We knew it all along! Using cognitive science to explain how andragogy works

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Abstract

Purpose – This paper aims to link recent findings in cognitive neuroscience to better understand how andragogically informed instructional practices impact cognition and learning.

Design/methodology/approach – The research questions guiding the study is in what ways can the recent findings in cognitive neuroscience help to inform adult education theory, including andragogy in particular, to deepen our understanding of how andragogical instructional principles and practices can improve learning? We adopted Torraco's (2005) integrative literature review approach of providing enough details regarding the selection of the literature and the identification and verification of emerged themes of main ideas.

Findings – The core assumptions of andragogy (self-direction, prior experience, readiness to learn and immediacy of application) have a connection to the neural networks related to memory and cognition.

Research limitations/implications – First, this study provides fundamental foundations for combining cognitive neuroscience and adult learning to illuminate how cognitive neuroscience contributes physiologically to adult learning. Second, the findings in cognitive neuroscience related to the four assumptions for andragogy help to provide scientific explanations and interpretations for adult learning theories influencing human resource development (HRD), such as self-directed learning, experiential learning and role theory.

Practical implications – First, HRD practitioners could use the integrative approach between andragogy and the cognitive neuroscience to reduce the issues of learning activities in generation differences. In addition, cognitive neuroscience research may contribute to improving teaching and instructional techniques.

Originality/value – The contributions of this study is that it provides an integrative review about why and how anagogical principles work through the lens of cognitive neuroscience. Based on the findings, we suggested a model of adaptive cognitive neuroscience-adult learning structures.

Keywords Management education, Andragogy, Adult learning and education, Cognitive neuroscience, Readiness to learn and immediacy of application, Self-directed learning and prior experience

Paper type Conceptual paper

Some time ago, Forrest and Peterson (2006) called for educators, those preparing future managers in particular, to examine their teaching and the influences upon that teaching by suggesting the thoughtful application of the principles and practices of andragogy. It was suggested that educators adopt the language of andragogy, aligning to its educational practices to fully engage adult students of management education. This call

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speaks to human resource development (HRD) as a profession, as HRD scholar-practitioners need to have a thorough understanding of the most effective ways of educating upcoming organizational leaders, and their work bridges the gap between adult education and management education. Too, HRD educators need to pay fastidious attention to how they "train the trainers" in the use of andragogic principles. Finally, for those HRD educators working at institutions in which HRD courses or programs are housed in schools of management or business, the Forrest and Peterson's (2006) appeal to management educators is of particular interest.

Forrest and Peterson's (2006) call for action included imperatives to use such techniques as role-play, group discussion, service learning and problem-based learning, in an attempt to provide relevance to learning experiences. The idea of using problem-based instructional techniques (which helps adults apply their experiences to learning activities) is not new to education in general nor to management education, where they have been utilized for many years. It has been suggested by Brownell and Jameson (2004) that the use of problem-centered instruction allows students to bridge between cognitive, affective and behavioral leaning processes.

In addition, it has been suggested that scholars should work to bridge the gap between science and education, suggesting that interdisciplinary work in the area of cognitive neuroscience would help to focus more closely on establishing research-based practices (Ansari and Coch, 2006). Yet, little has been written to link cognitive neuroscience to education in general, and instructional techniques in particular, and the work that has been completed has proven to be challenging at best and not particularly fruitful in terms of specific application (Bruer, 1997). Although recent studies have emphasized the connection between adult learning and neuroscience (Collins, 2015; Holmer, 2014; Knowles *et al.*, 2014), more research needs to be conducted in the field.

Although there have been calls to link cognitive neuroscience to pedagogy and pedogological principles (Ansari and Coch, 2006; Fuller and Glendening, 1985), especially for children (Posner and Robarth, 2005), to date little has been written about cognitive neuroscience and its connection to the practices of adult education in general, and management education in particular, especially within the context of adult learning theory. Thus, the purpose of this paper is to inform adult learning theory and management education with new information available in these areas. Therefore, the research question to be explored is:

RQ1. In what ways can the recent findings in cognitive neuroscience help to inform adult education theory, including andragogy in particular, to deepen our understanding of how andragogical instructional principles and practices can improve learning?

To address the research question, we examined related studies using Google Scholar and Business Source Premier databases. We adopted Torraco's (2005) integrative literature review approach of providing enough details regarding the selection of the literature and the identification and verification of emerged themes of main ideas. We searched for the appearance of mixed terms, such as "cognitive neuroscience", "brain", "andragogy" "adult learning" and "adult education". We limited our search to studies conducted between 1980 and 2013.

Andragogy has a well-documented history in adult education, with contemporary usage being popularized with Knowles' (1970) work *the Modern Practice of Adult*

Education: Andragogy vs Pedagogy. Although widely popular among educators, a good deal of critique regarding the concept of andragogy emerged, as there was widespread criticism regarding the use of the term "theory" to describe andragogical principles, among the strongest of which were developed by Davenport and Davenport (1985) and Hartree (1984), who suggested that andragogy lacked definition and theoretical grounding; significant critique of the principles of andragogy are of particular interest. Importantly, recent advances in cognitive neuroscience may help to further clarify how andragogy, its principles and practices are key to aiding retention and plasticity among adult learners.

