CHAPTER 2

From Curiosity to Interest
Accumulated Knowledge Supports Long-Term Persistence of Information-Seeking Behavior

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2.1 Introduction

Accounts of information-seeking attempt to explain how a person is motivated to seek information when there is no apparent tangible or instrumental reward for finding it. Intriguingly, research on information-seeking emerges from two separate traditions that rely on independent theory and investigative methods: one focusing on information-seeking motivated by "curiosity," the other on information-seeking motivated by "interest" (Murayama, 2022; Peterson & Hidi, 2019). This dichotomy between curiosity and interest as seemingly distinct motivational forces persists despite both traditions claiming lineage from early psychological research that used the terms synonymously (Berlyne, 1949, 1950; Day, 1982). Beyond terminology, however, the different traditions provide unique insights into the motivations underlying information-seeking behavior. Researchers studying curiosity typically provide detailed quantitative investigations into one-time information-seeking behavior, using cognitive, neuroscientific and computational methods (e.g., Gottlieb et al., 2013; Lau et al., 2020). For example, Lau et al., (2020) investigated how peoples' risky decision making (i.e., that potentially involved electric shocks) was influenced by their motivation to satisfy their curiosity about how a magic trick was done. In contrast, interest researchers provide strong qualitative theoretical accounts of the long-term development of information-seeking behavior on a particular topic, which is functionally important in applied psychological disciplines, such as education (e.g., Hidi & Renninger, 2006; Sansone & Thoman, 2005; Schiefele, 2009). For example, Hidi & Renninger (2006) provide a theoretical account of how students' interest in a subject develops from initial engagements (e.g., intrigued by some historical facts) to an established predisposition toward re-engagement (e.g., in-depth, voluntarily study of an historical period over a prolonged period).

As a consequence of these siloed research traditions, on the one hand we have extensive quantitative empirical investigations of one-time information-seeking behavior, and, on the other hand, we have detailed theoretical models of long-term task engagement. Yet these aspects remain unintegrated – that is, we lack a coherent and empirically supported account of how people's motivation to seek information in specific domains develops over time. In this chapter we provide a brief overview of these separate research traditions, and aim to connect their relative strengths using the recently proposed reward-learning framework of knowledge acquisition (Murayama, 2022; Murayama et al., 2019). This conceptual framework explains long-term development of information-seeking behavior (focused on by interest research) by extending existing reward-learning models that mainly account for one-time information-seeking behavior (focused on by curiosity research). By linking these two research traditions, we aim to highlight and facilitate much-needed empirical investigations into long-term development of information-seeking that research on curiosity has hitherto somewhat overlooked.

2.2 Interest Research: Long-Term Development of Information-Seeking

Researchers studying interest from an educational perspective focus on theoretical models accounting for the long-term development of information-seeking. In other words, the big question they seek to answer is: "How do learners sustain engagement in information-seeking behavior on a particular topic over a long period of time?" In doing so, they seek plausible (nonquantitative) models of development to account for and foster the process by which students might become interested in a topic and become self-motivated learners (selective persistence; Prenzel, 1992), generating questions and independently seeking out information on that topic. To this end, they offer two key insights on information-seeking. First, individuals' information-seeking in particular domains develops, progressing from momentary information-seeking on a topic to repeated, self-sustained engagement in information-seeking on that topic (Section 2.2.1). Second, this development toward self-sustained engagement is driven by accumulated knowledge (Section 2.2.2).

