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Routine Expertise, Adaptive Expertise, and Task and Environmental Influences

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Organizations seek employees who can deliver high performance in dynamic environments. This means finding individuals who can deal with external forces. According to Moore's Law, technological capacities double every year (Brynjolfsson & Mcafee, 2014) so organizations must face increases in computing power, the growth of artificial intelligence, and further technological changes yet to be defined. In addition to technology as an external force, organizations have to expect changes in other areas, such as globalized competition and the changing mind-sets, which together can result in destabilized operating environments (Schreyögg & Sydow, 2010; Wiggins & Ruefli, 2005). These factors can create dynamic environments, which are more difficult to navigate for individuals. This

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is because it requires simultaneously maintaining efficiency-focused processes, that is, processes that enable them to operate in the known environment, while also possessing flexibility-focused processes, which are processes that allow them to respond to the changes in the environment (Eisenhardt & Martin, 2000).

Dynamic environments mean that individuals need to be efficient, while also being flexible. One of the hallmarks of expert performance is efficiency with task execution, through automatization of processes (Arts, Gijselaers, & Boshuizen, 2006; Ericsson & Lehmann, 1996). This automatization is context specific, as experts take time to learn and internalize procedures for a specific domain (Ericsson, Krampe, & Tesch-Römer, 1993; Macnamara & Maitra, 2019). However, while this automatization leads to performance gains under routine situations, it results in a breakdown of performance when changes are made to the environment and individuals fail to develop adaptive expertise (Hatano & Inagaki, 1986; Schwartz, Bransford, & Sears, 2005). To develop adaptive expertise, opportunities to recognize changes in the environment and develop new solutions is needed, as well as opportunities to become proficient in certain tasks to free cognitive resources necessary to scan the environment for change.

In this chapter, we focus on the importance of adaptive expertise for succeeding in dynamic environments. We begin by explaining what adaptive expertise is, and how environmental and task characteristics influence its development. The link between dynamic environments and performance levels rests on adaptive experts' ability to recognize changes and opportunities for adapting procedures. Based on our discussion of adaptive expertise, we conclude with a list of practical implications for organizations seeking to develop adaptive expertise in their employees.

What Is Adaptive Expertise?

Adaptive expertise is the ability to maintain an expert level of performance in novel situations (Hatano & Inagaki, 1986). Hatano and Inagaki (1986) originally applied the concept to children, explaining how different factors influence their knowledge acquisition. The authors' main premise

is that expertise performance can be achieved through a procedural or conceptual understanding of the domain. Through a procedural understanding, individuals can execute a skill at the level of an expert. However, there is a lack of understanding as to why the skill needed to be executed in a certain way. To attain adaptive expertise, Hatano and Inagaki (1986) posit that an individual needs not only procedural understanding by conceptual too. Conceptual understanding leads to a more deeply developed and fine-grained knowledge base gained through repeated practice of a skill in a variety of environments. Because the different environments provide new information about when and how to execute the skill, individuals are able to determine why a certain skill has to be executed in a specific way.

Hatano and Inagaki (1986) describe three factors that support or hinder the development of adaptive expertise: build-in systematic randomness, the risk of performance, and the reward of gaining conceptual knowledge. The first factor refers to systematic and naturally occurring variations in the environment. This factor asks if a situation is novel or random or if the variability of the situation means there's little chance for learning or exploration. For example, growing plants, when done outside, provides natural variations due to changes in sunlight and rain. This helps a gardner to build a deep and fine-grained understanding of the various conditions different plants require in order to grow. The second factor describes what is at stake for an individual if they deviate from the known and established procedures to try out something new. If the stakes for performance are high, individuals may be reluctant to try out new ways to perform a procedure. Thus, individuals shy away from playful behaviors and instead continually perform the skill in the same way to avoid a risk of failure and the associated consequences. Novelty avoidance does not lead to a deep and fine-grained understanding of the skill as variations are avoided and the status quo is maintained. The third factor, reward of gaining conceptual knowledge, refers to the societal norms regarding a desire for speedy performance or understanding. Due to the deeper processing it requires, developing conceptual knowledge is more time consuming than developing procedural knowledge. Individuals seeking conceptual knowledge spend more effort understanding why a skill is performed, instead of simply focusing on performing a skill at an

expert level in the quickest possible way. If the societal norm places a high value on quickly performing, individuals may be reluctant to spend the necessary time to achieve a conceptual understanding.

