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Biological implicit measures in HRM and OB: A question of how not if ☆

William J. Becker [a,*], Jochen I. Menges [b]

[a] Texas Christian University, United States
[b] University of Cambridge, United Kingdom

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ABSTRACT

Scholars in the disciplines of human resource management (HRM) and organizational behavior (OB) have primarily focused on explicit processes and measures in their research, but much of human feeling and behavior is triggered through implicit processing outside of conscious awareness. In this article, we discuss how explicit and implicit processes interact to shape work emotions, attitudes, and behaviors, and we suggest that scholars should incorporate biological measures for assessing implicit as well as explicit processes into their research designs. We provide guidance for such endeavors by describing how several biological implicit measures can be used in HRM and OB research. These measures include cortisol measurement, skin conductance, event related potential (ERP), and functional magnetic resonance imaging (fMRI).

1. Introduction

Many current theories of human resource management (HRM) and organizational behavior (OB) have been developed with a model of the human mind that assumes a large degree of conscious control and deliberation. As a consequence, empirical research has naturally operationalized theoretical constructs with explicit measures such as surveys or interviews. In stark contrast, physiological research shows that the conscious information processing capability of the brain is more than 100 thousand times less than total information bandwidth coming into the brain (Zimmerman, 1989). Advances in psychology further show that information processed outside of consciousness nonetheless influences how we feel, think, and behave (e.g. Fazio & Olson, 2003). Therefore, the current tacit model of the human mind on which HRM and OB research relies is incomplete and in some cases incorrect.

In order to address these shortcomings, a number of organizational scholars have called for HRM and OB researchers to pay greater attention to the role of *implicit* processes, attitudes, and emotions in their accounts of workplace attitudes and behaviors (e.g. Barsade, Ramarajan, & Westen, 2009; Becker, Cropanzano, & Sanfey, 2011; George, 2009). A recent accounting showed that 84% of studies published in Industrial and Organizational Psychology contained self-report measures, 49% contained behavioral measures, but only 1.5% utilized biological implicit measures (Austin, Scherbaum, & Mahlman, 2002). As we will show, even when implicit processes predominate their explicit counterparts, people are largely unaware of their influence. In these cases a combination of implicit and explicit measures are necessary to develop and test accurate models of organizational behavior.

Therefore, in this article we elaborate on the shortcomings of an overreliance on explicit measures and offer a practical introduction to a number of promising biological measures of implicit work attitudes and emotions. We will take a broad view of implicit processes that includes the actual brain processes and the states (attitudes, emotions, stress, behavioral tendencies, etc.) that they produce. By adding biological implicit measures to their toolbox, HRM and OB researchers can begin forging their way deeper into the subconscious of organizational life and develop theories that incorporate implicit and explicit drivers of emotions, attitudes, and behaviors.

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* Corresponding author. Tel.: +1 817 257 7567.
E-mail address: w.becker@tcu.edu (W.J. Becker).

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2. Why implicit measures are needed

Many theories of workplace behavior assume and emphasize our conscious control over attitudes and actions. Ajzen's (1991) Theory of Planned Behavior provides a prominent example that has been drawn on heavily in a wide range of theoretical and empirical work. It suggests that the best predictors of people's behaviors are their explicit behavioral intentions and that these intentions, in turn, result from people's explicit attitudes, subjective norms, and behavioral control. Expectancy–valance theory provides another example, which maintains that motivation results from at least three conscious cognitions — our expectancy that we can perform the action in question, our valance or desire for the consequences, and our instrumentality or belief that successful performance will lead to outcomes that we desire (VanEerde & Thierry, 1996).

The underlying assumptions of these and many other current theoretical perspectives are based on a traditional model of the human brain that posits individuals as active agents who consciously deliberate over each of their attitudes, emotions, and behaviors (Brief, 1998; Simon, 1976). In stark contrast, a growing body of neuroscience research indicates that much of the brain processing that shapes workplace attitudes, emotions, and behavior takes place outside of conscious awareness (e.g. Barsade et al., 2009; Becker et al., 2011; George, 2009). For this reason, greater attention needs to be placed on implicit measures for investigating and incorporating non-conscious processing into accounts of workplace behavior.

We should emphasize that we are not suggesting that a shift toward implicit measures will invalidate findings from explicit measures. Rather, we argue that current theories are limited and possibly biased in systematic ways by a reliance on explicit measures. Even Ajzen (1991) acknowledged the existence of dispositional influences on behavior that were not captured within the Theory of Planned Behavior, and, indeed, the empirical relationships between self-report attitudes and intentions and observed behaviors have often been relatively modest (e.g. Ajzen, 1996). By incorporating a balance of implicit and explicit measures into HRM and OB research, scholars will be able to develop more complete and integrated theories of workplace phenomena.