2.2.1 Development of Information-Seeking

A common distinction made in interest research is between momentary experiences of focused attention on a subject caused by environmental factors (termed situational interest) and a predisposition to re-engage with a particular subject (termed individual interest; Hidi & Renninger, 2006; Krapp, 2000). The four-phase model of interest development attempts to model the development of students' interest in a topic, from initial momentary experiences to sustained self-motivated re-engagement (Hidi & Renninger, 2006; Renninger & Hidi, 2016). Under this model, in the "triggered situational interest" phase, an individual focuses their attention on a subject when they notice incongruous information or recognize personal relevance in it (e.g., reading an article about the French revolutionary Maximilien Robespierre). Following this, in the "maintained situational interest" phase, individuals continue to focus attention on the subject over an extended period (or perhaps re-engage after the initial instance of triggered interest subsides – e.g., returning to the original article on Robespierre). The model proposes that it is possible to develop individual interest following these phases of situational interest. The "emerging individual interest" phase (phase three) relates to a developing predisposition to re-engage with a subject (e.g., seeking out more articles about notable French revolutionaries), which becomes "well-developed individual interest" (phase four) when this predisposition is established (e.g., regularly engaging with historical sources about the French Revolution). Though the phases chart a potential developmental trajectory, Hidi & Renninger (2006) note that not all instances of triggered situational interest necessarily develop into an individual interest (and not all emerging interests become well-developed) – that is, a person with an individual interest can still experience situational interest in that subject. Therefore, the phases of the model are not exactly akin to unidirectional developmental stages. Nevertheless, the model provides a theoretical framework for how one-time information-seeking triggered by environmental stimuli can develop into an established disposition for a person to engage in self-motivated information-seeking (not requiring environmental triggering).

2.2.2 Knowledge Accumulation

The second particularly insightful observation made by interest researchers concerns the role of knowledge in driving the development of long-term information-seeking. In the four-phase model, students' individual interests are characterized in part by stored knowledge on a topic. In turn, this stored knowledge allows students to self-sustain their engagement by posing questions based on the knowledge that they do have, resulting in more engagement ("curiosity questions"; see Hidi & Renninger, 2006). This hypothesis has some empirical support. Alexander et al. (1994) demonstrated that students' interest in a specific topic was predicted by their prior knowledge of the topic. For example, students' scores on a test of key concepts and principles in physics, as well as their specific knowledge about black holes, predicted their interest in reading a passage of text about the work of physicist Stephen Hawking. More recently, Fastrich & Murayama (2020) showed that people's interest in a topic grew as they were presented with more information about it. In this study, participants repeatedly rated their interest in a lesser-known country (e.g., Bahrain, Lesotho) as they were given step-by-step information about that country (e.g., relating to geography or politics). This allowed the researchers to plot a trajectory for participants' interest as they acquired knowledge, and they demonstrated that participants' ratings of their interest in lesser-known countries increased as they received more information. Finally, Witherby & Carpenter (2021) found that people's ability to learn new information about a subject (e.g., American football or cooking) was better, and ratings of curiosity were higher, for subjects where they had more prior knowledge compared to those where they had less prior knowledge.

2.3 Curiosity Research: Momentary Information-Seeking Behavior Driven by the Reward Value of Information

Curiosity research typically relies on experiments investigating one-time information-seeking evoked by state curiosity (see Section 2.6.1). State curiosity is typically conceived of as the experience of an uncomfortable gap in a person's knowledge that needs satiation with specific and in-principle obtainable information, dissipating when this information is acquired (Grossnickle, 2016; Gruber et al., 2016; Kobayashi et al., 2019; Loewenstein, 1994; Peterson & Cohen, 2019). To this end, this research offers two key contributions to the study of information-seeking. First, it provides empirically supported reward-learning models for why humans seek information even when the information is noninstrumental in obtaining an extrinsic reward (e.g., money/food). Second, it provides a detailed investigation into what knowledge states are a prerequisite to motivate a person to seek information in a situation.

2.3.1 Information as a Reward

Recent curiosity research has mainly posited that information is rewarding in and of itself (i.e., it is intrinsically valuable), and therefore reward-learning processes can explain people's information-seeking behavior (Gruber & Ranganath, 2019; Kidd & Hayden, 2015). Research has demonstrated that people seek information even when it is not instrumentally valuable and may be costly or pointless to obtain (i.e., not directly leading to tangible reward; Charpentier et al., 2018; Kobayashi et al., 2019; Lanzetta & Driscoll, 1966; Rodriguez Cabrero et al., 2019; Van Lieshout et al., 2018). Furthermore, recent work indicates that people seek information even when it knowingly brings overtly negative consequences such as receiving electric shocks or experiencing feelings of regret (FitzGibbon et al., 2021; Hsee & Ruan, 2016; Oosterwijk, 2017). Since Berlyne (1960) argued that the resolution of states of novelty, uncertainty, conflict, or complexity is rewarding in and of itself, researchers have proposed various reward-learning models (or reinforcement-learning models) to explain such curiosity-driven information-seeking behavior. Historically, reward-learning models have attempted to explain why humans repeat actions that are instrumental in obtaining extrinsic rewards (e.g., food or money; see Berridge, 2000 for a review). Simply put, traditional reward-learning models posit that if an action leads to some reward in some situation, the value of the action increases and so is more likely to be performed when encountering the same situation again, and can be generalized to different contexts on repeated success.