Also helpful in defining adaptive expertise are individual characteristics in adults described by Bohle Carbonell, Stalmeijer, Könings, Segers, and Van Merriënboer (2014). First, is an individual's knowledge representation that is decontextualized and abstract. This form of mental knowledge representation is aided by analogical problem-solving skills and abstract reasoning skills. Hence, the ability to deconstruct a problem to develop similarities between situations aids the development of a fine-grained and detailed representation of domain knowledge. These skills are supported by self-efficacy and goal setting. Self-efficacy and goal-setting help individuals to create the right reward structure for engaging in a variety of practices, which Hatano and Inagaki (1986) argue is important for the development of adaptive expertise.

Adaptive expertise is often, in simplistic terms, compared to routine expertise (Hatano & Inagaki, 1986; Mylopoulos & Scardamalia, 2008). Individuals with high levels of adaptive expertise demonstrate flexibility, creativity, and innovation in the use of their knowledge structure and skills (Bransford, Brown, & Cocking, 2000; Hatano & Oura, 2003). On the other hand, individuals with routine expertise do not demonstrate these characteristics. Common between adaptive and routine expertise is a highly structured knowledge base that experts develop to help them perceive meaningful patterns in their work environment, mental models which drive the selection of task strategies, efficient problem-solving, and faster retrieval of domain-specific information from memory (Lajoie, 2009).

The tendency to juxtapose adaptive expertise with routine expertise is an oversimplification of reality. The execution of a complex task requires individuals to perform a number of subtasks. These subtasks can be routine, in the sense that regardless of the problem situation, the task is executed using the same methods. For example, when developing software, individuals may be using different programming languages, but all need to set up a folder structure. However, other subtasks will require individuals to adapt programming methods and procedures to the goal at hand (van Merriënboer, Clark, & de Croock, 2002), which means their

execution cannot be automated. Certain domains, such as classical music or some games, are more stable and thus consist of more routine tasks than non-routine tasks. Other domains, such as journalism or research and development, are less stable as more tasks are non-routine or contain non-routine elements. Therefore, it is more appropriate to view adaptive expertise as building on routine expertise, with adaptive expertise containing elements of routine expertise.

The ability to remain performing at an expert level even though the task is unfamiliar has been labeled by others as "flexpertise" (van der Heijden, 1998), super expertise (Raufaste, Eyrolle, & Mariné, 1998), elite expertise (Chi, 2011) or reflective expertise (Olsen & Rasmussen, 1989). The common aspect among these different terms is that once individuals achieve expert performance level, a distinction can be observed in the performance of experts on non-standard domain tasks. Even though under normal conditions an individual would execute tasks at an expert level, they find that they experience problems adapting to a new situation.

This phenomenon of divergent performance among experts has been studied under different names and in different scientific domains. Bohle Carbonell and van Merriënboer (2019) identified six different, but linked, research contexts which address the question of adaptability of expert performance: child rearing, the social aspects of child rearing, adaptive expertise, transfer, flexibility, and self-regulation. Although different methods and different words to describe the phenomena may be applied, the common thread for studies on divergent performance in experts is a desire to understand why certain individuals transfer performance from one situation to another, the cognitive processes responsible for the transfer of performance, and the environmental characteristics that enable or hinder a transfer. For example, Frie, Potting, Sjoer, van der Heijden, and Korzilius (2019) use qualitative methods to investigate the social and cognitive processes that lead known flexperts to acquire new knowledge and adapt to the environment by exploring the domain, validating ideas, and creating new knowledge and skills. Similarly, the work of Olsen and Rasmussen (1989) on reflective expertise describes how individuals use skill-based and rule-based behaviors for standardized tasks, but switch to knowledge-based behaviors if the task is novel and requires interpretation of unfamiliar aspects of a situation. A key feature

of Olsen and Rasmussen's (1989) work is that they argue that professional expertise requires all three types of behaviors: skill-based, rule-based, and knowledge-based. Hence, there is no clear-cut distinction between reflective and non-reflective expertise, something which is less well elaborated on within other concepts of adaptive expert performance.

In sum, adaptive expertise is developed through variation in practice and stimulated by an environment that favors and rewards the acquisition of conceptual knowledge instead of procedural knowledge. It is the ability to deal with a novel situation while avoiding a drastic drop in high performance. Adaptive expert performance is studied in a number of areas of human life, using a number of different terms and methods. This can lead to some confusion when researching the field. However, the commonality is that adapting expert performance begins with the realization that the environment or the task is different and that high performance requires a change in how the task is executed.

