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ARCTIC SHORES

Thought Leadership

A New Frontier

Impressions on the current state of neuroscience and innovative measurement

Organizations increasingly employ assessment services to inform hiring decisions, promotion, potential identification, professional development, and other types of talent management programs.

Recent years have not only seen a dramatic uptick in assessment testing in general, but also increasing interest in innovative approaches to testing. Neuroscience, artificial intelligence, machine learning, gamification, qualitative/text analysis, and even virtual reality are now commonly invoked, explored, or variously employed in existing and emerging human resources-related assessment services.

In traditional and prevailing approaches to psychological measurement, respondents are often presented with items or "statements" where they indicate their level of independent agreement or forced-choice preference. Items may also be criterion-referenced, such that they elicit a response that may be partially or entirely "right or wrong"—like many math problems. Although innovative assessments (like those using "gamified" components) are increasing in everyday application, item-response assessments remain notably common—and probably most common. This is for good reason: decades of scientific research show the non-trivial value-add of traditional testing approaches to HR-related activities.

Still, it seems a collective presumption exists that emerging technologies and research-based advancements in person- and group-measurement will promise better things—and very soon. Developments in general neuroscience have resulted from, notably, multidisciplinary and overlapping research where physicists, engineers, psychologists, computer scientists, medical professionals, and other experts have combined a remarkable array of understanding to contribute to related progress and ongoing efforts. Although high expectations are widely held and reasonable, many who are interested or even invested in these approaches may not realize the ways in which improvements are possible or more likely to occur, especially in the near future. Moreover, they also may not understand fully the current challenges and obstacles.

The purpose of this analysis is to describe the ways in which recent or forthcoming technological and scientific developments in neuroscience are likely to add value to person- and group-measurement for use in applied HR activities. Although neuroscience advancements have shown great potential for positive benefits in training

activities and learning, this paper is focused on how neuroscience and other innovations are likely to impact measurement for applied descriptive and predictive purposes. We also note that training and measurement, of course, have potentially useful areas of overlap and synergy.

Our discussion is loosely framed in terms of how and why advancements are likely to affect organizations regarding measurement processes and, by extension, ROI for businesses that offer or use related services. Substantive benefits in these terms are likely to emerge in two ways, including (1) what is measured, and (2) how things are measured. Before discussing these, we first outline what applied neuroscience really means to the typical organization.

A New Frontier

Research trends in neuroscience have rarely overlapped with the commercial world, with most findings in neuroscience contributing to clinical practice and diagnostics. Generally, neuroscience has explored population-wide rules (e.g., how memory, attention, and other systems function in all people) rather than explaining individual differences used in organizational psychology and human resources, such as personality and intelligence. So, what does applied neuroscience look like in occupational environments, and why would it be useful, given its historic lack of relevance?

Neuroscience covers a broad array of subdivisions. Here, we primarily discuss cognitive neuroscience, which is the convergence of cognitive psychology and brain measurement. Indeed, some have coined the phrase Occupational Cognitive Neuroscience (OCN), relating to "terms that refer to cross-disciplinary perspectives on organizational research, which take as their foci of study the cognitive mechanisms that drive human behaviors in response to organizational manifestations" (Senior et al., 2015). The neuroimaging techniques that measure brain function and structure most commonly employed in this field include MRI, EEG, MEG, and NIRS. The mechanisms underlying these measures is not the focus of this discussion. We focus instead on the benefits and limitations of these techniques in applied environments. Importantly, all of these methods have generally been confined to laboratories and clinical settings. This is predominantly due to interference from external electromagnetic signals, the size of equipment, and the need for both a stable power supply and wired data connection. But recent advances in battery life, wireless technology, and other hardware components mean that some neuroimaging techniques are now being used in occupational environments.

Advances in portable neuroimaging hardware have now enabled brain measures to be collected while people carry out their workplace tasks. Portable EEG (a headcap that uses diodes to measure electrical activity on the scalp that originates in the brain) has been used in the field for a broad array of professions, including pilots, drivers, construction workers, athletes, and air-traffic controllers (Borghini et al., 2014; Park et al., 2015; Aricò et al., 2016; Zander et al., 2017; Li et al., 2020). fNIRS (another type of headcap that uses the absorption of infrared beams to determine blood oxygenation levels in the brain) is being explored as a tool in "neuroeconomics," where the quality of decision-making directly translates into the productivity of financial services (Kopton & Kenning, 2014).

