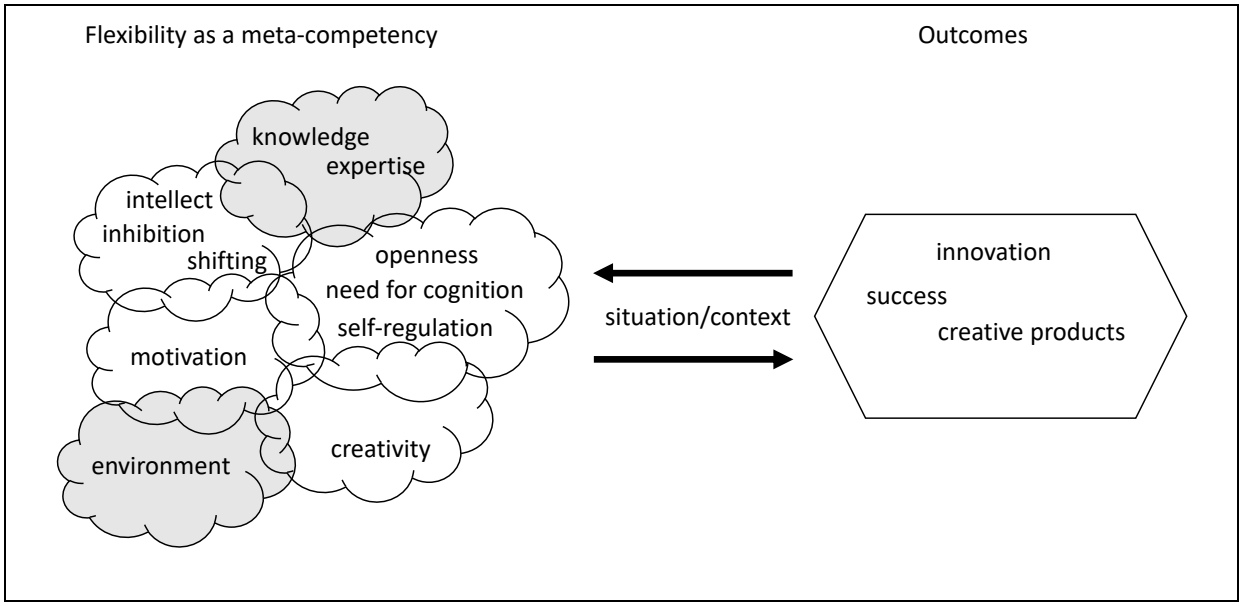


**Figure 1.** Flexibility as a meta-competency emerging from a cluster of cognitive and conative factors linked to outcomes via situation/context interactions

This being said, since an individual's *meta-cognitive awareness* to optimally match their strategy to the task and the situation is central to our model (as represented in Figure 1 above), we believe that the scales researchers use would benefit from increased sensitivity to these interaction variables. On one end of the 'meta-cognitive' continuum lie the instructed switching tasks which periodically include explicit instructions to switch from one well-defined task strategy to other – equally well defined – alternatives (e.g. categorising visual stimuli according to phonetics or by semantic features).

On the other end of the spectrum lie measurements which purport to boast greater 'ecological validity', such as the Firechief microworld by Omodei and Wearing (1995) used to study cognitive flexibility in Cañas et al. (2003) and Cañas et al. (2005). In these substantially less structured tasks, although the goal state is embedded within an intuitive context (prevent a fire from spreading), creativity (defined traditionally here as the spontaneous and divergent generation of plausibly appropriate ideas) is both incentivised and necessary in the decision-making process, as individuals must formulate their strategies 'from scratch' in order to build up a diverse strategic cache for when a change occurs. When compared to tightly constrained laboratory tasks (such as the WCST and Trail Making Test), proponents of these types of complex problem-solving tasks argue that their ill-structuredness and demands on creative thinking more closely mirror the challenging experience of naturalistic problem-solving outside the laboratory (Dörner & Funke, 2017; Scherer, 2015), where decision-makers are often required to generate their own novel solutions to novel problems and decide on their own when it is optimal to shift in response to sudden unannounced changes in the task environment.[3] Going forward, while we recognize there are challenges in consolidating past efforts into a rigorous focused measure of cognitive flexibility — chief among them being the delicate balance between the domain-specificity (that is needed to justify the label of being more "ecologically valid" than other assessments) and generalisability of the particular problem-solving environment used — these examples illustrate the utility of measuring a dynamic construct (i.e. cognitive flexibility as we have presented it) with a similarly dynamic paradigm.