In information-seeking research, reward-learning models treat information itself as a reward (not some directly resulting extrinsic reward from the action, e.g., food/money). Information-seeking behavior can therefore be reinforced simply by obtaining information, increasing the value of information-seeking behavior (making this behavior more likely in the future). This explains why people seek information even when it might result in negative consequences (e.g., electric shocks) – namely, because information-seeking behavior has an expected reward value that is strong enough to override the expectation of negative consequences. The hypothesis that information has inherent value (like extrinsic rewards do) has been supported by evidence that the neural reward networks associated with extrinsic rewards (Iigaya et al., 2020; see also O'Doherty, 2004; Rushworth et al., 2009 for reviews) are activated when someone wants to know answers to trivia questions (Gruber et al., 2014; Kang et al., 2009) and when uncertainty over ambiguous pictures is resolved (Jepma et al., 2012). Furthermore, the same brain areas activate both when we are curious and when we are hungry, and this activation predicts information-seeking and food-seeking behavior respectively (Lau et al., 2020; see also Kobayashi & Hsu, 2019). Based on these findings, there has been an explosion of computational models aiming to provide quantitative accounts for how and what type of new information is valued (see Oudeyer & Kaplan, 2009 for a review).

2.3.2 Information Gaps

Curiosity research focuses on the role of knowledge for motivating one-time information-seeking. One good example is the information-gap theory of curiosity (Loewenstein, 1994), which articulates the mechanisms by which people initiate information-seeking behavior in the first place. Information-gap theories of curiosity require two interacting components regarding an individual's knowledge about a situation. First, an individual needs to have some level of retrievable knowledge that they can apply when encountering the situation. Second, based on that knowledge retrieval, the individual needs to have a metacognitive representation of how much they do not know about the situation – that is, whether there is an information gap in their knowledge. It should be noted that whether this representation accurately represents a person's "true" knowledge level is irrelevant – for example, if someone "knows" some information (i.e., has it stored in their memory) but fails to retrieve it, this representation is technically inaccurate (yet this is unproblematic for the account). The theory suggests that curiosity is triggered when someone encounters a situation where they metacognitively believe that they have an information gap (Loewenstein, 1994; Metcalfe et al., 2020). As such, information-seeking behavior is most highly motivated in a metacognitive sweet-spot where an individual retrieves enough knowledge about a situation to believe that they lack knowledge. This view suggests that you need some knowledge base about a topic to estimate the plausible extent or bounds of potential information about the topic and therefore build a representation of how complete your knowledge is. Accordingly, curiosity is unlikely to be triggered when someone retrieves very little or no knowledge pertaining to a situation, because they cannot estimate how much of a knowledge gap they have without a certain amount of knowledge. It is also worth noting that, according to this perspective, knowledge level and curiosity (motivation for information-seeking) have an inverted-U shape function; whereas a certain amount of knowledge is a prerequisite for triggering curiosity, curiosity is unlikely when someone retrieves a lot of knowledge about the

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situation, because they are unlikely to believe that they lack some knowledge. In fact, experimental work suggests that individuals reporting that the answer to a trivia question is on the tip of their tongue report being more curious about the answer compared to when they report not knowing or knowing the answer (Dubey et al., 2021; Kang et al., 2009; Litman, Hutchins, et al., 2005).

