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Learning what to learn across the lifespan: From objects to real-world skills

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ABSTRACT

One of the most difficult and important problems that all learners face across the lifespan is learning what to learn. Understanding what to learn is difficult when both relevant and irrelevant information compete for attention. In these situations, the learner can rely on cues in the environment, as well as prior knowledge. However, sometimes these sources of information conflict, and the learner has to prioritize some sources over others. Determining what to learn is important because learning relevant information helps the learner achieve goals, whereas learning irrelevant information can waste time and energy. A new theoretical approach proposes that adaptation is relevant for all age groups because the environment is dynamic, suggesting that learning what to learn is a problem relevant across the lifespan, instead of only during infancy and childhood. This paper reviews new research demonstrating the importance and ways of learning what to learn across the lifespan, from objects to real-world skills, before highlighting some unresolved issues for future research.

Keywords: Learning, infant development, cognitive aging

Importance of learning what to learn

The natural learning environment abounds with complexity. Not only are there many events from moment to moment, but also only some of these events are relevant for understanding the key experiences that are unfolding. Learning what to learn entails understanding what is relevant versus irrelevant. Not knowing what to learn arises when there are multiple potential targets to learn about, or when the learner does not know what the targets even are. For infants and children, this problem is especially challenging because they are still developing an understanding of what might be relevant. By contrast, adults regularly engage in goal-directed actions, such as driving to work, and often can teach themselves based on an understanding of what they need to learn. Once a learner figures out what to learn, then the remaining task is to learn the information, which can still be a challenge depending on the complexity of the information. Learning what to learn applies to basic levels of learning, such as learning about objects (e.g., Wu et al., 2011), as well as to higher levels, such as real-world skill learning (e.g., career skills, Darling-Hammond et al., 2014). If learners cannot determine what is relevant to learn, they risk experiencing delays in learning or learning something irrelevant, wasting time and energy. Moreover, learning irrelevant information may lead the learner down an unfavorable path for future learning.

Ways of learning what to learn

At least four ways of figuring out what to learn have been identified (Table 1). These include: 1) Learning from stimulus characteristics of the to-be-learned items (e.g., similarity, patterns; Aslin & Newport, 2012; Landau et al., 1988), 2) reinforcement/feedback (e.g., Mitchell & Le Pelley, 2010; Schultz et al., 1997), 3) people (e.g., Wu et al., 2011), and 4) prior knowledge

(e.g., known patterns and categories, Wu et al., 2013; unpredicted events, Stahl & Feigenson, 2015).

Table 1. Four ways of learning what to learn.

Four ways of learning what to learn	
Learning from stimulus characteristics	e.g., similarity, patterns
Learning from reinforcement/feedback	e.g., verbal feedback, reward
Learning from people	e.g., joint attention, social cues
Learning from prior knowledge	e.g., known patterns and categories, unpredicted events

Learning from stimulus characteristics. Costs and benefits emerge when relying on these four sources of information. From birth, infants learn from stimulus characteristics, such as patterns of events. Detecting patterns is particularly useful because it allows the learner to predict future events (e.g., Aslin & Newport, 2012). However, there are multiple patterns in the environment at a given time, and some are relevant, while others are not. Similarity in events or objects can help learners understand what to learn (e.g., cars have wheels), although sometimes things can seem similar but actually should be dissociated (e.g., Mom versus her sister). If learners relied only on stimulus characteristics, they would be driven willy-nilly by any event in the environment. As a result, the learner would acquire information about both relevant and irrelevant events that are more obvious, rather than mostly relevant events or more subtle events (e.g., subtle emotional expressions) that may be more relevant for a given circumstance.

Learning from reinforcement/feedback. Research also has shown that reinforcement and feedback, such as rewards and punishment, can indicate what to learn. This idea is not new, and indeed, much research rests on the fact that physical reinforcers, such as a sugar pellet for rats or stickers for children can be used to guide participants to complete tasks as intended by the experimenter (e.g., Mitchell & Le Pelley, 2010). There are many examples of reinforcement in infant learning, such as classic studies training infants to kick to make a mobile move to test the duration of infant memory (e.g., Rovee-Collier, 1999). Learning what to learn can be straight-forward in such supervised learning conditions, depending on the nature and timing of the feedback. However, human learners in the natural environment may not register or understand particular types of feedback, and are often in unsupervised or semi-supervised learning situations (i.e., situations with little or no feedback). Moreover, reinforcement-guided learning is slow because each training event has to be paired with a reinforcer, and therefore does not provide a good mechanism for rapid learning, especially during infancy (e.g., language learning in the first couple years of life).