Andragogy: principles and practices

Until the mid-twentieth century, adult educators relied primarily on research derived from areas of psychology and educational psychology, which were chiefly behaviorist in philosophy, to inform their knowledge of adult learning. Importantly, much of that information was derived from research on children (Merriam, 2001). Thus, the impetus for a push toward a theory that dealt with adults as the central figures in the learning process was an important step toward developing theory on "the art and science of helping adults learn" (Knowles, 1980, p. 43, as cited in Merriam, 2001). Andragogy, as defined by Knowles, initially started as a theory, but in response to critique became known as a primarily learner-centered set of assumptions (Hartree, 1984; Taylor and Kroth, 2009) around which a teacher is able to develop instruction.

Andragogy is grounded in the principle that teachers facilitate a climate of "adultness" in the classroom environment; an atmosphere of mutual inquiry and learning is taken on. Based upon these premises, Knowles (1970) defined four basic principles including:

(1) adults have a self-directed self-concept;

(2) adults bring a wealth of experience to the learning process;

(3) adults enter the learning process ready to learn relevant information; and

(4) adults are oriented toward immediate application of learning.

Learning is defined as a change in long-term memory (Kirschner *et al.*, 2006) and is key to realizing the principles of andragogy.

Andragogy critique and response

As with many theories, andragogy is not without its detractors. Knowles original work ascertained that his theory was not applicable to the learning and education of children, and the principles of andragogy could not apply to them in whole. Too, he suggested that the teacher, rather than the student or the classroom environment, were the source of either pedagogical or andragogical principles in the classroom (Knowles, 1970). Each of these issues was deliberated extensively within the literature and was among several areas of criticism on the theory of andragogy. Importantly, much scholarly discussions have taken place regarding the "adultness" of andragogy, and whether andragogy could, indeed, be applied to the education of children. Importantly, several arguments were made for cases in which some children are more independent and self-directed than the some adults (Merriam, 2001). Too, it was suggested that some children may have experiences that are more rich and extensive than do some adults

(Hanson, 1998). These critiques continue, as various scholars suggest that andragogical principles are increasingly implemented in the pre-adult classroom (Cavanaugh *et al.*, 2009).

Too, a good deal of critique took place within the scholarly literature as to whether Knowles' conception of andragogy constituted a "theory". Importantly, andragogy has been variously defined as a theory of adult learning, a theory of adult education, a technique for adult education and a set of assumptions that should be used to guide the teaching and learning of adults (Davenport and Davenport, 1985). The lack of a strong definition paralleled critiques by Hartree (1984) who suggested that andragogy is not a theory at all, but rather a set of guiding principles to be applied to the education of adults. Eventually, Knowles addressed some of these critiques by beginning to refer to andragogy as a set of assumptions. Too, he added a fifth and sixth assumption to his list, which included:

- that adults need to know the reason for learning something; and
- adults are driven by intrinsic motivation to learn.

Importantly, the last two assumptions have been accepted in varying degrees by adult educators and are often omitted from discussions of andragogy within the scholarly literature (Forrest and Peterson, 2006); thus, only the first four assumptions will be further examined within this paper.

Finally, andragogy has been the recipient of significant critique because little research has attempted to empirically validate it as either a theory or a set of assumptions. Results of existing research are often inconclusive and contradictory and offer little in terms of specific empirical evidence to support its use (Merriam *et al.*, 2007; Taylor and Kroth, 2009). Yet, the discussion around andragogy still takes place, and it is often cited in the adult education (Merriam *et al.*, 2007), higher education (Rogers, 2001), and management literature (Akin, 1991; Conklin, 2009: Forrest and Peterson, 2006). In light of recent enhancements in cognitive neuroscience, a theoretical examination of andragogy is in order. A look at how andragogical assumptions can be articulated and executed to systematically improve instruction implemented through the lens of cognitive neuroscience will help to better understand how androgogically based instruction may affect the overall learning experiences of adults.

Andragogy in the classroom

The core principles of andragogy have long been used in the classroom. And, although it is often referred to as "pedagogy", there has been a call to institute the language of andragogy as we design educational experiences (Forrest and Peterson, 2006), as well as a call to better understand the impact of applying andragogy to instruction (Taylor and Kroth, 2009).

Assumption 1: adults as self-directed learners

The first assumption of andragogy is that adults are self-directed learners (Knowles, 1980). This assumption, according to Forrest and Peterson (2006), is based upon the notion that adult learners come from the perspective not of compulsory learners, but learners who fill multiple roles within their lives and, upon entering the world of higher education, make choices about their education as a part of those roles. Thus, adult learners direct their educational experiences in ways not possible by children.

Importantly, andragogy suggests that adult learners become increasingly self-directed as they mature (Knowles, 1973) and increasingly take the initiative to diagnose their own learning needs. In the needs assessment process, learners formulate goals, procuring resources and implementing strategies to meet the educational goals they have set for themselves (Knowles, 1973).