2.4 Interim Summary: Commonalities and Differences of the Two Research Traditions

Clearly, there are important commonalities across curiosity and interest research. Both traditions aim to explain information-seeking behavior with a focus on people's motivation to acquire information which is not contingent on immediate extrinsic incentives. Both underscore the intricate relationship between a person's pre-existing knowledge and their information-seeking behavior; one's learning history has a considerable impact on whether information-seeking is initiated and sustained.

On the other hand, the research traditions show marked differences in their focus. In contrast to interest research, curiosity research does not typically consider how curiosity might drive repeated engagement with a subject over time. While there is a growing body of empirical studies on curiosity, these more exclusively focus on one-time or momentary experiences of information-seeking behavior. In fact, these studies mainly use short (i.e., less than one hour), arbitrary experimental tasks or quiz-style self-contained stimuli where uncertainty can be resolved and information learned in a moment – for example, the answer to a trivia question (Kang et al., 2009) or the identity of an unknown card (Rodriguez Cabrero et al., 2019). This focus may result from the roots of modern theories of curiosity in theories that treated curiosity as an appetitive drive, analogous to other drives such as hunger (Berlyne, 1960; see also Grossnickle, 2016). Under these accounts, information sates curiosity, as food sates hunger, so it is perhaps unsurprising that contemporary accounts do not consider how continued information-seeking may occur and develop after curiosity has been sated or subsided. However, by focusing on momentary information-seeking, this provides no insight into the important dimension central to accounts of interest, namely how individuals develop and sustain information-seeking in a particular domain over time (selective persistence). In contrast, interest researchers focus on stimuli that might promote re-engagement. Therefore, the information stimuli that participants engage with are large bodies of information to be worked through – for example, an entire introductory university psychology course (Harackiewicz et al., 2008), and information-seeking behavior is examined across relatively long periods, such as weeks or even years (Frenzel et al., 2012; Rotgans & Schmidt, 2017).

Consequently, work investigating knowledge (or representation of knowledge) prerequisites for triggering curiosity may not generalize outside of one-time information-seeking to more sustained information-seeking. For example, theoretical accounts of interest suggest that knowledge is accumulated over time when we repeatedly seek information in the same domain, which helps us generate new questions concerning that domain, leading to more information-seeking behavior (Alexander et al., 1994, 1995). This idea seemingly contradicts the view in curiosity research that knowledge and information-seeking behavior have an inverted-U shape relationship. From the standpoint of interest research, this curve could simply result from the type of stimuli used in curiosity research, because knowledge concerning these stimuli can be bounded: for instance, it is possible to be certain (or almost certain) that you know the answer to a trivia question, and so you may not need to seek information any further. In contrast, models of long-term engagement focus on knowledge of subject areas that are unlikely to be saturated: for instance, it is highly unlikely that you are certain that you know everything about the modern study of psychology.

2.5 An Integrative Approach: The Reward-Learning Framework of Knowledge Acquisition

We propose that unique contributions of the research traditions discussed earlier can be integrated into a coherent account of long-term information-seeking by conceptually extending existing reward-learning models of information-seeking, explicitly consolidating the role of existing knowledge in the reward-learning process. The proposed "reward-learning framework of knowledge acquisition" (Murayama, 2022; Murayama et al., 2019) is not a formal quantitative model unlike other models of curiosity, but rather aims to serve as a guiding framework for further development of quantitative models of people's real-life knowledge acquisition behavior (see Figure 2.1). The framework uses the term "knowledge acquisition" rather than "information-seeking" to stress the critical importance of individuals' knowledge base (built through experience of information-seeking).