Portable neuroimaging has perhaps been most extensively used to measure the brain activity of vehicle drivers and aircraft pilots. This is because both activities generally involve periods of intense decision-making and cognitive load that may result in catastrophic damage if crucial tasks are incorrectly completed. Fatigue can be particularly deadly in these types of roles, which is why many driver and pilot applications of brain imaging are being employed to identify operator drowsiness. Measuring fatigue with fNIRS has also been conducted with radiologists, where interpreting images has direct health consequences for service users (Pu et al., 2013).

The potential benefit is ever-growing for neuroscientific techniques and theory to be applied to individual differences in selection, training, and similar disciplines. However, there are less substantive ways that some companies are beginning to benefit from this new frontier in occupational science, which we will turn to now.

Beyond "Market Sizzle"

One impact neuroscience is having on applied assessment should evoke at least a small degree of caution among consumers. Consumers tend to have high, and sometimes unrealistic, expectations of science and technology, and even if related or incremental benefits in a given case are not real or measurable, there may be perceptions to the contrary. Whether intentional or not, companies seeking to profit can and will sometimes use this kind of collective optimism to boost perceptions of legitimacy and "progress," and to boost profitability. In fact, the desire to pursue related innovation in whatever way possible is often due to company

decision-makers themselves holding the same kind of high and sometimes unrealistic expectations of scientific progress.

Consider, for example, that numerous test makers currently assert that their tests involve or leverage advancements in neuroscience or some other innovation, even though the tests have all or many of the hallmarks of more traditional testing (e.g., multi-item response and/or criterion-referenced testing with traditional scoring methods). In these cases, innovative claims are often based on citations and references in marketing or technical documents that simply refer to unrelated independent research, wherein measured constructs have been corroborated or "detected" using measurement, vernacular, or dissemination approaches more typically found in neuroscientific research. Although this is perhaps fair, the extent to which neuroscience is involved or has informed testing may be smaller than is understood or invoked in promotional materials.

In other instances, an ad-hoc study(s) may produce characteristic correlations between scores from the "traditional" tests and scores secured via measurement approaches most typically in found neuroscience (e.g., measuring brain activity via fMRI). This legitimizes the former by direct association because the dimensions measured in the proprietary measurement tool have been "corroborated" or "confirmed" to some extent with the more innovative technique, which is (not necessarily mistakenly) presumed to be better or perhaps "more real." Although this type of legitimacy-granting association is arguably better and more substantive than the one described above, neither including references nor doing a direct study of this kind will necessarily change, improve, or inform test construction in many cases. In other words, an association can be noted or demonstrated, but test quality and efficiency may not necessarily be affected, and nothing new may otherwise be measured or done.

In summary, while "marketing sizzle" may benefit some commercial organizations for the short term, it's not always coupled with the more substantive potential benefits of genuine neuroscientific research and development. Reliance on marketing poses a risk of inflating a "neuroscience bubble," which would detract from the compelling applications of this technology to real-world scenarios. This is neatly summarized by Gartner's annual "Hype Cycle for Emerging Technologies" (Gartner, 2019), where neuroscientific technology in human resources applications must overcome the "Peak of Inflated Expectations" before the inevitable realization and application of its true capability. No doubt, the more that marketing sensationalism goes unchecked, the more dramatic the subsequent recognition of reality.

Increased interest in human resources neuroscience applications is clear in any case. But "what" constitutes a genuine application of neuroscientific methods and moves beyond relatively hollow uses of branding? Moreover, what substantive improvements in applied measurement are likely to emerge in the near term in ways that do affect what we measure and how we measure in applied work? Below, we continue to cast this discussion primarily in terms of neuroscience and related advancements, but we offer that some or many of the issues evoked here likely apply to other technologies that are emerging and are relatively well known.

What and How We Measure

From its beginnings, neuroscience has been conceptualized as a discipline with some inherent or potential relationship to psychology, while also being notably separate and having many potential applications unrelated to applied psychology and psychological measurement. Many compelling applications, for example, involve developing stem cell treatments for neurological diseases or helping individuals suffering from paralysis in medical contexts—among many others.

Yet even within areas creating more immediate interest among applied psychologists (e.g., cognitive neuroscience, psychobiology), diverse perspectives and "traditions" having degrees of overlap and diverse assumptions do exist (Marshall, 2009). For the purposes of this paper, we point out, at minimum, that some psychological pursuits within neuroscience even eschew, find foreign, or complicate the notion of "state/trait" or "psychological construct" measurement to some degree as they are widely and commonly understood. Notions such as "measuring a person's extraversion or memory functioning using neuroscience" may not always be well-received or accurate from some prevailing perspectives within neuroscience or cognitive neuroscience (Marshall, 2009).