In closing, it is evident that modern intelligence research should progress beyond its traditional psychometric leanings towards a more holistic process-driven approach which develops and incorporates more fully the cognitive and behavioural antecedents of real-world performance in

[3] Cañas et al. (2005) provides an example of how this dynamic methodology can be implemented. From an assessment standpoint, an individual's cognitive flexibility was operationalised with a similar logic as in the WCST, where their 'flexibility score' for a single session was calculated proportionally to the number of trials that it took after a parameter shift in the task system (e.g. the relative effectiveness of a particular discrete action, say, firing ineffective employees) to reattain their pre-shift aggregate performance and/or gradient of improvement. In doing so, the researchers were measuring cognitive flexibility through assessing whether participants registered the sudden shift in task conditions as an indicator that it would be beneficial to change their approach, as well as the speed and precision with which they were able to switch to an appropriate strategy.

greater theoretical detail. Due to how it emerges from an interaction between both cognitive and conative variables, and the interaction between these and dynamically changing task and/or situational factors, cognitive flexibility is one construct which has the potential to greatly enhance the explanatory reach of the field at large. In keeping with this rationale, we hope that the meta-theoretical model we have presented in this paper extends the study of cognitive flexibility beyond a narrow 'flexibility-as-ability' framing and acts as a preliminary catalyst for future research in line with an integrative approach.

## References


Ackerman, P. L. (1996). A theory of adult intellectual development: process, personality, interests, and knowledge. *Intelligence, 22*(2), 227-257.

Ackerman, P. L., & Beier, M. E. (2003). Trait complexes, cognitive investment, and domain knowledge. In R. J. Sternberg & E. L. Grigorenko (Eds.), *The Psychology of Abilities, Competencies, and Expertise* (pp.1-30). Cambridge: Cambridge University Press

Battig, W. F. (1979). Are the important "individual differences" between or within individuals? *Journal of Research in Personality*, *13*, 546-558.

Beckmann, J. F. (2006). Superiority: Always and everywhere? On some misconceptions in the validation of dynamic testing. *Educational and Child Psychology, 23*(3), 35-49.

Beckmann, J. F. (2014). The umbrella that is too wide and yet too small: why dynamic testing has still not delivered on the promise that was never made. *Journal of Cognitive Education and Psychology, 13*(3), 308-323.

Birney, D. P., Beckmann, J. F., & Beckmann, N. (in press). Within-individual variability of ability and learning trajectories in complex problems. In D. McFarland (Ed.), *General and Specific Mental Abilities*: Cambridge Scholars Publishing.

Birney, D. P., Beckmann, J. F., & Wood, R. E. (2012). Precursors to the development of flexible expertise: metacognitive self-evaluations as antecedences and consequences in adult learning. *Learning and Individual Differences*, 563-574.

Birney, D. P., Beckmann, J. F., & Yu, C. (in preparation). *Cognitive flexibility: A thematic review.*

Bui, M., & Birney, D. (2014). Learning and individual differences in Gf processes and Raven's. *Learning and Individual Differences, 32,* 104-113.

Cañas, J. J., Quesada, J. F., AntolÍ, A., & Fajardo, I. (2003). Cognitive flexibility and adaptability to environmental changes in dynamic complex problem solving tasks. *Ergonomics, 46,* 482-501.

Cañas, J. J., AntolÍ, A., Fajardo, I., & Salmerón, L. (2005). Cognitive inflexibility and development and use of strategies for solving complex dynamic problems: effects of different types of training. *Theoretical Issues in Ergonomics Science, 6*, 95-108.

Colquitt, J. A., LePine, A., & Noe, R. A. (2000). Toward an integrative theory of training motivation: A meta-analytic path analysis of 20 years of research. *Journal of Applied Psychology, 85,* 678–707.

Cosden, M. A., Ellis, H. C., & Feeney, D. M. (1979). Cognitive flexibility—rigidity, repetition effects, and memory. *Journal of Research in Personality, 13*(4), 386-395.

Credé, M., Tynan, M. C., & Harms, P. D. (2017). Much ado about grit: A meta-analytic synthesis of the grit literature. *Journal of Personality and Social Psychology, 113*(3), 492–511.

DeYoung, C. G., Peterson, J. B., & Higgins, D. M. (2005). Sources of openness/intellect: cognitive and neuropsychological correlates of the fifth factor of personality. *Journal of Personality, 73*(4), 825-858.

De Baene, W., Albers, A. M., & Brass, M. (2012). The *what* and *how* components of cognitive control. *NeuroImage*, *63*, 203-211.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64,* 135–168.

Dörner, D., & Funke, J. (2017). Complex problem solving: what it is and what it is not. *Frontiers in Psychology, 8*.

Ericsson, K. A. (2003). The search for general abilities and basic capacities: Theoretical implications from the modifiability and complexity of mechanisms mediating expert performance. In R. J. Sternberg & E. L. Grigorenko (Eds.), *The Psychology of Abilities, Competencies, and Expertise* (pp.93–125). Cambridge: Cambridge University Press.

Fleeson, W. (2001). Toward a structure- and process-integrated view of personality: traits as density distributions of states. *Journal of Personality and Social Psychology, 80*(6), 1011-1027.

Gottfredson, L. S. (2018). *g* theory: How recurring variation in human intelligence and the complexity of everyday tasks create social structure and the democratic dilemma. In R. J. Sternberg (Ed.), *The nature of human intelligence* (pp. 130-151). New York: Cambridge University Press.

Good, D. (2014). Predicting real-time adaptive performance in a dynamic decision-making context. *Journal of Management and Organisation, 20*(6), 715-732.