Self-direction, as a concept, has been addressed in various ways by scholars, who have developed several models and methods for dealing with and applying self-direction into the classroom environment (Merriam, 2001). In education, in general, and in management education, in particular, there are many ways in which instructors allow for greater application of self-direction by students. For example, some instructors allow students to choose readings based upon the competencies and aptitudes that will be most beneficial to them. This practice is informed by a long history of viewing students as partners in the educational process (Forrest and Peterson, 2006). The idea of self-direction has various, multiple points of application in education, from allowing for choice in writing papers and projects, to the shared development of the course overall (Bostock, 1998; Lengnick-Hall and Sanders, 1997). A good example of how self-directed learning can be implemented in the classroom is provided by Conklin (2009) who suggests the implementation of appreciative inquiry as an approach for providing students with the opportunity to help create a classroom environment that is in line with their own desire for education. This is completed through such processes as the development of the "preferred classroom" in which students use a multi-step process with guided conversations to generate ideas about what the class should be and what that might represent for the meaningfulness of the course to individual students.

A linkage to neuroscience. Recent work in cognitive neuroscience helps to corroborate the need for self-directedness in terms of its impact upon the effectiveness of adult education. Self-directedness is generally considered the convergence of three important areas self: intentionality, intelligence and agency (Christensen and Hooker, 2002). Self-directedness is defined as the ability to anticipate interaction processes, evaluate their self-performance, and based upon that evaluation, improve self-performance over time while simultaneously developing new intermediary goals via self-reflection (Christensen and Hooker, 2000). Self-processing and social cognition have been an area of cognitive neuroscience in which research has reached a fevered pitch (Uddin *et al.*, 2007). Social awareness in terms of bodily and physical self is often found in the fronto-parietal area of the brain, while self-awareness in terms of self-representation and the evaluative self are housed in the cortical midline area (Uddin *et al.*, 2007). Importantly, the prefrontal lobe is also the area in which executive- and regulation-based behaviors are maintained. These behaviors are part of the larger, higher-order self-regulation executive processes that include such processes as attention, choice and decision-making (Banfield *et al.*, 2004). An area of the prefrontal lobe, the ventro-medial prefrontal cortex is the portion of the brain that directs individuals' ability to make decisions and regulate those decisions. Thus, individuals with damage to the brain in that area are often unable to make decisions. This becomes problematic in that although they know and can comprehend what they should do in a given context, they find they are not capable of executing the decision (Banfield *et al.*, 2004).

A linkage to how adults learn. Knowles' contention that adult learners work best as self-directed learners is predicated on the idea that adults have multiple roles to fill and

guide their own learning based on that. Based upon a review of current cognitive science findings, it becomes apparent that individuals become increasingly self-directed as they become better able to manage complex interactional processes and make cognitive choices and plans based upon those complex interactions (Christensen and Hooker, 2000). Although not proof, it appears to be the case that Assumption 1 is best analyzed through the lens of creating opportunity for interaction. If that is the case, then it would appear that the most important portion of self-directed learning in adult education may be providing students the opportunity to practice the interaction processes by which they become increasingly adept at making choices for increasingly complex sets of operational and behavioral interactions (Uddin *et al.*, 2007), thereby becoming better and better at predicting what portions of the interaction will be most influential to the outcome. It would stand to reason that by allowing students to choose an assignment. A critical look at Knowles' initial writing on the topic of Assumption 1 may not provide a strong connection to interaction; however, the way that it has been interpreted and applied, such as the recommendation for allowing for assignment choice (Forrest and Peterson, 2006), does indeed appear to apply well, as cognitive neuroscience suggests that it may be the process of making the choice, not the outcome of that choice, which will provide the greatest learning opportunity for adult students. Thus, although it may or may not have been Knowles' intent, it appears that the way his assumptions are currently applied to the adult classroom augments sustained learning processes, especially for strengthening higher-order executive functioning.

Assumption 2: prior experience and the adult learner

The second assumption of andragogy is that students come to the learning process with a wealth of experience (Knowles, 1980). Andragogy in the classroom takes multiple forms, but should look like a laboratory in which prior experience merges with instructional learning to create an opportunity for reflection (Forrest and Peterson, 2006). It has been suggested by Forrest and Peterson (2006) that the collective experience of an individual develops into identity and invariably the self-image of that individual. The result is that set of cognitions from which all learning is shaped, at the adult level. Thus, an individual's experiences should be the basis for any instruction that takes place – the purpose of adult education is to building upon the experiences and knowledge already in place and should emphasize filling in gaps in that knowledge (Forrest and Peterson, 2006).

It is widely accepted practice within management education to use student experience as a base for scaffolding new knowledge, which helps to improve overall learning (Boud *et al.*, 1993) and retention (Knowles, 1980). Importantly, the application of information into long-term memory, according to Kirschner *et al.* (2006, p. 77), is the "ultimate justification for instruction". The use of problem-based education has a long history, and helps to provide a forum within which students are able to apply their experiences to improve learning, both short and long-term (Bigelow, 2004; Coombs and Elden, 2004; Rhem, 1998), and improves motivation (Mallinger, 1998). Additionally, it has been argued that the use of experiential learning and the practice of eliciting prior experience can enhance learning in those students who do have experience upon which to draw, is transformational for those students that do not have a great deal of experience upon which to draw and can enhance emotional intelligence and emotional competencies for both groups (Sheehan *et al.*, 2009).