From a practical view, we define implicit processes as those brain functions that occur relatively automatically and outside of conscious control and awareness, and explicit processes as those that occur through conscious executive control (Becker et al., 2011). At this initial stage, we do not differentiate implicit processes from the implicit attitudes, emotions, physiological responses, and behaviors that they produce. Similarly, we define implicit measures as any research method capable of capturing or tracing implicit brain processes or their outcomes including psychosomatic outcomes. The focus of this article will be on biological implicit measures, which we view as the most direct window for investigating implicit processes.

In the next section we will detail three issues from cognitive neuroscience that further highlight the need for HRM and OB scholars to incorporate implicit processes and measures into their theories and research. First, the neuroscience literature suggests that implicit processing always plays a role in determining our emotions, attitudes, and behavior. Second, there are some situations—potentially more than we realize—in which implicit processes alone determine our response. Lastly, the fact that implicit influences remain largely outside of consciousness creates an important dilemma for how our conscious mind interprets our feelings and actions. As we expand our model of the human mind we also need to expand our measures. Therefore, implicit measures will be a necessary addition to the OB and HRM research toolkit.

The first issue raised above arises from the growing support for dual process models of the brain in cognitive neuroscience that include both implicit and explicit processes (Lieberman, 2007; Ochsner & Lieberman, 2001). As these dual process models have matured, the evidence suggests that implicit processes are not limited to situations of habit (Wood, Quinn, & Kashy, 2002). Rather it appears that most of our responses actually begin with automatic implicit processes that can be subsequently moderated by explicit processes if both sufficient time and motivation exist to do so (W. A. Cunningham, Zelazo, Packer, & Van Bavel, 2007). Of particular interest for HRM and OB scholars, this work has investigated discriminatory attitudes. In one striking study, brain imaging showed that both black and white subjects demonstrated an immediate and negative emotional response when presented with unfamiliar black faces (Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005; Phelps et al., 2000). Moreover, these responses did not correlate with subjects' explicit race attitude measures.

Moving on to our second point, there is growing evidence that implicit processes not only come first, but that they also often play a dominant role in shaping our feelings and behaviors (Bargh & Ferguson, 2000; Lieberman, 2007). For example, Westen, Blagov, Harenski, Kilts, and Hamann (2006) showed how implicit attitudes can short circuit explicit deliberation. In this study, individuals with strongly held political beliefs disregarded credible information that ran contrary to their preferred position through an implicit emotional process rather than through conscious deliberation. Taking this further, it has also been shown that implicit processes alone are capable of producing decisions and actions (see reviews in Bargh, 1994; Schmader & Johns, 2003). For example, the mere implicit activation of an elderly stereotype caused participants in an experiment to walk more slowly down the hallway when leaving the experiment than a control group (Bargh, Chen, & Burroughs, 1996).

This brings us to our last point whereby the very nature of implicit processes within the brain poses a significant challenge to incorporating them into our research. Implicit processes are not only immediate and automatic; they are also largely unavailable for introspection even after having produced significant behavioral response. A compelling, if somewhat extreme, example of this involves "blindsight" where individuals cannot "see" due to trauma to their visual cortex, but their optic nerves are undamaged (e.g. Leh, Johansen-Berg, & Ptito, 2006; Stoerig & Cowey, 1997). When they are presented with visual stimuli they are able to respond at better than chance even though they clearly state that they do not know what they are responding to. This highlights a problem for researchers who wish to investigate implicit processes because it is not possible to simply ask subjects about their implicit attitudes or emotions due to the fact that they are largely inaccessible to the conscious mind.

The blindsight example also illustrates a basic difficulty in untangling explicit and implicit processes. The blindsight subjects are unique in that they could not attempt to explain their implicit responses because their explicit visual processes were obviously impaired. In contrast, normal individuals regularly seek to make sense of their feelings and actions which we have shown derive from both implicit and explicit processes operating in concert. However, because only explicit processes are available for introspection, we overweigh the influence of explicit processes and are largely unmindful of their non-conscious counterparts. Cognitive science defines "the binding problem" as the phenomenon through which various implicit and explicit processes and inputs are integrated seamlessly by the conscious mind into a unitary perceptual experience (Kolb & Whishaw, 2008). The essence of the binding problem is that we generally perceive our thoughts, decisions, and actions to be under our conscious control even when this is not the case (Hohwy, 2004). Although this phenomenon is mostly adaptive for our daily lives, it creates problems for researchers because it makes it easy for subjects and researchers to underestimate the importance of implicit processes.