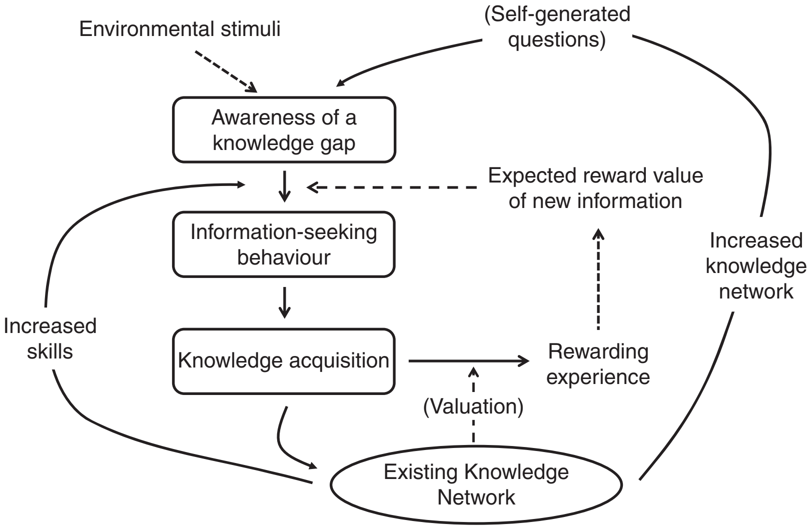

Figure 2.1 The reward-learning framework for knowledge acquisition.
Note. For a more detailed figure, see Murayama (2022).

Like previous reward-learning models typically used in curiosity research, the framework holds that information itself is valuable, and so information-seeking is motivated by the expected reward value of information-seeking behavior. However, the framework holds that information gained about a topic can lead to further information-seeking, because the information itself has unique *self-boosting* properties that other rewards lack (i.e., food/money), which result from knowledge accumulation (see Murayama, 2022). This framework therefore applies a critical aspect of theories of interest to modify current theories of curiosity to account for long-term information-seeking, attempting to provide a more comprehensive account for people's information-seeking. In the following sections we explain three ways in which knowledge accumulation fosters the prolonged and increased engagement of people's information-seeking behavior.

2.5.1 Knowledge Accumulation Influences Awareness of Knowledge Gaps

The core component of the framework is that knowledge accumulation can lead to self-boosting of information-seeking behavior – that is, long-term engagement with information-seeking resulting from a feedback loop when someone successfully seeks information (see "Increased knowledge network" in Figure 2.1). When information is found, as well as reinforcing information-seeking behavior because the information is rewarding, it also means that the information is consolidated into a person's knowledge base. When a knowledge base increases, this can result in the potential for more unknown information to become apparent than before – that is, when a person increases their knowledge base on a topic, this increases the amount of potential information gaps in their knowledge that they could become aware of. This seems slightly counterintuitive, but see Figure 2.2

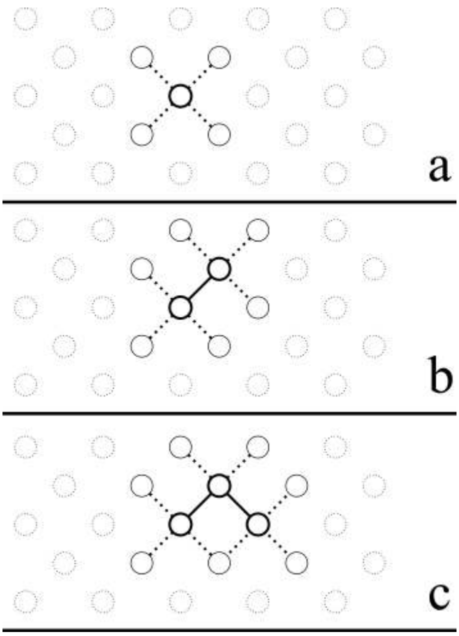

Figure 2.2 Expanding knowledge base results in increased potential for awareness of information gaps
Note. Nodes represent pieces of information; bold outlines represent known information (i.e., knowledge), light outlines represent unknown information that is related to known information, and lighter dotted outlines represent information more distantly related to known information. Edges between nodes denote the relationship between information; dashed edges represent information gaps (i.e., between known and unknown information), and solid lines show that there is no information gap (i.e., the information is connected). As more information is acquired (i.e., connections are made between known and unknown information), the number of potential knowledge gaps increases (e.g., from 4 potential gaps in figure 2a, to 6 in figure 2b, and 8 in figure 2c).

for a demonstration using a simple network (note that the basic idea holds for more complicated real-world networks; see Murayama, 2022). To give a real-world example, consider a person watching a nature documentary featuring a great ape, the species of which they do not recognize (maybe they think it is a gorilla, but they are not confident). They seek the information and find out it is a "western lowland gorilla." This information gain (i.e., an added node in their knowledge network) would result in a larger number of possible links to new information, not yet in their knowledge base, compared to if they had not made the information gain (compare number of dashed edges in Figure 2a and 2b from addition of one node). This increases the chance for them to become aware that they have more gaps in their knowledge (e.g., gaps about the multiple species/subspecies of gorilla). The way in which a person actually becomes aware of gaps resulting from an expanded knowledge base, and boosts their information-seeking in a specific domain, can occur through both bottom-up and top-down processes.