A linkage to neuroscience. A discussion of experience and the idea of "self" are invariably linked within the cognitive neuroscience literature. The notion that individuals come to know themselves, in an autobiographical way, is processed in the right fronto-temporal region of the brain (Keenan *et al.*, 2000), and is important to an understanding of how individual experience and learning readiness may impact an adults' ability to learn in the classroom. Higher-order self-awareness is an important part of recognition, introspection and inevitably higher-order self-awareness and introspection at the meta-cognitive level. But, experience holds several domains within the field of cognitive neuroscience, as experience is a reflection of autobiographical retrieval, as well as a junction of autobiographical memory. The autobiographical retrieval process is complex in that it requires the activation processes in several areas of the brain (Schechter *et al.*, 1998). Importantly, for the retrieval process to be successful and create an accurate representation of the past experience, multiple areas of the brain need to be activated in sequence which includes both the separation of similar episodes and the verification of those episodes (Schechter *et al.*, 1998). Thus, the act of bringing prior experience to the adult classroom in itself is a complex cognitive task.

But important to the issue of application of experience in the classroom is that different aspects of specific episodic memory activate different emotions and thus different areas in the brain (Erk *et al.*, 2003). It is widely known that experiences, and an individual's ability to retain, recall and evaluate those experiences, are essential to the learning process. Conversely, the experiences themselves are known to have an impact upon the anatomical networks within the brain (Posner and Robarth, 2005). Importantly, not all experiences affect individuals in the same way, and the way individuals remember certain events can be impacted by such things as emotional response, fear and stress response, which often reside in the hippocampus (Goswami, 2004). This is further helped through the process of scaffolding and particularly by the development of schema within the neocortex, the process of schema development happens within multiple areas of the neocortex and aids in the encoding and storage of new and relevant information. This process that largely take place in the hippocampus and the schema that results, ultimately aids in the *faster storage of later materials* (Morris, 2006). Thus, the implication for this process is that the application of prior experiences within the adult classroom is aided by previously developed schemas. Further, new information that enters the neocortex but is not associated with an existing schema is rapidly lost (Morris, 2006). Importantly, the application of previous experiences, and the schema that results, in addition to emotions that may result from those previous experiences, are known to improve neuroplasticity, i.e. changes in grey matter that are induced by training, among learners (Draganski *et al.*, 2004) – the view that the adult brain is incapable of change has been replaced with new information that shows it can, indeed, grow new cells and make new connections. This is especially true in the area of the hippocampus (Blakemore and Frith, 2005), which is the area where prior experience resides.

A linkage to how adults learn. Knowles' contention that adult students learn better when they are able to or are encouraged to apply prior knowledge to new learnings appears to have some merit, based on some key findings within the newly emerging area of cognitive neuroscience. However, a review of the literature in that area appears to show that the inclusion of the application of prior knowledge within the adult classroom is framed around the context of emotion and/or schema and schematic development.

Importantly, based on findings, Knowles' assumption appears to fit *if* one or both of those contexts are met within the educational context. Importantly, it appears that if adult education is framed in such a way that engages learners' experiences and forces learners to both recall and engage in the application of those experiences in a way that supports emotional engagement and/or *pre-existing* schema, each of these will help to speed the rate of encoding and induce changes in grey matter and improve retention and recall.

Assumption 3: readiness to learn

The third assumption of Knowles' andragogy is that as adults, we become more focused on learning opportunities and outcomes that are increasingly oriented to learning topics and subject matter that are positioned to address areas of developmental tasks that aid in the enhancement or improvement of our social roles (Taylor and Kroth, 2009). This idea is further examined through the lens of management education by Forrest and Peterson (2006) who suggest that adults often find little interest in exerting effort to learn things that are not relevant to their roles. Thus, a newly promoted manager may suddenly be interested in learning such things as performance feedback, which is an interest related to the new role he or she has taken on in the workplace. In relation to readiness to learn, the goal of andragogical adult education practice is to allow learners to identify their interests and recognize their learning needs within the facilitative framework of the instructor. The instructor, then, provides the structure around which self-directed learning (see Assumption 1) can take place. That learning should be centered on learner roles (Robles, 1998). Knowles (1980) argues that readiness to learn should be the guiding principle upon which all educational programs dealing with adults should be developed. This, according to Ozuah (2005), is because adults are ready to learn those things that are relevant to their social roles and have a strong belief in learning in those areas that that will help them to effectively cope with real-life situations and problems.

Forrest and Peterson (2006) suggest that management education is a prime area in which readiness to learn can be applied. As a primarily work practice-related field, management education is oriented toward allowing students to learn information related to either current or proposed social roles as supervisors and managers. Thus, readiness to learn is built into the conception of management education at its core. They suggest such instructional techniques as role-play and mentoring to help provide relevance for students. The issue of relevance to social roles is of major concern and has been discussed in both general education and in management education (Augier and March, 2007). Kayes (2002), for example, strongly advocates for the use of experiential learning in the management classroom and suggests that instructional experiences should bridge with the learners' roles to allow for the inclusion of personal and social learning. This, he suggests, helps to aid the connection between personal and social knowledge which thereby allows learners to organize information in a meaningful way, via the use of the conversational learning approach in which students work through language to better understand the role of a manager.