Stimulating the Development of Adaptive Expertise

Adaptive expertise is the result of switching from fully or semi-automated processes to fully conscious and manual behaviors by experts with domain knowledge (Ericsson, 2006). According to Olsen and Rasmussen (1989) this domain knowledge is expressed through skill-based, rule-based, and knowledge-based behaviors. The level of automaticity distinguishes these different forms of performance. While skill-based performance is fully driven by internalized procedures, knowledge-based performance requires conscious action by the individual to decide the plan of action. Building on the work of Olsen and Rasmussen (1989), van Merriënboer, Jelsma, and Paas (1992) argue that expertise performance can be composed of performance on recurrent automated skills, recurrent skills, and non-recurrent skills. Recurrent skills can be expressed through stable procedures and represent standard domain-relevant tasks. Some of these recurrent skills can be automated, while others are only semi-automated. Non-recurrent skills do not have stable procedures that can be followed

when a situation is present. These are knowledge-based processes, where the execution requires a conscious effort and is guided through knowledge of the domain and the task (Olsen & Rasmussen, 1989). This means that the exact steps that have to be executed differs for every unique situation. Based on this distinction, adaptive expertise becomes visible through performance on non-recurrent skills, as these skills cannot be automated. To acquire non-recurrent skills, individuals need to possess (automated) recurrent skills. This provides them with the necessary supporting knowledge and frees cognitive resources that are needed to engage in non-recurrent skills. By freeing cognitive resources, individuals with adaptive expertise can recognize changes in contextual factors which require them to stop fully or semi-automated processes and switch to fully conscious processes.

The execution of non-recurrent skills requires acquisition of schemas, cognitive structures that link particular problems to specific problem categories, which are associated with a plan of action (Barnett & Koslowski, 2002; Schwartz et al., 2005). Van Merriënboer, Jelsma, and Paas (1992) argue that these schemas can involve causal reasoning, decision making, or qualitative reasoning. The acquisition of these schemas is aided by inductive processing leading individuals to recombine existing knowledge, which results in more general schemas that are more widely applicable across situations.

The environmental condition individuals operate in impacts their ability to deal with unfamiliar problems and develop the schemas necessary for adaptive expertise. Hatano and Inagaki (1986) argue that individuals who achieve expert performance while working in a very regulated and structured environment, like a kitchen with cups and scales or a greenhouse with climate and light control, develop a less profound knowledge about their domain of expertise. This is because these individuals only learn to execute domain-specific skills because the environment contains a specific set of structural features. If structural aspects of the environment change, performance will change as individuals have to adapt to the changes.

Adapting to the environment requires cognitive readiness (O'Neil, Lang, Perez, Escalante, & Fox, 2014), the ability and willingness to

recognize changes in the environment, and to adapt to them. In essence, individuals need to switch cognitive gears by halting the automatic execution of domain procedures and switch over to conscious decision making (Louis & Sutton, 1991; Olsen & Rasmussen, 1989; van Merriënboer et al., 1992). Not all individuals are able and willing to switch from an automatic process of task execution to a manual process. This manual process of task execution requires effort, which Ericsson and Lehmann (1996) describe as deliberate practice, which consists in identifying the aspects of performance that can be improved with reasonable time and associated training. Engaging in deliberate practice is a necessary activity to raise performance levels from novice to expert and to avoid stagnating performance (Ericsson, 2009; Ericsson & Lehmann, 1996). Ericsson (1998) argues that being able to execute tasks with minimal effort, thus making behaviors automatic, is the goal of everyday activity. Once individuals can engage in a task with minimal cognitive effort, they are said to have reached expert performance in this task. To further improve their performance, individuals need to counter this automaticity in their thinking and behavior by seeking out aspects of their performance that can be improved. This countering of automaticity is done by engaging in deliberate practice.

However, deliberate practice at work requires that the work environment be highly structured (Shanteau, 1992) as individuals rely on environmental cues to evaluate their performance and adapt. Certain work environments have a high level of regularity, implying that certain environmental cues are always followed by the same consequence (Shanteau, 1992). Environments, which are characterized by a high regularity between an environmental cue and its consequence, are described as high-validity environments (Shanteau, 1992). In the workplace, such environments consist of a high proportion of recurrent work skills. This high-validity provides individuals with ample opportunities to learn the causal relationship between environmental cues and consequences. This feedback loop of cue-consequence gives individuals the opportunity to learn and acquire domain-relevant patterns. A pattern forms schemas and structure of the domain by describing domain-specific concepts or triggers, attributes, and the relationship between the attributes (Fiske & Taylor, 1991). These schemas can be understood as scripts and decision trees

detailing what actions to execute when faced with a specific environmental trigger. If the scripts become too detailed, they can limit individuals' flexibility forcing the focus to be on a sequence of actions and not on causal relationships. Overall, the high frequency of cause-and-action yields clearly visible patterns, which individuals perceive as domain-relevant patterns (Kahneman, 2011) and these become internalized.