Our conscious mind weaves a continuous self-narrative to make sense of our thoughts and actions. Because of the binding problem, this is accomplished solely through the lens of conscious explicit processes. This is especially problematic when implicit and explicit influences on our thoughts and actions diverge (e.g. Blackmore, 2005; Johnson, 2004; Lieberman, 2007). In these cases the conscious mind is unaware of the implicit process and therefore confabulates a plausible but not necessarily accurate explicit account of the implicitly influenced attitude, emotion, or behavior in question. A simple example of this can be found in early studies of choice behavior where subjects frequently selected the right-hand most option among identical items and then provided reasonable but inaccurate justifications for their preference (Nisbett & Wilson, 1977). In these cases, self-report measures will not reflect the true causes of job attitudes and behaviors. This is likely to be of particular concern for qualitative research where subjects are often asked to provide retrospective accounts of their feelings and behaviors.

In short we believe that there is strong evidence that responses to workplace events begin with implicit processes which produce implicit emotions and attitudes and trigger varying degrees of subsequent implicit and explicit processing that produce expressed emotions and attitudes and observed behaviors. This modern view of the brain clearly suggests that implicit processes must be incorporated into our theories of organizational behavior and that a range of biological measures should be integrated into our research. It is important to note that we believe that incorporating implicit measures will strengthen rather than weaken the value of explicit measures. Even when explicit responses are found to be inaccurate, they still reveal important insights about the social forces and norms that produced them.

3. Biological measures of implicit processes

Demonstrating that implicit processes matter is not sufficient. Researchers also need guidance on how to incorporate implicit processes into their research and, specifically, how to measure and interpret these implicit processes. To this end, we now shift to discussing a range of methods that are currently available. This discussion is not meant to be a comprehensive review of all available methods. Rather, we focus on a number of biological methods for assessing implicit processes that are particularly promising for application HRM and OB research. We provide a brief description of each technique and weigh advantages and disadvantages from both a theoretical and practical view. Our aim is to provide researchers with enough information to consider these and other methods that are most appropriate for their questions of interest and direct them to detailed information on how to carry out each method.

The biological methods presented here measure bodily responses that can be linked to specific implicit processes in the brain. These methods allow researchers to isolate and trace the influence of implicit processes on actual work attitudes, emotions, and behaviors. These methods differ in their temporal and spatial resolution of implicit process measures and in the types of research questions that each is best suited to address. Further, the methods cover a wide range of technical sophistication. As a result, some can be easily adapted to field studies while others are currently only practicable for experimental settings. Our approach differs from previous reviews (e.g. Mauss & Robinson, 2009) in that we do not focus on any one type of implicit process. Even though many of the examples we provide have investigated stress or emotion, we believe that the methods included here can be adapted to explore a broader spectrum of implicit processes including habit, intuition, and bias. Consequently, for each biological measure we provide a brief overview of the method, discuss its advantages and disadvantages, and outline the types of implicit processes and research questions that it is best suited for. Our primary aim is to encourage HRM and OB researchers to systematically apply complimentary implicit and explicit measures across studies to answer increasingly more precise research questions.

Organizational scholars have not been unaware of the promise of utilizing biologically based measures. A number of studies have successfully used genetic indicators as an implicit measure of personality and linked these to stable job attitudes and values (for review, see Ilies, Arvey, & Bouchard, 2006). Organizational researchers have also used physiological measures to assess

Table 1
Overview of promising implicit measures for HR research.

Biological implicit measure	Description	Spatial resolution	Temporal resolution	Cost	Setting
Cortisol	Saliva samples are analyzed for cortisol levels.	Poor (global arousal)	Poor (chronic stress)	Modest	Primarily field
Skin conductance	Electrodes on fingers measure autonomic response.	Low (global arousal)	Good (phasic stress)	Modest	Primarily field
ERP	Electrodes on scalp measure electrical activity in brain.	Good (broad regional activity)	Excellent (phasic arousal)	Moderate	Primarily lab
fMRI	MRI imaging measures changes in blood oxygenation in the brain.	Excellent (specific brain areas)	Moderate	High	Lab only

well-being and stress in the workplace (e.g. Semmer, Grebner, & Elfering, 2004; Wright, Cropanzano, Bonnett, & Diamond, 2009). In the 1950's over 13% of studies in organizational psychology included physiological measures (Austin et al., 2002). These examples demonstrate that even though the methods we propose may seem ambitious, there are encouraging precedents in the extant literature. Therefore, we are confident that all of the methods presented can be successfully adopted in HRM and OB research. With this in mind, we present these methods in order of the relative ease with which they could be implemented (see Table 1 for a summary).

3.1. Cortisol

We begin with cortisol as an implicit indicator of stress. Employees in competitive environments may downplay, exaggerate or be unaware of the level of stress they experience and, thus, their verbal reports may distort the actual extent to which they experience acute or chronic stress. Adding cortisol as a measure to tap into stress more directly can yield more accurate results regarding the actual bodily stress level that an employee experiences.