A linkage to neuroscience. The notion of readiness to learn and the idea of social roles as having an impact upon a desire to learn have implications for cognitive neuroscience. Although cognitive neuroscience does not speak directly to adult social relationships and social roles as an active force in the motivation to learn, there is a great

deal of discussion around the physiological guideposts for social relationships and how those may impact brain development and behavior from infancy to adulthood (Decety and Sommerville, 2003). Early in infancy, representations of "self" seem to be closely related with representations of "other" for those individuals with whom infants have developed a strong bond (Decety and Sommerville, 2003), while adults are known to readily confuse their own traits and attitudes with those of intimate others. Cortical regions of the brain are responsible for the construction of internal models of self and representations of other people. From the interpretations of the cognitively developed contextual models that are constructed, a framework for the embodiment of the relationship between self and other is created (Adolphs, 2003). Importantly, humans are innately interested in identifying the psychological traits of others and work toward a standard for increased helping and social support.

In addition to the conceptions of self and other, the conception of readiness to learn is also predicated on the conception of schema development. Similar in fashion to the way that it is applied to Assumption 2, in this case, the learning is based upon frameworks that are either previously known by the individual or identified by the individual to be an area for which new schema need development. In either case, the neurobiological process remains the same; connections are developed within the neocortex – particularly within the hippocampal region – and aids in rapid encoding and recall (Morris, 2006).

A linkage to how adults learn. Knowles' contention that adults learn best when the learning is connected to a social role has a strong biological basis. The need for social connection and acceptance is a strong psychological motivator. It has been hypothesized that mammalian social pain is the derivative of physical pain, both which reside in the same region of the brain called the anterior cingulate cortex (Eisenberger and Lieberman, 2004). These connections help to support the motivation behind adults' desire to learn and grow in areas in which social roles are present. This area, connected to the prefrontal cortex, is also suspected to play a part in such processes as decision-making and empathy. All of these activities reside within the area of the brain that also deals with such things as social rejection and the sense of experiencing others' minds (Lieberman *et al.*, 2002).

Also, like in Assumption 3, the implications of applying learning to previous knowledge, as is a premise of schema theory, are grounded in the understanding that we learn best when we are able to scaffold new information to existing neurological frameworks. In both cases – the need for social/emotional connection and the use of schematics for neural connection – new cognitive science helps to illustrate why those appear to explain, at least somewhat, how Assumption 3 works biologically. Indeed, there is a strong neurological basis for adults' motivation to learn things that support social roles. The primarily evolutionary foundation which represents the overlap between social and physical pain, and how and where these are processed within the human brain (Eisenberger and Lieberman, 2004) help to explain why adults are highly motivated to learn in areas that help to improve and/or advance social roles, as we are physiologically designed to support these important relationships. The use of previously developed schema should have an easier time encoding incoming information. It is unclear whether each of these conditions is assured by all adult learners, and in all learning experiences, however if we use Knowles' assumption as a

guideline for *how* to teach adults, the evidence points toward Assumption 3 as a standard that has some further evidence.

Assumption 4: immediacy of application

The fourth assumption of andragogy is that adults are oriented toward immediate application of learned knowledge (Knowles, 1980). Adults learn to perform a task, solve a problem, or improve their life such that they seek a life-centered, task-centered, problem-centered, or performance-centered orientation to learning (Knowles, 1980). In other words, adults regard learning as a process for improving their ability and competence to deal with practical problems they currently have. Thus, most adults have a desire to be able to apply knowledge and skills they learn today to living more effectively tomorrow. Adults learn knowledge, skills, values and attitudes most effectively when they are presented in the context of application to real-life situations (Knowles *et al.*, 2005).

This assumption provides an important implication for teaching: learning experiences for adults should be organized around competency development and life situations. In management classroom, for example, demonstrating how to use what students learn is very important. Most students in management want to use their knowledge in the workplace, so they tend to learn concepts and activities that enhance understanding of the workplace, its problems and potential solutions (Forrest and Peterson, 2006). Adult students are motivated to learn to the extent that they perceived that the learning will help them perform tasks or deal with problems they have. Providing students with opportunities to apply their learning to the real world, different teaching methods (e. g. just-in-time teaching) should be used or their primary interests (e. g. employment and job hunting) should be addressed. In particular, just-in-time teaching allows student to experiences and solve the actual issues and problems in organizations (Forrest and Peterson, 2006; Watson and Temkin, 2000). From this assumption, teachers should pay attention to how students can apply what they learned to the real issues.

A linkage to neuroscience. From a cognitive neuroscience perspective, the application of knowledge in adult learning can be explained by the function of neuroplasticity. Plasticity is the physical manifestation of the ability to adapt to changing circumstances and acquire new information. It means the ability of the nervous system to adapt continually to changing circumstances (Blakemore and Frith, 2005). Changes in the brain gradually occur as we use the functions of our brain. We cannot acquire and retain new skills and knowledge without practicing and applying those. Brain cells can change the specific job they perform depending on how much they are used; they are developed and improved through continuous application of skills and knowledge. Adults can develop their skills and abilities through practice.