Neuroscience and related innovations ultimately do have implications for what we measure in applied psychology, how we measure, as well as how we think about what is measured. Whether cast in terms of person or group (e.g., project or leadership teams) "construct" measurement or otherwise, advancements in neuroscience have great potential to uncover previously unconceptualized measures

and/or approaches that could provide unique and incremental utility in both descriptive and predictive ways for applied use.

This may seem additionally promising when considering that psychologists are not uncommonly guilty of recasting old measures in new or different terms (e.g., Judge et al., 2002). This kind of recasting can be useful for descriptive purposes, but most often results in zero or near-zero incremental improvement in predictive sense across studies, at least. In other words, neuroscience offers renewed promise in terms of facilitating new measures and new ways of thinking about measurement that could improve the extent to which we are able to describe, explain, and especially predict what and how well people or groups will do in given situations over time. Recent developments in neuroscience, for example, measure within- and between-person "synchrony," in ways that may revolutionize how we think about teamwork in organizations and have tremendous potential for describing and predicting the success of teams in organizations (e.g., Hu et al., 2017). Synchrony may yield even single "scores" or indications involving how people are working and thinking together, in a way that is direct and predictive of person or team outcomes (Cheong, 2019).

From an applied psychologist perspective, more tangible benefits also involve that measurement techniques developed in cognitive neuroscience have the potential to facilitate better measurement of constructs that are already commonly used, known to be useful, or that are already measured in conventional ways. "Learning Agility" and related (yet divergent) constructs such as emotional intelligence, resilience, logic, and motivation have shown clear underpinnings and corroborations in direct brain and physiology measurement, around amygdala functioning and beyond (Stewart, 2014).

This is also true for commonly measured constructs in clinical psychology[1]. Here, the potential value-add of innovation is the ability to measure not new but known and useful constructs in better, faster, easier, and more reliable ways for describing respondents and predicting performance. Although we make reference to "corroborating" correlational studies like those described above, we speak here of using this type of information to develop and implement innovative measurement approaches, and not only to report associations in pursuit of legitimacy or some other end that precludes designing and implementing better things.

Consider, for example, that clients or consumers of testing services are very often concerned that prevailing and traditional testing methodologies are prone to faking and impression management, and that results are, therefore, possibly unreliable. Veiled, more complex, or more direct measurement innovations are likely to provide better related solutions soon—and to some degree, already are. Neuroscience measurement is often achieved via devices that directly or indirectly measure respondent physiology and brain activity[2] (for example, brain computer interface feedback in the workplace for training purposes and "flow" theory for completing cognitive tasks rather than questionnaires) and often in a way that is coupled with stimuli that prompt such activity. Although perhaps not impossible to fake in every case, it seems a fair and collective presumption that direct measurement like this can be made to be far more difficult to ultimately fake, or can be made to greatly facilitate and improve faking detection. Recent research clearly supports this (Meade, et al., 2018), even in personality measurement, which is among the types of measurement most commonly used in human resources applications[3]. Impression management and fake-ability are also likely to be mitigated by the fact that neuroscience-based measures have far more potential to veil "desirable responses," or the nature of what is being measured, compared to test forms prompting problem-solving or rating-scale on clear and often relatively direct statements about behavior or thought-related tendencies. For example, pupil size and/or eye movements are ostensibly difficult to fake and potentially interesting to psychologists because it can be telling in terms of responses to stimuli and reactions to situations. These even have potential to measure personality (Hoppe et al., 2018).

1 See for example: https://www.drakeinstitute.com/
2 fMRI, a functional-imaging technique commonly used in neuroscience, measures brain activity indirectly through blood flow oxygenation while still essentially measuring physiology and physiological responses. For our purposes here, we emphasize the distinction between physiological measurement and traditional "item response" in psychology, particularly when we invoke the notion of Neuroscience measurement being direct or "more direct."
3 Also note that the "Neuroscience of Deception" is a well-established ongoing research program at Harvard whose success is even creating high-profile discussions surrounding the use of Neuroscience measurement in courtrooms to detect lying.