Cortisol is the biological intermediary that links physical and psychological stress to adverse health outcomes (Charmandari, Tsigos, & Chrousos, 2005; Miller, Chen, & Zhou, 2007). The measurement of cortisol is fairly simple. The system involved in releasing cortisol is the hypothalamic-pituitary-adrenocortical (HPA) axis. In response to stress, the hypothalamus first secretes corticotropin-releasing hormone (CRH), then CRH stimulates the pituitary gland to secrete adrenalcorticotropic hormone (ACTH), and finally ACTH signals the adrenal gland to secrete cortisol. After about 15–20 min, the level of released cortisol can be measured in the saliva (the largest effect sizes in cortisol studies are obtained 21–40 min after stressor onset; see Dickerson & Kemeny, 2004). Participants provide saliva either by chewing a swab of cotton (called salivette) or by spitting into tubes. In order to assess reliability, researchers collect several samples of saliva from the same person in the course of a day for a period of several days (Miller et al., 2007). The saliva is then processed and analyzed by either the researcher or an offsite laboratory.

Cortisol has been used as an implicit indicator of stress for many years in psychological research and has also been incorporated in a number of organizational studies. Although some early studies were criticized because they measured cortisol only once or at inappropriate intervals (Fried, Rowland, & Ferris, 1984), as research with cortisol matured several impactful studies were conducted. For example, Fox, Dwyer, and Ganster (1993) found that nurses who believed they had little control at work responded to increases in perceived work load with heightened levels of cortisol at work, whereas nurses with high control at work did not show such a physiological reaction. In a later study, the same researchers found that cortisol levels mediated the relationship between job demands and health care costs. The extent to which salivary cortisol remained at high levels for several hours after work explained 25% of the variance in subsequent health care costs (Ganster, Fox, & Dwyer, 2001). Hence, research on cortisol is theoretically and empirically well established, and cortisol as a biological indicator of stress is widely accepted (Charmandari et al., 2005).

From a theoretical viewpoint, cortisol would be useful in determining if an attitude or behavior is linked to a stress-inducing process or a more imperceptible bias or habit. Cortisol is a useful implicit indicator of stress in studies that focus on physiological responses to socially challenging or uncontrollable situations, on coping with stress, and on consequences of chronic stress. Researchers initially thought that the release of cortisol represented a general bodily response to a wide range of stressors, but recent advances in cortisol research have shown that cortisol changes follow complex patterns. Specifically, meta-analyses found that the release of cortisol depends on (a) particular types of stressors, (b) the person experiencing stress, and (c) the duration of exposure to stress (Dickerson & Kemeny, 2004; Miller et al., 2007). First, among the psychological types of stressors, implicit social evaluative processes are associated with the largest changes in cortisol levels and the longest recovery times (Dickerson & Kemeny, 2004). Given that most organizations are competitive arenas in which employees strive to obtain positive evaluations by others in order to get ahead, the use of cortisol thus remains attractive for HRM and OB scholars. Furthermore, cortisol levels shift with the subjective stress people experience (Miller et al., 2007) and, therefore, depend on individual coping strategies (Gaab et al., 2003). Accordingly, organizational researchers used cortisol measurements, for example, to objectively demonstrate the stress-reducing effect of emotional intelligence training. Compared to a control group, a treatment group of adults receiving emotional intelligence training (including strategies for effective coping) had significantly lower cortisol secretion one year after the training than a control group that received no such training (Kotsou, Nelis, Grégoire, & Mikolajczak, 2011). The implicit assessment of stress in this study is much more convincing than explicit self-reported accounts of reduced stress, because the latter are likely influenced by demand effects. Moreover, cortisol levels are elevated at stress onset but decline over time (Dickerson & Kemeny, 2004; Miller et al., 2007). Therefore, cortisol measures can be used to indicate chronic stress, but the specific pattern of cortisol secretion depends on a number of conditions interested researchers need to carefully consider (see Miller et al., 2007). Finally, by including cortisol into their design, researchers would be able to investigate the link between arousal and explicit attitudes and behaviors of interest. Higher levels of acute stress would suggest an emotion-based process. Chronic stress would likely indicate a more cognitive process that created inner conflict, while a lack of stress could be the result of habit or ingrained bias.

Recent psychological studies suggest further innovative ways to use cortisol in research designs that could be adopted for organizational research. Among these designs are dyadic models that assess the extent to which people covary in the cortisol secretion. For example, a study on married couples found that the levels of salivary cortisol of husband and wife covary over the course of several days. When one member of the couple has a higher-than-usual cortisol level, the other has so as well. The strength of this association depends on marital satisfaction such that the trajectories of cortisol changes are more closely linked in couples with low, rather than high, marital satisfaction (Saxbe & Repetti, 2010). HRM and OB scholars could assess similar patterns in workplace dyads, for example, between supervisors and subordinates and examine the extent to which the patterns depend on job satisfaction. They could also go to a group-level analysis to examine whether members of groups converge in their levels of cortisol secretion and how patterns of such convergence affect group performance.