While a lack of structure in the work environment makes it more difficult to receive the necessary feedback to evaluate performance, making changes to routines and evaluating their outcomes is still necessary. A mastery approach to performance is argued to be beneficial for the acquisition of adaptive expertise (Hatano & Inagaki, 1986). Individuals who adopt a mastery approach to tasks seek as their goal not merely to achieve performance standards according to task requirements, but aim for understanding the task and improving their knowledge and skills (Elliot & McGregor, 2001). Changes in performance according to a mastery approach is thus compared to one's previous performance and knowledge, and not compared to performance standards set by others.

In addition to a certain environment, Bohle Carbonell, Könings, Segers, and van Merriënboer (2016) posit that adaptive expertise requires: the belief that domain knowledge can change (perception on domain skills) and the ability to innovate and change one's knowledge structure and skills (innovative skills). Although task variety and work experience are related to individuals' perception of domain knowledge stability, only task variety is related to the innovative skills within adaptive expertise. This means that, through work experience and variability of practice, individuals learn that domain knowledge is not stable and needs to be continuously updated to continue to perform at a high level. In other words, task variety or variety in some other form is central to the development of adaptive expertise. To develop the necessary, innovative skills to deal with unfamiliar problems, individuals need to be exposed to task variety. It is the innovative skills that differentiate individuals who are with and without adaptive expertise. The variety of tasks provides individuals with greater opportunities to observe and test relationships between environmental cues and implemented solutions. This variety of experiences leads to a mental representation of knowledge which is de-contextualized. This weakens the link between a specific situation

and the solution, and thus enabling easier adaptation to changing circumstances (Bohle Carbonell et al., 2014).

For example, a gardener who is responsible for a wide variety of plants growing on different soils, and who is also in charge of landscaping will develop an abstract and decontextualized knowledge representation of plants. This person will develop knowledge about how to grow plants, which plants impact the growth of other plants, and how to use landscaping features such as ponds, walls, or hills to help plants grow and produce fruit. The result is a knowledge representation of plants with many associations between elements of plants (soil type, nutrition needs, sun needs, and so on).

Within an organizational context this means that having task variety and working in an exploratory environment leads to individuals developing a conceptual understanding of procedures and thus knowing why they should be using a specific procedure in a specific situation (Schwartz, Brophy, Lin, & Bransford, 1999). Allowing individuals to explore different solution paths can lead to the development of adaptive expertise (Bohle Carbonell et al., 2014). As noted earlier in this chapter, the repeated reuse of specific procedures leads to expert efficiency, but reduces adaptability, problem-solving, and the creativity of experts (Dane, 2010). Barnett and Koslowski (2002) report that consultants provide higher quality solutions to business problems of restaurants (even when compared to restaurant owners) due to the consultants' diversity of experiences. This variability of practice has led consultants to develop greater abstraction of problems allowing them to create a deeper understanding of their domain. This means that individuals need dynamic environments and to work on tasks outside of their area of expertise so as to facilitate the recombining of an individual's domain knowledge and to experience the limits of their schemas.

One way that variety in practice as an individual works on different problems or in different domains (Barnett & Koslowski, 2002; Dane, 2010) is addressed in stimulating adaptive expertise is through analogical reasoning. Analogic reasoning is the skill that helps individuals transfer

solutions from one domain to another domain by identifying similarities between a familiar source and an unfamiliar target in order to generate inferences about the target (Holyoak, 2012). It requires individuals to develop a mental library of cases of prior situations they have encountered and dealt with. These cases provide stories, narrative description, and logical explanation summarizing past experiences. This library serves as a way to know how an individual approached situations in the past, and how successful they were (Jonassen & Hernandez-Serrano, 2002). Barnett and Ceci (2002) propose that transfer of problem-solving skills from the source to the target situation occurred if individuals understood why a certain problem-solving strategy was successful. Thus, the mental library of cases needs to include information about why a specific work approach was successful in the given situation. In uncertain environments, these cases can provide a more useful tool than abstract reasoning when having to make decisions (Jonassen & Hernandez-Serrano, 2002; Klein & Calderwood, 1988).

Of course it goes without saying that adaptive expertise, with its reliance on this mental library, cannot be developed as a novice since there is no prior knowledge of the domain (Schwartz et al., 2005) or cases to draw on. Schwartz et al. (2005) talk about an optimal adaptability corridor, where the path from novice to adaptive expertise alternates between acquiring domain-level knowledge and introducing changes to stimulate innovative skills. The optimal adaptability corridor will be shaped by task characteristics, such as regularity of feedback from the environment. Individuals need to have acquired a minimum amount of domain expertise before beginning to learn how to deal with unfamiliar problems. Only once an individual is no longer a novice, is it possible to introduce changes in the environment or the task. If changes are introduced too early, it can lead to frustration, as individuals do not have the necessary foundation for adaptation. If changes are introduced too late, individuals will struggle to adapt as their knowledge representation is embedded too much within the homogenous situations they have experienced.