For instance, it is very important skill for taxi drivers to remember where the building is (spatial memory) and how to find the destination (spatial navigation). The hippocampus in the brain plays a significant role in these two functions. The size and ability of the hippocampus are directly related to the time the person has driven a taxi and experiences of driving taxis (Burgess *et al.*, 2002). This reflects the notion that the ability of the hippocampus to generate new neural connections depends on how many individuals have used it in learning processes.

A linkage to how adults learn. Given what is known about physiological changes in the brain, and resulting brain function, the bridge between learning and application is

especially important. Brain plasticity can be explain by Hebbian learning and long-term potentiation (LTP) (Blakemore and Frith, 2005). Hebbian learning is a concept that explains how neurons can learn via the restructuring of connections. LTP is defined as an enduring increase in the efficiency of a synapse that results from incoming neuronal activity. LTP results in stronger connections between nerve cells that leads to long-lasting changes in synaptic connections. These changes in connections are thought to be responsible for learning and memory. Importantly, Hebbian learning and LTP help to explain how the physical structure of the brain can change with experiences and learning, each of which modifies the brain's chemical characteristics (Blakemore and Frith, 2005).

In particular, LTP improves synaptic strength during learning, and these changes can last for long periods, making it a probable mechanism for memory storage (Lisman *et al.*, 2012). The functions and related elements of LTP play a role in enlarging and strengthening the synapses in this area. These findings in cognitive neuroscience provide the implication that adults *can* continuously develop their learning abilities according to their orientation to learning (such as a life-centered, task-centered and problem-centered or performance-centered orientation to learning). Given what is now known about memory and storage, in addition to the applicable materials written about schema theory in the sections on Assumptions 2 and 3 above, it may be worthwhile to consider Assumption 4 in its own right. That is, while Assumptions 1, 2 and 3 above are suggestions for practice that are contextual to the individual learner, and that learner's social, economic and psychological background, Assumption 4 appears to have wider application. That is, it is difficult to find materials in the literature that suggest an opposing view to Knowles' suggestion that we allow for rapid application of learning materials.

Discussion

The suggestion that management educators adopt the language of andragogy to both define and guide management education and instruction and to align educational practices to fully engage adult students (Forrest and Peterson, 2006) was a call to action. Andragogy as a topic of study has had both strong advocates and strong detractors (Merriam, 2001), which allows us to look at andragogy with introspection – analyzing it formatively and systematically. At first view, andragogy seems too removed from brain activity for linkage to be quickly apparent. However, some interesting new information is offered by cognitive neuroscience that helps to make a bridge between brain functioning, andragogical principles for adult instruction and instructional techniques.

Cognitive neuroscience is a burgeoning field that provides some very interesting insights into how the brain works. And, although much remains to be done in this area, cognitive neuroscience provides some interesting support to the much analyzed and often criticized field of andragogy (Cozolino and Sprokay, 2006; Merriam *et al.*, 2007; Leuner *et al.*, 2006; Lövdéna *et al.*, 2013; Taylor and Kroth, 2009). A look at the assumptions through the lens of cognitive neuroscience helps to establish why each of these do, indeed, provide a more encompassing and comprehensive educational experience for adult students, from a physiological perspective.

A fresh look at Knowles' assumptions appears to make a significant connection to the application of Schema Theory. As noted above, a review of the assumptions shows a distinct connection between Knowles' theory and an application of schema theory (and

thereby the cognitive neuroscience that explains it) is especially interesting, as while a thorough review of his writings does not indicate an explicit connection to that line of inquiry, it appears to be inherent in his materials. Of further interest is that schema theory, historically, started to gain prominence within the literature around the same time that Knowles was developing his principles of andragogy. According to Sherwood and Lee (2003), much of the initial theory development of schema theory was initiated by Schmidt (1975) and was particularly related to motor learning – especially regarding the learning of "correct" movements and was considered behaviorist in nature. Given that much of Knowles' early work was also produced in the mid-1970s, it appears that both lines of inquiry were in development in parallel. Thus, it may be that while there appears to be no connection between the two, it appears that andragogy is closely related, and an application of, schema theory. The implication for this is that we may consider looking more closely at other avenues in which schema theory has relevance and application to both HRD and adult learning theory as a way to further the field – especially given its now known neuroscientific basis.

It is known that training creates physiological changes in the brain, which has been widely studied in educational settings and is elemental to the notion of plasticity (Posner and Robarth, 2005). A great deal of research has looked at content-specific domains such as mathematics and reading (Posner and Robarth, 2005) to better understand where and how the brain reacts to training in those areas. However, also, a great deal of research has looked at socio-emotional neural processing and how the brain functionally executes important social, emotional and behavioral processes that are related to brain functioning in such areas as retrieval, recall and information processing. Importantly, while this article discusses areas of the brain where major processing occurs, it must be understood that much of what takes place physiologically requires interaction between and among several areas of the brain, and involves multiple brain functions even for a single cognitive-emotional process such as simple decision-making (Naqvi *et al.*, 2006). However, the current research helps to establish a bridge between adult learning theories and techniques and more generalized knowledge about brain functioning and basic actions of retention and recall.