Innovation may also facilitate measuring known constructs that are, nonetheless, otherwise difficult or impossible to measure. For example, in recent years there has been increased interest and desire for measures of (variously conceptualized) "self-awareness." Related measures have shown utility in ways that predict both person performance in various categories as well as company-level performance (Zes & Landis, 2013; Cashman 2014). Yet most agree that self-awareness is difficult and problematic when measured via "self-report," and good studies have found better ways to secure related measures, with measurement of the extent to which self-ratings match others' ratings of the same person being among one of the common approaches, however conceptualized. "Person-other" approaches, however, are often cumbersome and inefficient, and typically require notable effort and participation from individuals other than the person(s) being targeted for measurement. This is most often not feasible in some talent management applications, such as hiring. It is not unreasonable to expect, however, that neuroscience or some other innovative approach might soon be able to secure this or other known but difficult-to-obtain construct measures in much more reliable and efficient ways. In fact, developments have already emerged in terms of "self-awareness," but are yet to be widely applied (e.g., Heatherton, 2011).

Clearly, there may be other challenges in cases like these, but it is not uncommon for consumers to request scores on other constructs that are difficult to measure, like "integrity," "honesty, "good judgement," or similar things. Moreover, some psychological constructs and research streams once held great promise for applied human resources measurement, but fell out of favor largely due to difficulty or tremendous inefficiency in securing person scores. "Integrative complexity" (Schroder et al., 1967; Suedfeld et al., 1992), for example, was once of notable interest to applied human resources due to its relative independence from other common measures and its great potential for incremental utility. To this day, however, its use has not proliferated because prevailing approaches to high-quality measurement involve people writing essays and for reviewers to review those essays in detail. This is typically not conducive to even moderate volume human resources applied measurement. As such, innovations may release the potential of existing, known, or relatively "old" constructs like these and others that are commonly desired or believed to be notably useful but are not yet commonly used or evoked in applied measurement.

Even with things that are and have been commonly measured, a typical and "traditional" psychological test battery used in human resources application usually takes an hour or more to complete. This often concerns clients or consumers of testing services, and it is not uncommon for testing to be disfavored, declined, or modified to address related concerns. Moreover, long tests are often associated with fatigue, which can impact response quality, test reliability, and likelihood of individual participation. At this point, the emergence of faster tests are not expectations based only on intuition. Without considering inevitable "gear-related" and accessibility challenges to widespread application, rapid decision-making paradigms used in cognitive neuroscience, such as the lexical decision-making task, have already been adapted to show potential to be "orders of magnitude" faster than other tests. This is even when coupled with components of more traditional testing methods and measurement of well-known constructs (Meade et al., 2018; Shipman, 2018). At the very least, more person-data can be collected much more quickly once all required individuals are present and measurement apparatuses are secured and working properly. In general, recent advancements in neuroscience and related areas are allowing for "astonishing" amounts of brain-related data to be directly measured quickly, and much quicker than ever before (Gao et al., 2019). As our understanding of how brain functioning relates to cognitive tasks, we are more able to make inferences in how task-based behavior relates to constructs used in occupational science.

Lastly, whether some psychological construct is known or yet to be discovered, neuroscience has great potential to increase measurement reliability and validity in even the broadest and most technical terms. Here we speak of measurement reliability issues that are independent of and are present even in the case of "zero-faking." Prevailing psychological measurement is often fraught with technically conceptualized "measurement error," and acceptable and even superior examples of psychological measurement yield scores with error[4]. Many or most psychological tests typically used in applied human resources measurement

4 This pertains to scoring individuals or some discreet unit to which a score can be attached. Removing psychological measurement error is far more advanced when doing aggregate research that leverages statistical inferencing (e.g., Bollen, 1989).

show non-trivial error in within-person test-retest terms, or the extent to which test items are tapping the latent construct they purport to measure. Despite prevailing approaches in application, typical "acceptable" indications of psychological measurement reliability (e.g., rtt ≥ .70) provide that scores are most appropriately reported in strata often conceptualized as "low, average, or high." The more fine-grained within- and across-person distinctions that are often desired, expected, or often (and sometimes erroneously) assumed are noninformative or misinformative (Wright, 1996).

Although reliability issues are likely to persist in some ways, and we don't expect neuroscience to be an immediate panacea in this regard, neuroscience/physiological type measurement is nonetheless typically far more direct, more conducive to fast or increased within-person repetition[5], and potentially mitigates faking to a greater degree. As such, the potential for more reliable measurement (cast even in technical terms) seems self-evident and is variously discussed, assumed, and sometimes observed already (see, for example, Zuo et al., 2019). Note also that, as a rule, more reliable tests tend toward greater descriptive precision and predictive utility. Increased predictive utility is even expressible mathematically, such that it is not uncommon for research psychologists using more traditional measurement to apply a "correction" to coefficients that express the magnitude at which one measure is predictive of another. This correction is essentially an attempt to remove the impact of measurement error, and it always increases the magnitude of predictor coefficients.