From a practical viewpoint, cortisol studies have advantages over other biological implicit measures, in that the data collection is non-invasive, quick, and easy. Participants can be instructed to collect saliva samples themselves in actual work settings, provided the researcher can minimize the risk that participants would violate the protocol (see Kudielka, Broderick, & Kirschbaum, 2003). For stress research, it is also important to note that obtaining saliva is not stressing in itself and so spurious effects are fairly unlikely. Nevertheless, the cortisol method has some disadvantages that make it less suitable for some OB and HRM research questions. Specifically, its application is limited to certain stress reactions and to distinct stressors, as discussed above. Also, for cortisol studies researchers need to recruit a large number of participants because the effect sizes are typically small (for concrete recommendations on sample size, see Dickerson & Kemeny, 2004; Miller et al., 2007). Nonetheless, salivary cortisol remains the prime biomarker of stress and so we encourage OB and HRM scholars to use cortisol as a bodily measure of stress at work. Specific guidelines for conducting cortisol studies are readily available on the Internet (see Stewart & Seeman, 2000).

3.2. Skin conductance

Skin conductance measurements provide another readily adoptable physiological measure for organizational researchers. It has been well established that the electrical properties of human skin fluctuate in response to underlying neuropsychological processes (Boucsein, 1992). Changes in skin conductance have been directly linked to increased eccrine sweating triggered by activity in the sympathetic branch of the autonomic nervous system. Skin conductance measures reflect broad arousal within the brain as opposed to the more localized measures that will be discussed later. Nonetheless, skin conductance measures have been successfully utilized to measure important implicit processes such as stress, affective arousal and cognitive processing (Nikula, 1991; Sequeira, Hot, Silvert, & Delplanque, 2009).

Therefore, skin conductance represents a tractable method for researchers who are interested in investigating implicit responses to workplace events and decisions. It is particularly attractive because the equipment is relatively compact and unobtrusive allowing onsite measurements to be made relatively continuously while subjects engage in actual work-related behaviors and decisions. Measurements are typically made using a base module and a laptop computer. Two or more small electrodes are attached to fingers on one of the subject's hands and data collection can begin almost immediately. Most skin conductance measurement systems include the ability to also monitor heart rate and provide an additional measure of autonomic response.

Skin conductance changes can be examined within two different temporal frames. Short term conductance fluctuations in response to discrete events are termed skin conductance response (SCR). Longer term tonic differences in skin conductance are referred to skin conductance level (SCL). An SCR is a sharp phasic rise and fall in skin conductance that occurs over several seconds following some event that triggers autonomic activity (such as making a risky decision). The primary challenge with SCRs is that the participants must experience the event of interest numerous times within the course of a single experiment in order to provide enough data for analysis. Nonetheless this approach could be adapted to investigate a number of workplace phenomena such as implicit discrimination, ethical decisions, and receiving feedback to suggest just a few. SCLs in contrast are recorded and averaged over longer periods of time from several to 10 min and compared to baseline measurements. This approach is capable of reflecting elevated periods of arousal or cognitive effort that may occur during more diffuse or sustained tasks that are not easily adapted to the event related approach. In potential work related applications SCRs provide indications of dynamic affective responses while SCLs could provide a measure of tonic arousal or stress.

From a theoretical standpoint, skin conductance can be used to investigate and test research hypotheses that predict increases in affective arousal in the work place. It complements cortisol in that discrete stimuli and events can be observed and arousal levels can be linked to observed outcomes. Similar to cortisol, it is useful in differentiating between implicit processes that rely on arousal from those that result from habit or bias. A link between SCRs and explicit behavior or expressed attitude would suggest an emotion-based process. Elevated SCLs would likely indicate more cognitive processing and inner conflict. An absence of arousal response would most likely suggest the presence of habit or bias. In order to demonstrate the usefulness of skin conductance research consider the following two examples from the literature. In the first example, researchers showed that anticipatory emotional responses evidenced by SCRs predicted advantageous decisions by normal adults in a gambling task (Bechara, Damasio, Tranel, & Damasio, 1997). In addition, subjects with brain damage to their emotion processing center did not show these anticipatory SCRs and performed poorly on the gambling task. In this case skin conductance allowed researchers to measure implicit emotional responses and demonstrated their importance for decision making. In a related study it was shown that older adults who generated anticipatory SCRs in this same gambling task performed as well as younger adults (Denburg, Reknor, Bechara, & Tranel, 2006). However, a portion of older adults did not produce anticipatory SCRs and performed poorly. This suggests that poor performance among older adults was not due to general aging but rather a specific impairment in implicit emotional processing. These examples provide a roadmap for how skin conductance can be adapted to trace implicit affective processes in work related situations and differentiate them from low arousal biases and habits.