Regarding the bottom-up process, because of an expanding knowledge base in a specific domain, a person may be more likely to engage in information-seeking in that domain when encountering further environmental stimuli that could trigger it (see "Environmental stimuli" in Figure 2.1). This is boosting domain-specific information-seeking through bottom-up processes, and it relies on environmental stimuli that can cause individuals to become aware of a knowledge gap to trigger it. Returning to the gorilla example: initial information gain about the "western lowland gorilla" (itself a bottom-up, stimuli-driven information search) expanded the individual's knowledge base to make it more likely that they will become aware of the possibility that there are multiple unknown subspecies of gorilla. When that person by chance encounters a picture of a different looking gorilla (environmental stimuli), they may become aware of this information gap (they may not know what type of gorilla this is), and be motivated to seek out information about it. This sustains their engagement with the topic; initial information-seeking makes the probability of further stimuli-driven (e.g., bottom-up) information-seeking more likely (i.e., increases their likelihood of information-seeking being triggered by environmental stimuli). In contrast, another individual who did not make initial information gain about gorillas (therefore not expanding their knowledge base) lacks the same increased potential to become aware of the same gap when having the chance encounter with the picture and so would not seek more information (see Murayama, 2022 for a discussion of the Matthew effect).

Regarding the top-down process, a person may self-generate their own questions about a subject as a result of newly gained information (and an expanded knowledge base), leading them to engage in independent research (as proposed by interest researchers: e.g., Renninger & Hidi, 2016; see "Self-generated questions" in Figure 2.1). This is top-down boosting of domain-specific information-seeking; it is self-generated, not relying on environmental stimuli to trigger it. In terms of the reward-learning model, increased knowledge allows people to interrogate their expanded knowledge base to become aware of gaps and motivate themselves to actively seek information. Returning to the example, the initial and spontaneous information-seeking may motivate a person to actively seek more information about gorillas (e.g., reading books or journal articles, watching nature documentaries), sustaining their engagement with the topic. In contrast, a person who did not initially seek the information about the specific type of gorilla lacks the expanded knowledge base that could facilitate the generation of these questions, and would therefore be less likely to engage in further information-seeking.

2.5.2 Knowledge Accumulation Increases Skills or Perceived Competence

The process of information-seeking can also facilitate long-term engagement in information-seeking in a particular domain because of skills acquired through repeated information-seeking. The importance of perceived skills or competence to acquire and comprehend information has been relatively underexamined in the curiosity literature (for notable exceptions, see Mirolli & Baldassarre, 2013), but plays a critical role in explaining our information-seeking behavior in daily life. Importantly, in accumulating knowledge, people's ability to comprehend new information (incorporating it into their knowledge base) improves simply because people with more knowledge have more internal resources to resolve knowledge gaps. As a result, the increased confidence in their perceived skills for information-seeking promotes further information-seeking (see "Increased skills" in Figure 2.1). This would support long-term engagement in a specific domain for an individual, because of domain-specific and domain-general boosting effects. Regarding the former, information-seeking in a certain domain may require more specialization than others, which would increase as a person engages in more information-seeking in that domain, honing their skills in seeking specific types of information (e.g., finding that a particular journal is the best place to find information about gorillas). This would increase the likelihood of people engaging in information-seeking in that domain when presented with new opportunities (i.e., environmental situations that make an information gap pertinent) or when they self-generate questions. Regarding the latter, one's information-seeking in a particular domain can be self-sustained or boosted by domain-general skills for information-seeking resulting from knowledge accumulation in other domains (e.g., their skill in interpreting journal articles relating to their undergraduate psychology course may generalize to interpreting articles about gorilla ecology, and vice versa).