Ongoing Obstacles and Challenges to Implementation

Despite real potential for developing better things, it seems that the "buzz" surrounding neuroscience may still be larger than actual widespread implementation in applied non-clinical contexts. Although many high-profile innovations are in development, these appear limited to specific sectors such as drivers, pilots, and the military. More traditional testing approaches and their components are still most commonly used broadly throughout human resources. In terms of neuroscience expanding into other sectors, there are several obstacles for its implementation in broader occupational sectors and role types.

Consider, for example, that it is not uncommon for companies to contract with testing service providers to test hundreds or thousands of people over a long period. Yet neuroscience measurement has long been associated with lab-based and clinical measures that require long periods of setup and are often costly (e.g., head caps that require conductive gel or MRI machines). Testing hundreds or thousands of individuals (who are often job applicants) via this type of neuroimaging is obviously not feasible. fMRI is also quite expensive and can be somewhat physically invasive (e.g., spending a notable time in a tightly enclosed space with loud noises). Moreover, traditional MRI devices emit a strong magnetic field and are not entirely without potential risks. Individuals with pacemakers, for example, may be advised to not participate. As such, fNIRS and EEG are two techniques gaining the most traction in occupational settings due to their portability and relatively fast setup time.

Yet, even to the extent that portable neuroimaging devices are made quicker, smaller, and more feasible, their use in applied contexts presents additional challenges. Consider a likely use-case wherein participants are measured during their daily work activities. Most research with this type of measurement has been conducted in lab or clinical settings with experimental control in place and where stimuli and related responses can be relatively isolated. In applied settings, "signal to noise" issues can be far less controlled and can present as technical issues, data interpretation challenges, or both. There is only a paucity of research involving how to best secure and interpret portable neuroimaging results in applied non-laboratory settings. Physical movements will be inevitable and common during meetings, daily interactions, and/or tasks in an occupational setting. Studies have already shown this challenge with portable EEG data measured while individuals are walking on treadmills (Snyder et al., 2015). However, with continued research, more is being understood about the best data analysis techniques and hardware design specifications to minimize physical movement and other sources of noise (Pinti et al., 2018).

Of course, less invasive, more cost-effective, and potentially more feasible devices have already

5 This, in some sense or potential sense at least, is analogous to having "more items per test/construct," albeit with a strong possibility of securing this increase in time periods that are exponentially faster. Having more items per test is strongly and directly associated with increased measurement reliability, even in the mathematics of test reliability.

proliferated to some degree. fNIRS, for example, is potentially less problematic in terms of physical movement noise than EEG and is equally portable (Pinti et al., 2018). Securing the measurement device still requires a notable time commitment, however, and typically involves a technician who can appropriately secure the cap to the respondent and make sure it is working correctly. Moreover, fNIRS has its own inherent limitations, including relatively poor time resolution compared to EEG, and it is restricted to measuring only certain parts of the cortex. Sunlight interferes with optical detectors used for fNIRS, and interference resulting from physical movement is still a potential concern in terms of dislodging headsets and/or causing blood flow changes in the brain not associated with cognitive processing (Pinti et al., 2018). As such, challenges remain for fNIRS technology in applied settings. These challenges attenuate the extent to which neuroscience measurement is feasible and its potential to produce less measurement error than traditional methods.

Applied neuroscience is not likely to realize its potential and become pervasive until related measurement can be done online, with common handheld devices, or at least with smaller inexpensive devices that can be secured easily and work well. To this end, many companies are working to bridge the gap with assessments whose origins and designs are rooted deep in the cognitive neuroscience research literature, but do not use neuroimaging measurement tools like EEG, MRI, or fNIRS. For example, companies like Arctic Shores, Revelian, BrainCheck, and others have employed occupational psychologists, cognitive neuroscientists, data scientists, and app/interface developers to create progressive assessments having gamified or other novel testing components. These multidisciplinary teams combine gamified elements with classical cognitive tasks in order to mitigate applicant test anxiety, improve subjective experience, and reduce demographically homogeneous candidate pools by using "stealth assessment." In terms of widespread use in applied contexts, these approaches currently represent the most accessible and substantive innovations emerging from neuroscientific theory and development.