Several areas of the brain are implicated in the cognitive processes required for the application of the andragogical principles. Cortical regions including the neocortex, prefrontal cortex and the connected anterior cingular cortex, as well as the hippocampus and cortical midline structures, play crucial roles in the activities of learning and cognition. Andragogy makes several assumptions about adult learners that, when applied appropriately, can improve adult learning outcomes both academically and socio-emotionally (Knowles, 1980). The four core assumptions of andragogy are:

(1) adults have a self-directed self-concept;

(2) adults bring a wealth of experience to the learning process;

(3) adults enter the learning process ready to learn; and

(4) adults are oriented toward immediate application of learning.

These above assumptions provide an opportunity for further analysis of cognitive-instructional linkages to how these processes take place in the brain. Figure 1 helps to establish the working structures of cognitive neuroscience as a guidepost for applying this learning. Importantly, many of the structures and cognitive processes

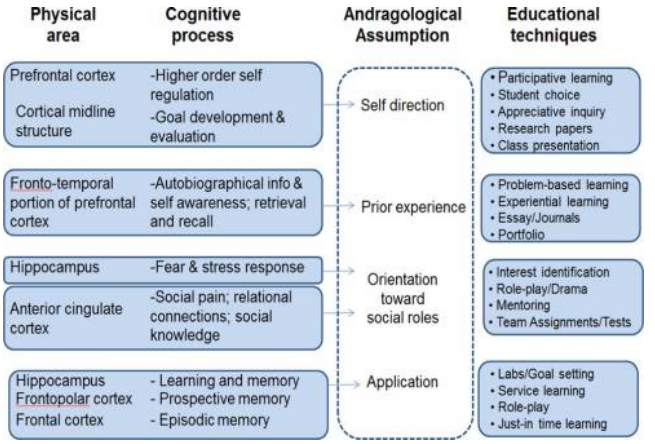

Figure 1.
A model of adaptive cognitive neuroscience-adult learning structure

applied when andragogy is utilized help to establish that andragogy may indeed improve encoding, retention and recall, which are related to the establishment of long-term memory. This may be especially true of those instructional applications of andragogy that enhance and or increase emotional arousal (Cahill *et al.*, 1996), stress response (Shors, 2001) or social stress if at moderate levels (Payne *et al.*, 2010). Thus, those areas of andragogy and the educational techniques that are used that call for reflection upon previous experiences and social cognitions can indeed enhance the retention in learning experiences (Figure 1).

Importantly, in addition to providing a basis from which andragogy can be understood, this line of inquiry allows us to look more deeply at the *individual cognitive mechanisms* that guide the principles and make explicit choices about what and how we teach that go deeper than Knowles' assumptions and applications of those. In fact, this allows management educators to pick and choose the individual elements that drive each of the assumptions in a way that best suits the context and content of the learning, such as a focused effort of learning materials that will elicit emotion, draw on social connections or initiate existing schemas.

Implications for HRD theory

This study provides important theoretical implications. First, it provides fundamental foundations for combining cognitive neuroscience and adult learning to illuminate how cognitive neuroscience contributes physiologically to adult learning. Through connecting adult learning assumptions and cognitive neuroscience, we tried to build a scientific basis to support andragogy beyond the field of adult education. Based on this review, new theories or approaches could be developed to illustrate adult cognitive control or complexity for adult learning and HRD. Additionally, this review provides one example of a possible interdisciplinary approach to develop the field of adult learning and make appropriate connections between adult education, management education and HRD.

Second, the findings in cognitive neuroscience related to the four assumptions for andragogy help to provide scientific explanations and interpretations for adult learning theories influencing HRD such as self-directed learning, experiential learning and role

theory. For example, experiential learning has been defined as a process that links education, work and personal development and has explained experiences through perceiving and processing information (Kolb, 1984). For experiential learning, cognitive neuroscience can explain not only the information-processing mechanisms for learning at the cognitive level but also the brain systems that illustrate the processes at the neural level (Ochsner and Lieberman, 2001). HRD can use a variety of dynamics and learning activities in practice by using the findings related adult learning in cognitive neuroscience.

Implications for HRD practice

This has several implications for educators in general and adult, management and HRD educators in particular. First, andragogy has been suggested by Forrest and Peterson (2006) as a way to strengthen and support students. However, while they were able to explain the application of andragogical principles to the management classroom, they were unable to explain why or how those principles work. This paper helps to better elucidate how instructional techniques guided by andragogy can improve long-term memory and retention, which are the cornerstones of educational outcomes. Based upon the application of cognitive neuroscience to andragogy, there are some specific techniques and applications that can, and should, be used in the management classroom.

Discussions surrounding the use and inclusion of activities that help to promote andragogical assumptions have been well documented and there are many examples of effective application of the assumptions both in practice and in scholarship. Yet, there has been a failure to fully incorporate andragogy as a philosophical mind-set for management educators (Forrest and Peterson, 2006). Promotion of these techniques by HRD scholars and practitioners will help to provide management educators with basic information on anagogical principles; explanations of why and how the principles work through the lens of cognitive neuroscience may further this cause.