Nonetheless, skin conductance is less suitable for detecting chronic stress. For example, skin conductance and blood pressure were utilized as implicit indicators of stress in a study that examined the effectiveness of stress reducing interventions for the workplace (Bruning & Frew, 1987). Significant effects for the interventions were found for blood pressure, but not for skin conductance. Although we applaud this early use of biological implicit measures, the disappointing results for skin conductance illustrate the importance of carefully selecting implicit measures that are consistent with the construct of interest. In this case the authors were investigating changes in chronic stress, but skin conductance is better suited to capture phasic changes in stress levels. Thus, a positive example of the usefulness of skin conductance can be found in a study that looked at training for job interviews (Hollandsworth, Glazeski, & Dressel, 1978). This study found that interview training reduced skin conductance response during a subsequent job interview. Further, this implicit measure of anxiety also correlated with improvements in objective measures of interview performance.

From a practical standpoint, skin conductance methods are attractive due to their reasonable cost and potential to be used in actual work environments. The equipment is robust, readily available, unobtrusive, and relatively easy to operate. This makes it well suited for use in field studies that investigate implicit attitudes and emotions in the workplace. Another advantage is the ability to collect data in real time as subjects are experiencing the events or behaviors being studied. In addition, there is a rich cognitive science literature to draw from regarding the relationship between skin conductance and implicit affective and cognitive processes. The primary challenge to adopting this method is the relatively complex designs required to obtain reliable SCR data. This will require the participants to repeat the same, or very similar, task, decision, or behavior multiple times during data collection. Figner and Murphy (2011) caution that the more subtle the stimuli, the more repetitions that are necessary to achieve the necessary statistical power. In the Denburg et al. (2006) study, each participant made one hundred decisions. An hour or more of subject time is often required to collect data. This may require that the activities being studied be scripted, simulated, or at least scheduled in advance. In addition, the fact that skin conductance reflects general brain activity or arousal and not any single neuropsychological process may prove a limitation for some investigations. In short, skin conductance provides an attractive and cost-effective starting point for a wide variety of questions regarding the role of implicit processes in OB and HRM. There are a number of excellent guides to help even relative novices maximize the strengths and overcome to challenges of using skin conductance measures (e.g. Figner & Murphy, 2011).

3.3. Event related potential

Event related potential (ERP) methods represent another promising avenue for tracing the implicit responses of individuals in HRM and OB research. ERP (sometimes referred to as EEG) involves monitoring brain activity from just outside the scalp. Therefore, similar to SCR methods, ERP is able to detect implicit and explicit responses in the brain to environmental stimuli. Unlike skin conductance, which measures a more distal response via the sympathetic nervous system, ERP provides a direct measure of activity in localized central nervous system regions. Therefore ERP is able to address different questions than SCR. Although both can provide information about automatic affective reactions, ERP can distinguish between a number of different types of processes within the brain.

The basic principle behind ERP is that the firing of neurons in the brain produces subtle localized changes in the electromagnetic field just outside of the brain (Luck, 2005). By placing electrodes at various locations around the scalp we can record and analyze these changes in response to experimental events. The spatial resolution of ERP is not very refined, but it is sufficient to differentiate between some types of brain processes. Among the processes most likely to interest HRM and OB scholars, ERP can differentiate sensory, affective, cognitive, language, and error detection processes (Picton & Stuss, 1980). Another strength of ERP is its excellent temporal resolution that allows researchers to determine the order in which processes are evoked within the brain and associate these processes with behavioral responses. In this way researchers could learn whether an observed outcome directly followed an implicit or explicit brain process.

The equipment required to conduct ERP experiments is moderately expensive but relatively easy to set up and may already exist within many psychology departments. The basic equipment consists of two computers, an electrode cap, and an amplifier/interface. ERP experiments can be susceptible to interference from electronic noise, so it is generally preferable to conduct experiments in a shielded room, which also can typically be the greatest expense (Luck, 2005). However it may be possible to perform ERP research without shielding in work settings if electrical interference can be minimized. Although data collection is relatively straightforward, the experimental design and data analysis are fairly complex and requires dedicated self-study, training, or participation in ongoing experiments to master. Luckily, these are one-time expenditures and the cost of maintaining an ongoing program of ERP research is relatively modest.

From a theoretical perspective, ERP is ideal for testing predictions of both global and more localized brain activity and affective arousal in response to workplace events. The greater spatial resolution of ERP allows researchers to consider and investigate more specific brain processes and responses than does skin conductance. In this way, ERP can be used to investigate habit or bias-based responses in addition to arousal-based responses. As an example of what can be accomplished with the ERP method, consider a recent experiment from social psychology. Ito and Urland (2005) investigated the effect of attentional focus on the processing of race and gender. They found that when individuals had more complex processing goals, such as being asked to judge the personality of targets that varied in race, that explicit processes associated with race categorizations were activated sooner than if they were given a simple goal of identifying the target's race. They did not however find a similar relationship when the gender of targets was varied. The authors concluded that processing complexity affected the timeline for social categorical processing and that attentional cues that might attenuate stereotype processing had little effect on these early implicit processes. This example is interesting because it shows how ERP can be brought to bear on questions that are clearly of interest to HRM and OB scholars and outlines a paradigm that could be readily adapted to a variety of work related implicit processing questions.