2.5.3 Knowledge Accumulation Increases Expected Reward Value of New Information

Not all information is valued equally. Topic-specific knowledge accumulation means it is likely that a person will assign greater value to information about that topic, providing a feedback loop that facilitates domain-specific long-term information-seeking (see "Valuation" in Figure 2.1). For example, people tend to value knowledge that is associated with their own goals and identities, which together form the core value of the self (Sedikides & Strube, 1997). This "self-scheme" reflects one's learning history: people's goals and identities are strongly influenced by what they have experienced and learned in their daily life (Conway & Pleydell-Pearce, 2000). Therefore, every piece of new information one acquires becomes part of the existing self-scheme, in turn providing a basis for the valuation of upcoming information. In other words, domain-specific knowledge acquisition may enhance the value of the new information in that domain, selectively facilitating information-seeking behavior (e.g., if someone views themselves as an expert in gorillas, they will value information about gorillas over information about cooking, preferentially seeking information about gorillas).

In sum, we have shown that knowledge accumulation can influence three critical components of the reward-learning process of information-seeking. Knowledge acquisition increases (1) awareness of knowledge gaps, (2) skill and perceived competence in comprehending new information, and (3) the reward value of new information. The reward-learning framework of knowledge acquisition extends previous reward-learning models by incorporating the role of knowledge accumulation. Importantly, these processes work in a way that facilitates further information-seeking behavior, making the knowledge acquisition process increasingly self-reinforcing and sustainable. Thus, the framework not only explains one-time information-seeking behavior (already captured by existing reward-learning models), but also how this one-time information-seeking behavior can be sustainable over a long time period. We should emphasize that the proposed framework aims to present a way in which to link curiosity and interest research with reward-learning models. It does not aim to provide a full computational account of long-term engagement in knowledge acquisition. Recently, there have been various computational accounts for many important aspects of information-seeking behavior: for example, how knowledge gaps are quantified and transform depending on the value of information (Oudeyer & Kaplan, 2009), how hedonic value of information is integrated in the information-seeking process (Kobayashi et al., 2019; Sharot & Sunstein, 2020; see also Murayama, 2022), and how predicted value for certain information generalizes to related but novel information (Schulz, Bhui, et al., 2019; Wu et al., 2018). The proposed framework leaves detailed computational accounts to ongoing work, while providing a bigger picture view on how these studies should be expanded in the future. For example, the proposed framework underscores the importance of understanding how knowledge is structured in our mental representations, suggesting the potential benefit to be gained from memory research in examining long-term information-seeking behavior.

2.6 Going Further: Information-Seeking over Situations and the Life Course

To conclude the chapter, we consider two important related areas based on the reward-learning framework of knowledge acquisition: how the development of a tendency to seek information in a particular domain sometimes extends to formation of a more general attitude for information-seeking, and how long-term engagement takes place over the life course.

2.6.1 Development of Attitudes Toward Information-Seeking: Trait Curiosity

Trait curiosity represents another strand of research not yet discussed in this chapter. This refers to people's general tendency to experience (state) curiosity in situations where they have opportunity to be curious, namely their domain-general inquisitiveness (Kashdan et al., 2004; Litman & Spielberger, 2003). Importantly, this is not analogous to individual interest as trait curiosity is seen as a stable and domain-general trait, and so unlike models considering individual interest it does not provide a clear way of investigating how an individual's information-seeking in a *specific* domain *develops* over time. However, we believe that trait curiosity can be considered as an extended and generalized outcome of long-term information-seeking in multiple specific domains.

First, the fact that some people tend to be generally more or less inquisitive, or open to new experiences (explicitly linked to curiosity: see John & Srivastava, 1999; McCrae & Costa, 1987), clearly impacts on long-term engagement, interacting with the factors discussed earlier. If a person is more inquisitive or open to novelty (i.e., novelty-seeking), then we expect them to seek information more across all domains. This plausibly leads to an increase in domain-general skills for information-seeking, which in turn supports long-term engagement in specific domains (as discussed earlier). Inquisitive people (i.e., high in traits associated with curiosity) are also more likely to interrogate their own knowledge to find information gaps, or to seek information when gaps are presented (Harrison et al., 2011; Litman, Collins, et al., 2005), thus increasing the boosting effects of knowledge accumulation.