Developing Adaptive Expertise in Organizations

Organizations operate in an increasingly dynamic environment with amplified frequency of technical innovation, globalized competition, and entrepreneurial actions (Schreyögg & Sydow, 2010; Wiggins & Ruefli, 2005) that can destabilize the operating environment. Given the benefits of adaptive expertise outlined to this point in the chapter, organizations hoping to succeed in a dynamic environment need to support the development of adaptive expertise. This means organizations must put in place processes to efficiently execute day-to-day activities while also creating space for flexibility to adjust to unexpected situations. More specifically, organizations need to ensure task variety, autonomy, and supportive cultural norms in order for employees to develop valuable adaptive expertise.

Organizations seeking to develop adaptive expertise in their employees need to offer individuals the opportunity to engage in a variety of tasks in the workplace. A variety of tasks gives employees the opportunity to experience diverse organizational problems. In formal learning environments, variety of practice has been reported to have a positive impact on learning to solve novel problems (Paas & van Merriënboer, 1994) and consume and use a large amount of information efficiently (Martin & Schwartz, 2009). Organizations can make use of various work functions and locations to create a variety of practice. Take, for example, expatriate assignments. While on the surface the job role may be similar, differences in sociocultural factors lead to significantly different job duties (Mendenhall & Oddou, 1985). Similarly, variety in the environment can also be created by transferring individuals to other functions. Individuals from different job functions approach problems from different perspectives (Cronin & Weingart, 2007). These differences are visible in discussions and in how tasks are executed. Thus, a move to a different department within an organization creates variance and pushes individuals to engage in analogical thinking without the more drastic life-changing events of relocating them to a different country.

Variety can also be applied to activities outside of an individual's job role. For instance, Google's 20 percent rule permits employees to spend

20 percent of their work hours on projects outside of their job role (Schrage, 2013). Other organizations could allow employees to engage in volunteer activities, to provide opportunities to work in other domains (Dane, 2010). Variety of practice, and thus exploration, through volunteering programs allows for individuals to not be evaluated on their performance, while doing work, which provides the freedom to explore new ways to execute tasks. In these ways, organizations encourage individuals to explore challenges that are not directly related to their job, but because of the lower risk it may still help develop adaptive expertise.

Second, organizations should also offer employees the autonomy to try out new methods to reach a specific organizational objective (Ellström, 2001). Autonomy at work has been reported to positively influence adaptive performance (Schraub, Stegmaier, & Sonntag, 2011) because it gives employees the opportunity to create their own variety of practice by developing new ways to complete a task. Through this autonomy, individuals further develop their knowledge structures, hence developing abstract cognitive schemas. The common idea behind variety of practice and autonomy is to let employees develop better cognitive schemas by identifying gaps in current thinking (Ward, Gore, Hutton, Conway, & Hoffman, 2018). Individuals can then use these knowledge-based rules when confronted with unfamiliar situations where automatic procedures fail (Olsen & Rasmussen, 1989). However, environments that carry high risk for individuals who deviate from the official procedures, are not beneficial for the development of adaptive expertise (Hatano & Inagaki, 1986). It is difficult for specific organizations and industries, such as healthcare, emergency care help, or the airline industry to give individuals the freedom to try out new procedures if it constitutes a high risk for patients and clients. In these environments, simulations can be used to offer employees the opportunity to deviate from practice (Joung et al., 2003; Joung, Hesketh, & Neal, 2006) and to develop adaptive expertise.

Finally, organizational cultural norms about performance are influential to employees' ability to develop adaptive expertise. Organizational norms that favor achieving high levels of performance as quickly as possible are counter to the development of adaptive expertise. In such environments, procedural knowledge is regarded as more important than conceptual knowledge. This is visible through onboarding and training

processes, which do not give employees sufficient time to understand the why behind the procedures. Similarly, performance management systems that do not include sufficient emphasis on learning and what knowledge employees have gained over the year reduces the employees' willingness to deviate from practice as it can harm their performance and thus how they are evaluated by their manager.

In sum, adaptive expertise is important to successfully operating in increasingly dynamic environments. With employees exposed to novel situations more frequently, organizations that provide employees with opportunities to develop deep conceptual understanding of their domain through variety, autonomy, and supportive cultural norms are better able to navigate these dynamic environments.

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