More recently, ERP was used to investigate inspirational leadership, another topic of direct interest to HRM and OB researchers (Waldman, Balthazard, & Peterson, 2011). The authors argued that increased coherence in the right frontal lobes of the brain during leader communication should be associated with inspirational leadership because it requires greater emotional regulation and visionary communication. In a study of actual leaders from a variety of occupations, they found that right frontal coherence was positively related with a direct coding of socialized visionary messages contained in leader communications. Further, the implicit neurological measurement was more strongly related to the direct visionary communication coding than was a validated perceptual measure of inspirational leadership that was completed by each leader's subordinates. These results are particularly important for our purposes because they demonstrate how implicit and explicit measures can capture different but complementary information about organizational phenomena. By capturing both types of measures, researchers can probe more deeply into the forces that drive workplace behavior.

From a practical standpoint, ERP affords researchers the opportunity to employ a common method to investigate work-related implicit attitudes and emotions both in the lab and in the field. The ERP method is well documented and includes a rich literature in cognitive science and social psychology to draw from for guidance regarding collection methods, data analysis, and interpretation of results. The equipment can typically be obtained or borrowed from a number of sources (including many Psychology departments) at a moderate cost. The data collection process is relatively straightforward and unobtrusive and lends itself quite readily to a wide variety of workplace settings and research questions. The practical strengths of the method also include its excellent temporal resolution and ability to collect data in real time as subjects engage in work experiences and behaviors.

The main challenges of conducting ERP research include the relative complexity of the required experimental design and data analysis and its susceptibility to electromagnetic interference especially when experiments are conducted in actual work environments. As with skin conductance, the design complexity stems primarily from the need for repeated measures of similar stimuli to reliably identify brain responses. This can require relatively long data collection sessions. Lastly, the spatial resolution of ERP is quite low and many specific brain processes cannot typically be identified. In short ERP has the potential to greatly expand the types of questions that OB and HRM can pursue regarding the role of implicit processes in shaping workplace attitudes, emotions, and behavior. Once again, there are a number of excellent guides to help even relative novices successfully employ ERP with or without assistance from or collaboration with outside departments (Donchin & Lindsley, 1969; Luck, 2005).

3.4. Functional magnetic resonance imaging

Functional magnetic resonance imaging (fMRI) represents the latest and most technologically advanced of the current implicit measurement techniques and it also provides the clearest window into the implicit processes that shape specific attitudes and behaviors. With fMRI methods, researchers are able to go beyond the general types of brain processes identified by ERP, and monitor the activity of specific areas of the brain (Ullsperger & Debener, 2010). This in turn allows us to trace specific types of implicit processes in response to stimuli and relate them to specific behavioral responses, decisions, and expressed attitudes and emotions of interest to HRM and OB researchers.

The fMRI method operates on the principle that neural activity in the brain causes changes in the blood oxygen level in the localized region of the brain where neurons are firing (Huettell, Song, & McCarthy, 2003). The amount of oxygen in the blood determines its magnetic properties (BOLD signal) and these properties can be measured using MRI technology. As this technology has advanced, researchers have been able to isolate differences in neural activity in smaller and smaller sections of the brain. The current technology can analyze brain volumes (voxels) on the order of a few millimeters. Despite its excellent spatial resolution, the BOLD response is not a direct measure of neural firing and changes in the signal lag can occur more slowly than the actual action potentials responsible for neural activity (Attwell & Iadecola, 2002). Therefore, the temporal resolution of fMRI methods is not as good as that provided by ERP. Promising new fMRI techniques are being developed that will allow researchers to move beyond looking at static activity levels within the brain and instead investigate connectivity and information flow within the brain (Huettell et al., 2003). These methods are particularly promising for investigating the interaction between implicit and explicit processes.

The equipment necessary for fMRI research is by far the most expensive and technologically complex of all the methods discussed here (Huettell et al., 2003). Setup and operation costs of an MRI lab are on the order of millions of dollars and outside the means of most business schools. However, most hospitals and university medical centers have MRI machines that are specialized or suitable for conducting fMRI research. Often these facilities are willing to rent MRI time (the current rate is approximately $500 per hour) including the services of an MR technician to operate the MRI and collect the data. Therefore the most daunting task facing OB and HRM researchers is to design effective experiments and analyze and interpret the resulting data. The fundamentals of experimental design are similar to those for skin conductance and ERP methods (Ullsperger & Debener, 2010). Cues and stimuli must be presented visually or audibly and responses are currently limited to 2 or 3 button hand signal devices. Similar to ERP, many trials are required to obtain reliable results and experimental sessions typically last an hour or more.