Second, while there has been a great deal of discussion and critique regarding the practical application of andragogy, the integration of andragogy within the cognitive neuroscience context helps us to better understand how it works and why it has so many proponents. It has been acknowledged (White, 2000) that the application of andragogical principles for adult students who may not have a great deal of personal experience must be handled with care; the needs of more experienced students must be balanced with the needs of younger or inexperienced students who may not have the well from which to draw. However, it is important to recognize that students do not fall neatly into stereotypical categories (White, 2000) and providing andragogically based instructional opportunities for younger or less experienced college-age students is an important step toward helping them gain similar cognitive growth from instruction as older, more experienced learners. HRD practitioners could use the integrative approach between andragogy and the cognitive neuroscience to reduce the issues of learning activities in generation differences.

In addition, cognitive neuroscience research may contribute to improving teaching and instructional techniques. Application of self-direction (Assumption 1), prior experience (Assumption 2) and learned knowledge (Assumption 4) all have a connection to the neural networks related to memory and cognition. Learned knowledge in particular is related to procedural memory, prospective memory, episodic memory, short-term and long-term memory. Prospective memory, for instance, involves doing

one task while keeping in mind the intention to do something else in the future (Blakemore and Frith, 2005). Meanwhile, episodic memory refers to memory of events that have occurred with us in a specific time and place. Applying each of these to the management or HRD classroom, teachers can, and should, use role-play (to enhance an episodic memory) and project planning exercises (to increase a prospective memory). Thus, this paper does have implications for what instructional techniques HRD professionals and management educators use and how they use them.

Finally, although this paper is intended to help illustrate for management educators and HRD scholars and practitioners in particular about how the application of Knowles' assumptions can provide a backbone for extending and enhancing learning, it is important that we also acknowledge that many of Knowles' principles are based on the context of the learner – social, economic and psychological factors. However, one could certainly use the review above as a way to initiate individual learning experiences that are based on neuroscience, without using Knowles' assumptions in any formal way. That is, although it is clear that many of the concepts and conditions that are described by Knowles and applied by Forrest and Peterson (2006) are supported by current research in neuroscience, nothing indicates that any one of the learning conditions exemplified by Knowles is more or less effective than any other. Thus, HRD practitioners are encouraged not only to apply and use Knowles' principles broadly but also to apply important neuroscientific concepts such as schema theory, LTP and information on episodic memory to their teaching and training strategies.

It is worthy of note that while this article is intended to help elucidate how and why andragogy appears to be an effective set of principles upon which to create and develop training and instruction, actually *testing* this, in an empirical manner, offers some significant challenges. In particular, because each of Knowles' assumptions require so very many neurobiological processes, it would be difficult to either attempt to create a measurement that would measure the application of principles on learning outcome, or create a learning environment in which one could reduce the noise involved in such a measurement process, as to establish how much impact applying Knowles' principles actually has on learning outcomes.

Recommendations for future research

Although this review helps to build bridges between management education, adult education, HRD and the burgeoning area of cognitive neuroscience, there is still much to be learned about how the brain works, how learning happens and how we can best encourage long-term learning, application and critical analysis within the structure of higher education.

First, HRD researchers should clarify the relationship between different assumptions of adult learning and cognitive neuroscience. There are two additional assumptions for andragogy suggested by (Knowles *et al.*, 2005):

(1) that adults need to know the reason for learning something; and

(2) adults are driven by intrinsic motivation to learn.

Investigation into how the brain plays a role in each of these would be an important contribution to both adult education and cognitive neuroscience.

Second, HRD researchers should explore adult developmental factors influencing adult cognition and developmental in terms of cognitive neuroscience. For example,

there are seven primary mental abilities related to cognitive development for adults: perceptual speed, numeric ability, word fluency, verbal comprehension, spatial ability, memory and inductive reasoning (Thurstone, 1938). Using cognitive neuroscience, researchers can help to explain how these seven primary mental abilities work toward, and contribute to, adult learning.

Third, social cognitive neuroscience should be used to emphasize relevant context and social behaviors in adult learning and HRD. In this study, we focused more on cognitive and neural aspects of adult learning by adopting an individual approach. However, social interaction and context have much influence on adult learning and HRD practice. From a social cognitive neuroscience perspective, researchers can help to explain personal and social context, as well as cognitive and neural processes, in adult learning and HRD practice. Additionally, a deeper probe into how cognitive neuroscience can inform other learning theories would help to bridge the gap between adult learning theory and more recent scientific research. In this case, as in others, cognitive neuroscience can be used as an explanatory tool, which can help HRD scholar and practitioners more fully realize the benefits of the content and context of their instruction.

Furthermore, the relationship between emotion and adult learning can be explored in terms of neuroscience. Positive emotions play a significant role in learning process and experience and help adult learners to enhance long-term memory (Glick, 2011; Knowles *et al.*, 2014). By investigating the affective dimensions of andragogy from a neuroscientific perspective, HRD scholars can provide stronger evidence about the influence of emotion on adult learning process and outcomes.

Finally, more empirical research linking specific instructional techniques to changes in cognitive brain structures may help us to truly understand how instruction and training work and provide valuable information on best practices that go beyond conventional outcomes-based theories on instruction, to a real understanding of which techniques most effectively promote plasticity within neural structures.

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