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The role of rewards in motivation—Beyond dichotomies

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ABSTRACT

Background: A vast amount of research has examined how extrinsic rewards influence motivation in learning. Whereas some studies have indicated that rewards are beneficial for increasing students' motivation, others have argued that rewards undermine motivation, especially so-called intrinsic motivation.

Method: We conducted a narrative review, building on the *reward-learning framework of knowledge acquisition*. We argue that the two perspectives do not actually contradict each other and that researchers should look beyond the simple dichotomy of whether rewards are good or bad for motivation.

Results and conclusions: Rewards may be conceptualized as either extrinsic incentives (i.e., extrinsic rewards) or internal positive feelings that arise from the learning process or from knowledge acquisition itself (i.e., intrinsic rewards). Importantly, the reward-learning framework of knowledge acquisition suggests the possibility of *motivation transformations* in that extrinsic rewards can serve as an "entry point" for engagement, thus helping students start up the positive feedback loop of internally rewarding learning processes. However, once such a positive feedback loop has been established, extrinsic incentives could interrupt the process, potentially undermining long-term engagement. We outline several mechanisms that may transmit motivation transformations and related future research directions. Our discussions are enriched with references to gamification and educational videogames.

Should teachers worry that giving students gold stars or stickers for completing writing assignments decreases their motivation? Will it backfire if parents buy their child ice cream or give them extra pocket money as a reward for outstanding academic efforts or achievements? Given the popularity of videogames for educational purposes, should we be concerned that the rewards students receive in a game (e.g., badges, points, medals) have long-term negative consequences for their engagement and motivation? Reward systems are ubiquitous in education, and they have long been criticized for their potentially negative effects on students' motivation, especially intrinsic motivation (e.g., Deci et al., 1999; Kohn, 1993; Vansteenkiste et al., 2010). However, other groups of scholars have claimed that the detrimental impact of rewards has been greatly exaggerated and that rewards can, at times, even enhance (intrinsic) motivation (e.g., Cameron et al., 2001; Woolley & Fishbach, 2017). To date, a large number of studies have investigated how rewards affect individuals' motivation to learn, and empirical support is available for both perspectives: Extrinsic rewards decrease motivation (e.g., Deci et al., 1999; Murayama et al., 2010), but extrinsic rewards also increase motivation (e.g., Cameron et al., 2005; Woolley & Fishbach, 2017).

In this paper, we argue that the two perspectives do not actually contradict each other and that the whole discussion of rewards and motivation would benefit from moving beyond the simple dichotomy of whether rewards have positive or negative effects. We draw on the *reward-learning framework of knowledge acquisition* (Murayama, 2022; Murayama et al., 2019) to overcome this dichotomy and reconcile the contrasting perspectives. Specifically, we suggest that extrinsic rewards can help set in motion the positive feedback loop of internally rewarding learning processes, particularly for learners who are initially unmotivated. Once learners engage in learning (initially, in order to receive extrinsic rewards), many opportunities to experience internal rewards from learning arise. Hence, motivation that is based on extrinsic rewards can transform into motivation that is based on intrinsic rewards, a process we call *motivation transformation.*

However, we also caution that, as soon as a positive feedback loop of knowledge acquisition is established, extrinsic incentives may interfere with the process, and this interference, in turn, harms long-term engagement. We call for more research to build a robust body of

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knowledge on motivation transformations. Such an evidence base can then potentially feed into the development of personalized reward provision systems that acknowledge the significance of diverse types of rewards that cater to distinct tasks and individual students in various stages of the knowledge acquisition process.

1. Rewards and motivation: a long-standing debate

According to Schulz (2006, 2015), rewards induce particular behavioral reactions. Rewards act as reinforcers and have the potential to produce learning. Rewards are attractive; they are motivating, prompting approach behavior and decision making. Also, rewards have the potential to evoke positive emotions. Put simply, rewards make people come back for more; they are needed for survival, used for behavioral choices that maximize them and make people feel good about them (Schultz, 2007).