From a theoretical perspective, fMRI has the greatest potential to extend and integrate our theories of workplace behavior by taking our theories inside the brain (Becker et al., 2011). Because fMRI is able to test theories about specific brain regions and connections, it allows us to investigate experimental questions not answerable by any other explicit or implicit method. It is able to simultaneously examine implicit and explicit processes as well as arousal-based and habit or bias-based responses as well as the interplay between these processes and responses. In a study of moral decisions, researchers were able to determine that economic efficiency and equity were processed in different regions of the brain (Hsu, Anen, & Quartz, 2008). More importantly, equity was encoded in a region associated with negative emotional reactions. Further, individuals who showed a stronger negative response to inequity made decisions that reduced inequity even when this reduced efficiency. These findings suggest that our sense of justice is based on fairness and that it derives from our implicit emotions rather than conscious deliberation and rationality. In another study, fMRI was used to show that emotional empathy is unique from cognitive empathy (Nummenmaa, Hirvonen, Parkkola, & Hietanen, 2008). During cognitive empathy, only the frontal lobe regions associated with theory of mind and mental visualization were activated. In contrast, emotional empathy showed broad engagement of the mirror neuron system and emotional center of the brain. In addition, the motor cortex become more engaged indicating extensive implicit mirroring of the observed emotional states. This also suggests that emotional empathy primed the observer for action. The authors concluded that emotional empathy provides a promising neural mechanism for implicit emotional contagion.

More recently, an fMRI study appeared in an HRM/OB journal for the first time (Dulebohn, Conlon, Sarinopoulos, Davison, & McNamara, 2009). In this study the authors showed that distributive and procedural justice were distinct from each other. They found that violations of distributive justice produced a response in different regions of the brain than did violations of procedural justice. In addition to indicating that justice dimensions are unique, these findings also have implications for the relative impact and temporal considerations of each. This study demonstrated the potential value of fMRI methods for advancing HRM and OB theory. We believe that fMRI can be successfully employed in many topics of interest to HRM and OB researchers such as selection and leadership to name just a few.

From a practical view, fMRI presents a number of hurdles beyond its expense and technical complexity. The most vexing for HRM and OB researchers is likely is impracticality for use in field studies. As anyone who has experienced a medical MRI knows, the fact that experiments must be conducted inside an MRI machine limits the types of tasks that can be studied. In addition, the unique requirements of the experimental designs for fMRI will require researchers to develop creative new experimental paradigms to model workplace phenomena. However, these new paradigms may also reveal new insights both through the process of development and in the subsequent findings they produce. Another potential pitfall for HRM and OB researchers could be unfamiliarity among editors and reviewers with the unique features of the methods and analyses that are employed in fMRI. For example, acceptable sample sizes in fMRI studies can be as low as 12 or 13 subjects (e.g. William A. Cunningham et al., 2004). Also, the significance levels that are reported in fMRI results are different from those utilized in HRM and OB research due to issues with data smoothing and multiple comparisons (Huettell et al., 2003). Nonetheless, we are confident that these concerns will quickly dissipate as HRM and OB scholars begin to embrace and incorporate neuroscience into their research.

4. Conclusion

Many of our current theories are based upon a model of the human mind that is quickly becoming outdated and this is exposing the shortcomings of relying solely on the explicit measures associated with the old models. Recent discoveries in psychology and neuroscience draw our attention to facets of organizational life that are not readily reportable but rather unfold outside of awareness and influence perceptions and behaviors in the work place. Implicit attitudes and emotions, automatic bodily responses and non-conscious brain processes shape how people think, feel, and act at work. OB and HRM researchers have only begun to explore this implicit domain of organizational life. As we rethink our model of the human mind and adapt our theories accordingly we will need to incorporate new measures as well. To this end, we have described an array of biological implicit measures. Some of these measures have been widely used in the field while others are largely unfamiliar to the majority of organizational researchers. We believe that most every organizational research theme can benefit from considering implicit processes in at least one of three possible ways. First, we should integrate existing research on implicit processes, attitudes, and emotions from other fields into our theory building. Second we should incorporate implicit as well as explicit measures into our future research, even if we must utilize simpler implicit methods like cortisol or skin conductance. This will allow us to identify areas where implicit processes are most significant in advancing our theories. Lastly, we can draw on what we learn to engage in multi-disciplinary research to apply more advanced implicit methods to tease out the mechanisms through which implicit processes drive workplace behavior.

We conclude with a note of caution regarding how such insights might be used and applied. Although the measures we have discussed offer promising and exciting paths into the realm of the non-conscious, they can also generate sensitive data, because due to their very nature, the participants have little or no control over their results. Such situations provide the researcher with more power than is usual in OB and HRM research, but this power must thus be handled with great care and responsibility. If researchers pay careful attention to these ethical considerations, however, we strongly believe that incorporating biological implicit measures will greatly expand our understanding about why employees feel and behave as they do.

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