Learning from people. Related to research on supervised learning, people, such as caregivers and teachers, can provide information about what is relevant to learn, including verbal or written instructions, gestures, or body language. One of the major benefits of learning from people is that the to-be-learned information can range from simple facts to complex real-world skills, such as surgery. Infants learn better from live instructors than from recorded instructors (e.g., Kuhl et al., 2003), and infants tend to learn from types of people with whom they are more familiar (e.g., Xiao et al., 2017). Although there are clear benefits to learning from people, some costs include only exploring narrowly or imitating the teacher's actions exactly, even if they are irrelevant (e.g., Bonawitz et al., 2011; Nagell et al., 2003). However, narrow exploration may

save time from exploring in unnecessary directions, and faithful imitation can lead to learning of cultural practices. Therefore, the costs of learning from people are largely determined by the accuracy and biases of the teacher.

Learning from prior knowledge. Prior knowledge also can be a source of information about what to learn, such as if an event is surprising because you have only seen events that displayed the opposite actions before. Recent studies have highlighted that infants learn after both unexpected and expected events (e.g., Benitez & Saffran, 2018; Stahl & Feigenson, 2015). Although learning based on prior knowledge is useful, it is only beneficial if the learner's prior knowledge aligns with the current situation (e.g., Green et al., 2010; Orhan et al., 2014; Wu et al., 2013; Wu, Pruitt et al., 2017). For example, applying knowledge about English when learning Mandarin may hinder learning via incorrect assumptions about the insignificance of tones: Irrelevant information in one situation may be relevant information in another. One potential reason that explains infants' proficiency in tasks that are difficult for older learners (e.g., second language learning) may be that prior knowledge can interfere with learning in more mature learners. Another issue with prior knowledge is that learners have to have some knowledge before they can learn from prior knowledge. Therefore, there is a "chicken-and-egg" problem in models that aim to understand how infants and children learn, which is resolved by building in biases from the outset (e.g., Ullman et al., 2012).

Learning what to learn based on prior knowledge overlaps with, but is distinct from other types of learning such as perceptual narrowing or perceptual expertise training. For instance, studies on perceptual narrowing (e.g., Scott et al., 2007) highlight the importance of environmental exposure and prior knowledge on object recognition and categorization over the first year of life. Studies that train perceptual expertise on naturalistic categories (e.g., cars, birds,

Tanaka et al., 2005) or novel sets of objects (e.g., Greebles; Gauthier & Tarr, 1997) often specify what to learn about the objects, such as learning names or attributes of the items, and participants have to learn the diagnostic features or combination of features to distinguish similar items in a homogenous category. Perceptual narrowing and perceptual expertise studies are distinct from learning what to learn studies, which include paradigms where learners have to determine which of many targets to learn about, rather than being presented only with specific targets to learn about.

Prior knowledge also informs motivation and curiosity: Building on initial biases, motivation and curiosity can be informed by experience (e.g., Oudeyer & Smith, 2016). This issue is especially important when learners are faced with challenging learning tasks, such as a difficult math problem, and have low levels of prior knowledge and self-efficacy (belief that they can achieve their goals), which in turn leads to low motivation to learn the challenging tasks (e.g., Spencer et al., 1999).

Learning what to learn across the lifespan

Learning what to learn has been canonically, and intuitively, investigated as a problem with infants and children, who do not have the requisite knowledge to know what is relevant (e.g., Gopnik et al., 2015). With only a few biases from birth, such as preferring moving objects or face-like images, infants tend to encounter situations where they do not know what is relevant to learn. Without much prior knowledge about what might be relevant, infant learning is primarily driven by stimulus characteristics, intrinsic motivation/curiosity, and people, typically caregivers. Information itself can be rewarding (e.g., Bromberg-Martin & Hikosaka, 2009; Kidd

& Hayden, 2015), although this information cannot be too expected or too unexpected (both leading to disengagement; e.g., Kidd et al., 2012; Tummeltshammer & Kirkham, 2013).

Recent research also has demonstrated the benefits and development of learning from people in infancy (e.g., Wu et al., 2011). Learning from people is an essential skill to develop because caregivers often reliably identify what is relevant. Within the first year, not only do infants learn speech and action patterns from people, but also, they learn about object properties (e.g., sounds that specific objects make) and object functions (e.g., how to use an object). Once infants develop the knowledge that they can learn from people, they can use this knowledge to build more knowledge relevant to successful daily functioning, such as how to use particular objects (e.g., utensils).

From childhood to emerging adulthood, learning what to learn, especially in the classroom setting, can be challenging. For example, for undergraduates in large lecture halls, learning which concepts are key to learn and note down is fundamental to success in undergraduate classes, and can differ depending on the way students take notes (e.g., via longhand vs. typing; Muller & Oppenheimer, 2014). More generally, learning which skills are needed for career readiness also is important (e.g., Arnett, 2007; Darling-Hammond et al., 2014).