Second, trait curiosity levels may be increased by a person's domain-specific information-seeking. Under reward-learning (and reinforcement-learning) models, once a specific action-reward contingency is learned and reinforced, people may generalize, expecting that similar actions will be similarly rewarding. By engaging in repeated information-seeking behavior in one domain, people learn to expect a high reward value for information in that domain (reinforcement). Therefore, they may generalize the expectation, expecting similar reward value for information gained by information-seeking behavior in other domains, thus increasing domain-general inquisitiveness (generalization). Such cross-domain generalization mechanisms may be realized in computational terms under a hierarchical process (e.g., hierarchical Bayesian generalization; see Gershman & Niv, 2015). In other words, the expected reward value of information in a specific domain (reinforced by repeated information-seeking) may be generalized to information across domains, although this generalization may be countered by various factors in the new domain (e.g., prior knowledge about the new domain).

2.6.2 *Life-Long Development of Information-Seeking*

It is typically believed that children are more curious than adults, and adults become increasingly less curious as they age. But by considering information-seeking as the function of knowledge structure, we can delineate a more nuanced view on how motivation for information-seeking

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develops over the lifespan. For example, while it may be true that children are more curious in that they actively seek information, their information-seeking behavior may be unsustainable and less sophisticated due to the lack of an established knowledge base. In fact, Schulz, Wu, et al. (2019) found that children showed more directed exploration (i.e. purposefully exploring uncertain options) than adults, but failed to generalize their knowledge to efficiently explore the environment (see also Somerville et al., 2017).

What about older adults? Curiosity research has mainly focused on children and young adults, with less examination of information-seeking in middle or old age. Limited research suggests that older adults typically show reduced levels of trait curiosity and reduced exploration behavior compared to younger adults (Chu et al., 2020; Mata et al., 2013; Robinson et al., 2017). Thus, previous research suggests that there are age-related declines in information-seeking behavior, which is consistent with stereotypic portrayal of older adults. However, by incorporating the idea that knowledge is the basis for long-term engagement, we can provide more fine-grained explanations about developmental changes in information-seeking behavior in older adults. As described earlier, information-seeking behavior is supported by reward value of new knowledge as well as individuals' existing knowledge (Hidi & Renninger, 2006). Neuroimaging research suggests that the reward value of new knowledge may decline with age due to detrimental effects of age on the brain (see Sakaki et al., 2018 for a review). However, this reduced sensitivity to new information may be compensated for by the fact that individuals' knowledge develops with age; older adults tend to have richer and more extensive knowledge about the world (Dodson et al., 2007; Kavé & Halamish, 2015). Such age-related increases in knowledge may help preserve or even boost older adults' information-seeking behavior. In addition, the increased knowledge base that comes with age may result in qualitative changes in information-seeking behavior; as individuals age, their existing knowledge may play a bigger role in motivating their information-seeking behavior, and thus they may seek information relevant to their existing knowledge more than novelty (cf. Frenzel et al., 2012).

2.7 Concluding Remarks

The terms "curiosity" and "interest" are clearly related, but there are no agreed-upon scientific definitions. Both terms are used in common parlance, and so people have conceptualizations of their meaning which are perhaps naïve to, and pre-date, their scientific study. Therefore, there is no guarantee that they are underlined by distinct psychological processes (Murayama et al., 2019). However, this is not to say that this terminology should be entirely ignored; the terms may highlight important distinctions in people's intuitive understanding about information-seeking processes (Donnellan et al., 2021). This chapter illustrates how the two growing research fields identifying with their respective terminologies can be unified to provide a comprehensive understanding of information-seeking behavior. We hope that the integrated framework explored here serves as a call to action for the future investigation of "selective persistence" in information-seeking that has been examined in interest research – that is, people's extended engagement of information-seeking behavior in specific domains over time.

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