Such tests typically involve cognitive tasks, eye-movement tracking, reaction times, pupil dilation, facial expressions, or tone of voice (e.g., Zekveld et al., 2018; Sievers et al., 2019; Robinson & Tamir, 2005; Wichmann et al., 2016; Cheong, 2019). The extent to which these represent improvements over traditional methods may vary across cases. They may or may not notably reduce measurement error compared to traditional testing. They may or may not measure more efficiently, provide incremental predictive utility, mitigate fake-ability to a greater degree, measure new things, or measure old things that were previously unmeasurable. Yet even where they are "just as good" or "good enough" according to technical criteria or construct coverage, scalable and valid measurement approaches that are novel appeal to a market growing increasingly weary of traditional and relatively mundane testing. While it cannot be assumed in every case today, they do offer promise in terms of more substantive measurement improvements over time that are increasingly accessible for applied human resources. To the extent that the "future is now" or will otherwise arrive sooner, it is likely to express more in these ways and less via workplace neuroimaging.

In whatever way(s) data and measures are secured, it's also important to note that neuroscience, when not coupled with psychology, may sometimes fail to provide actionable insights in applied contexts. Neuroscience measurement alone can provide a wealth of information, but without translation, person-data can be non-informative or even misleading. Person-data collected from scans, biometric screenings, or other novel neuroscience-related approaches sometimes require interpretation. Moreover, interpretations may sometimes be the product of induction or study-specific associations that are not, or only loosely, based in an existing theoretical establishment in psychology or behavior. Stated differently—traditional, questionnaire-based measures generally benefit from higher face validity in terms of how items relate to workplace performance and person description. Interpreting the meaning or applicability of physiological measurement or cognitive tasks rooted in neuroscience will challenge consumers in some cases.

Privacy issues are also worth noting. Regardless of what might be done to address privacy or what the reality is, direct physiological measurement may likely be perceived as invasive, at least by individuals. This is probably especially true when measurement is done in pursuit of person-level psychology. It is true that certain personal devices commonly used today conduct physiological measurement, such as smart watches, fitness trackers, and related technologies. But these devices are not psychological: they are typically being used for personal non-shared data collection, and personal data are not typically being sent into cyberspace—at least not for third-party, potentially

high-stakes interests, such as hiring or potential identification. If neuroscience-type measurement ever does become possible on personal or handheld devices, then privacy concerns are likely to drastically increase and stand as an obstacle to the perceived benefits of such measurement as well. Moreover, neuroscience measurement can be and often is conceptualized as "health" or "medical" data. Although the associations with privacy may be self-evident and intuitive, this is of real concern to lawyers and legal departments, whether it be service-providing companies, consumers, client companies, or even beyond. Transparency and privacy control will be key factors in order for people to embrace neuroscience assessments.

Lastly, as with any testing, bias and related Equal Employment Opportunity Commission challenges may arise. These are real concerns, as legal boundaries often are yet to be fully understood when new technologies emerge, thus becoming clearer through court action. It is not uncommon for test makers to adjust test content, whether before or after calibrating data are collected, such that conscious or unconscious bias is eliminated. Neuroscience measurement may have to grapple with related issues in unfamiliar ways, and this process can produce delays and result in the need to iterate on approaches at various stages of development. Because neuroscience-type measurement in human resources applications have yet to be pervasive and high volume, scientists, related professionals, and lawyers have scarcely begun to grapple with such issues, provide guidelines, develop related methods, and learn and relearn via related and broadly definable experience. Very recent times, however, have already seen related issues begin to emerge in high-profile legal cases (see Glunt & Goglia, 2019).

Conclusion

Although the extent to which related innovations are currently impacting test development, and their widely applied use may be sometimes overstated ("market sizzle"), there are many areas in which we are beginning to see increasingly pervasive, real, substantive, and practical improvements in psychometric measurement based on neuroscientific techniques, theory, and research. Neuroscience is also likely to continue yielding new things to measure and new ways to think about measurement, and whether measuring known or novel things, consumers should expect and evaluate innovations in terms of whether testing has become more reliable, more precise, harder to fake, and more predictive of outcomes. Neuroscience has the potential to create these large and substantive improvements that have long been quite elusive.

Challenges remain on which tools and techniques will enable widespread and pervasive implementation. Measurement needs to be made more accessible, less invasive, and less associated with clinical or health-related contexts and interests. Substantive or perceived issues surrounding privacy and face validity will also need to be addressed, likely in multi-faceted ways. As these and other obstacles are removed, excitement about neuroscience-based innovations will be based decreasingly on "buzz" and increasingly on substantive and widespread value-add improvements in applied human resources activities.

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