Fewer studies have focused on learning what to learn beyond emerging adulthood, because in general, the problem has been conceptualized as more relevant from infancy to emerging adulthood. As learners mature and gain more knowledge, they can rely more on prior knowledge to determine what is relevant (e.g., Chen et al., 2017; Gopnik et al., 2015). This observation has led some to propose that children explore more often than exploit to adapt to the existing environment, whereas adults, who have adapted, exploit more than explore (Gopnik et al., 2015). A new theoretical approach (Nguyen et al., 2018; Wu et al., 2017) proposes that

adaptation is relevant for all age groups (rather than just infancy and childhood) because the environment is *dynamic*, rather than *static*. This theoretical approach suggests that learning what to learn is a problem relevant to the entire lifespan, from infancy to older adulthood. Although prior knowledge is helpful when it aligns with a static environment, the nature of a dynamic environment entails that knowledge about everyday skills acquired from decades earlier may become irrelevant over time. Relying only on prior knowledge could lead learners away from things that seem irrelevant, but are actually relevant as the environment changes, such as learning how to use new technological devices.

This issue is especially important for maintaining functional independence, (i.e., the ability to complete daily tasks independently), the hallmark of successful aging. For example, learning to use smartphones and online banking platforms has become necessary, and navigating with driverless cars is on the horizon. Learning new, difficult real-world skills may be problematic for older adults, who may not be as familiar with doing so. Some have proposed that older adults typically prioritize enjoyable situations and activities, such as social engagements, rather than enduring the frustrations of, perhaps, learning a difficult skill (e.g., Carstensen, 1995). Theories on compensation and coping in older adulthood recommend avoiding activities where one makes mistakes to prevent disappointment (e.g., Baltes, 1997; Brandtstädter & Greve, 1994), whereas models of growth (e.g., Wu et al., 2017) highlight that making mistakes are essential for learning and growth. Future research on learning what to learn in adulthood, especially older adulthood, may inform useful interventions to mitigate, delay, or even prevent cognitive and functional decline in late life.

Unresolved issues

There are a number of unresolved issues that can be tackled by future research. More studies are needed to better understand how these different ways of learning what is relevant interact to help or hinder learning in different situations. When information from multiple sources is consistent, learning can be facilitated, whereas when there is inconsistency, learning can be hindered, unless the learner is able to prioritize the appropriate sources of information over others. Future research also can compare the attention, memory, and executive capacities and neural underpinnings required for the four ways of learning what to learn. These findings can be linked to findings in related areas, such as curiosity and information-seeking. In addition, future research can investigate how people learn to use different sources of information to figure out what is relevant over seconds to decades, and from objects to real-world skills. Perhaps investigating across different time scales and levels of complexity across the lifespan will highlight similarities in the use of information sources, such as how one learns from people and patterns in different situations.

Another area for future research is to develop an effective training program for learning what to learn in healthy populations. Recently, there has been a surge of interest in training cognitive abilities, such as working memory and cognitive control, in healthy populations across the lifespan. Although cognitive training interventions can improve abilities on trained tasks, often computerized tasks (e.g., Simons et al., 2016), they may not help the learner understand what is relevant to learn in the real world. Moreover, trained effects often do not transfer to different domains. Complementary to cognitive training approaches, training participants to learn what to learn in real-world situations, from objects to skills, may benefit all ages across the lifespan. Learning what to learn is a skill that may be transferred across domains and levels,

ranging from specific features to attend to when solving a math problem to skills required for encore careers after retiring.

There is little research on how learning what to learn impacts individual differences in atypical developmental trajectories in infancy and childhood. For example, research on learning from people in typically developing infants, who use people as a shortcut to determine what to learn, provides a potential reason for why infants and children who exhibit overall lower levels of learning from people may experience delays. Therefore, if children do not learn well from people in specific situations, then interventions could help them understand what is relevant to learn by some other means. Compared to issues related to following social cues (Dawson et al., 2004; Reichle, 2018; Whalen & Schreibman, 2003) or issues with children's learning ability itself, less is known about situations when learning delays are primarily due to not knowing what to learn. How children differ in the way they learn to learn may inform tailored interventions to mitigate learning delays.

Finally, there is little research on how learning what is relevant impacts normal cognitive and functional decline in older adulthood. Especially in relation to learning new real-world skills, perhaps not knowing what to learn is among the drivers of typical cognitive and functional decline in healthy older adults. If this is the case, perhaps cognitive and functional decline trajectories in healthy older adults and atypical developmental trajectories with younger populations share similarities in terms of the function of learning what to learn.

Conclusions

Great strides have been made towards a better understanding of how learners figure out what to learn. In this paper, I have highlighted the importance of learning what to learn and the

current understanding of how learners do so across the lifespan. To build on this exciting research, future studies could provide a better understanding of how learners come to understand that different information sources can help them determine what to learn, and how learning what to learn impacts lifespan developmental trajectories in naturally-occurring situations, as well as in interventions. Research investigating such learning processes could have a high impact on the everyday lives of learners across the lifespan.

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