Gruber, M., MacMillan, I. C., & Thompson, J. D. (2012). From minds to markets how human capital endowments shape market opportunity identification of technology start-ups. *Journal of Management, 38*(5), 1421–1449.

Hersch, J., & Andrews, S. (2012). Lexical quality and reading skill: bottom-up and top-down contributions to sentence processing. *Scientific Studies of Reading*, *16*(3), 240-262.

Ionescu, T. (2012). Exploring the nature of cognitive flexibility. *New Ideas in Psychology, 30*, 190-200.

Ionescu, T. (2017). The variability-stability-flexibility pattern: a possible key to understanding the flexibility of the human mind. *Review of General Psychology, 21*(2), 123-131.

Kahneman, D. (2011). *Thinking, fast and slow.* New York, NY: Farrar, Straus and Giroux.

Kehagia, A. A., Murray, G. K., & Robbins, T. W. (2010). Learning and cognitive flexibility: frontostriatal function and monoaminergic modulation. *Current Opinion in Neurobiology, 20,* 199–204.

Krampe, R. T., & Baltes, P. B. (2003). Intelligence as adaptive resource development and resource allocation. In R. J. Sternberg & E. L. Grigorenko (Eds.), *The Psychology of Abilities, Competencies, and Expertise* (pp.31-69). Cambridge: Cambridge University Press.

Laureiro-Martínez, D., & Brusoni, S. (2018). Cognitive flexibility and adaptive decision-making: evidence from a laboratory study of expert decision makers. *Strategic Management Journal, 39*(4), 1031-1058.

MacLeod, C. M. (1979). Individual differences in learning and memory: A unitary information processing approach. *Journal of Research in Personality, 13*, 530-545.

Marr, D. (1982). *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. San Francisco: W. H. Freeman and Company.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: a latent variable analysis. *Cognitive Psychology, 41,* 49-100.

Nickerson, R.S. (1999). Enhancing creativity. In R.J. Sternberg (Ed.), *Handbook of creativity* (pp. 392–430). New York: Cambridge University Press.

Omodei, M.M., & Wearing, A.J. (1995). The Fire chief microworld generating program: an illustration of computer-simulated microworlds as an experimental paradigm for studying complex decision-making behavior. *Behavior Research Methods, Instruments and Computers, 27,* 303–316.

Raven, J. C. (1941). Standardisation of progressive matrices, 1938. *British Journal of Medical Psychology, XIX*(1), 137-150.

Ravizza, S. M., & Carter, C. S. (2008). Shifting set about task switching: behavioral and neural evidence for distinct forms of cognitive flexibility. *Neuropsychologia, 46*(12), 2924-2935.

Runco, M.A., & Smith,W.R. (1992). Interpersonal and intrapersonal evaluations of creative ideas. *Personality and Individual Differences, 13,* 295–302.

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.

Scherer, R. (2015). Is it time for a new measurement approach? A closer look at the assessment of cognitive adaptability in complex problem solving. *Frontiers in Psychology, 6.*

Schmidt, F. L., & Hunter, J. E. (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.

Sitzmann, T., & Ely, K. (2011). A meta-analysis of self-regulated learning in work-related training and educational attainment: What we know and where we need to go. *Psychological Bulletin, 137,* 421–442.

Spearman, C. (1923). The nature of 'intelligence' and the principles of cognition. London: Macmillan.

Spiro, R. J., Coulson, R. L., Feltovich, P. J., & Anderson, D. K. (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. In V. Patel (Ed.), *Tenth annual conference of the Cognitive Science Society* (pp. 375–383). Hillsdale, NJ: Lawrence Erlbaum Associates.

Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences, 23*, 645-726.

Sternberg, R. J. (1987). Coping with novelty and human intelligence. In P. Morris (Ed.), *Modelling cognition* (pp. 57–91). New York, NY: Wiley.

Sternberg, R. J. (1997). *Successful intelligence.* New York: Plume.

Sternberg, R. J. (2003). *Wisdom, intelligence, and creativity synthesized.* Cambridge University Press.

Sternberg, R. J. (2007). A systems model of leadership: WICS. *American Psychologist, 62,* 34–42.

Sternberg, R. J. (2011). The theory of successful intelligence. In R. J. Sternberg & S. B. Kaufman (Eds.), Cambridge handbook of intelligence (pp. 504-527). New York: Cambridge University Press.

Todd, P. M., & Gigerenzer, G. (2007). Environments that make us smart: ecological rationality. *Current Directions in Psychological Science, 16*(3), 167-171.

Torrance, E.P. (1988). The nature of creativity as manifest in its testing. In R.J. Sternberg (Ed.), *The nature of creativity: Contemporary psychological perspectives* (pp. 43–75). New York: Cambridge University Press.

Veldre, A., & Andrews, S. (2018). Beyond cloze probability: Parafoveal processing of semantic and syntactic information during reading. *Journal of Memory and Language*, *100,* 1-17.

Ward, P., Gore, J., Hutton, R., Conway, G. E., & Hoffman, R. R. (2018). Adaptive skill as the *conditio sine qua non* of expertise. *Journal of Applied Research in Memory and Cognition*, *7*, 35-50.