A large body of research has investigated how motivation is affected by so-called *extrinsic* rewards, which refer to incentives that reside outside of and are instrumental to the performed activity (Kruglanski, 1975). The issue of whether extrinsic rewards increase or thwart motivation has been hotly debated, and scholars in distinct research traditions have expressed opposing viewpoints on the roles of rewards. These controversies have even led to the conclusion that, over the last few decades, "rewards have become one of the most contentious concepts in social and educational psychology" (Hidi, 2016, p. 62).

For instance, researchers studying Self-Determination Theory (SDT; Deci & Ryan, 1985; Ryan & Deci, 2020; Vansteenkiste et al., 2010) have argued that extrinsic rewards can be detrimental to (intrinsic) motivation (*undermining effect*; Deci, 1975).[1] Intrinsic motivation refers to engaging in an activity for the inherent satisfaction and enjoyment of the activity itself. By contrast, extrinsically motivated activity is performed for separable outcomes (Ryan & Deci, 2000).

According to SDT, rewards can undermine intrinsic motivation, as they are perceived as controlling, and thus, they shift individuals from a more internal to a more external perceived locus of causality (see Flaherty, 1996; Zentall, 2010, for a different explanation; see Hidi, 2016 for a discussion[2]). This shift, in turn, curbs individuals' satisfaction of their psychological needs for autonomy and competence, which are thought to provide the foundation for the development of intrinsic motivation (Ryan & Deci, 2000). It has also been suggested that introducing a reward for an activity that has previously been perceived as interesting prompts individuals to attribute their motivation to the extrinsic reward, thus diminishing their intrinsic motivation (Lepper et al., 1973). Existing empirical research has supported the undermining effect (also known as the *overjustification effect*, Lepper et al., 1973, or the *crowding-out effect*, Frey & Jegen, 2001, depending on the respective theoretical framework) of extrinsic rewards on intrinsic motivation. The meta-analysis by Deci et al. (1999; see also Lehtivuori, 2023) documented that extrinsic rewards undermined intrinsic motivation in many of the investigated circumstances and for both behavioral assessments of intrinsic motivation (i.e., the amount of time participants spent on the experimental task in a free-choice period) and self-reported intrinsic motivation.

Other researchers have questioned the undermining effect (see, e.g., Reiss, 2005, for a summary of methodological and conceptual problems) and contended that rewards have the potential to increase (intrinsic) motivation (e.g., Cameron & Pierce, 1994, 1996; Eisenberger & Cameron, 1996; but see Deci et al., 1999, for a critique). In this vein, Cameron et al.'s (2001) meta-analysis showed that rewards that were linked to the levels of individuals' performance (performance-contingent rewards) either increased intrinsic motivation or did not differ from nonrewarded control conditions. In another study, rewards were provided over an extended period of time to undergraduate students, depending on their performance in learning phases. The results revealed positive effects of rewards on free-choice intrinsic motivation and self-reports of task interest (Cameron et al., 2005). Receiving extrinsic rewards (e.g., snacks, colored pens) during an in-class assignment further predicted high-school students' persistence in schoolwork (Woolley & Fishbach, 2016; see also Liu et al., 2022), and immediate rewards boosted persistence in a single session of studying among college students (Woolley & Fishbach, 2017). Goswami and Urminsky (2017) also found that the net effect of temporary extrinsic rewards on engagement was strongly positive.

The discussion of effects of extrinsic rewards has also been carried over to research on gamification (i.e., the use of game elements in nongame contexts, including the application of videogames for educational purposes, often referred to as serious games; Deterding et al., 2011; Laine & Lindberg, 2020). One of the goals of gamification in education is to increase learners' motivation. However, concerns have been raised that game elements (e.g., points or badges) may be viewed as a form of extrinsic reward that can undermine intrinsic motivation (e.g., Amriani et al., 2013; Bitter et al., 2022; Hanus & Fox, 2015).

As found in research on extrinsic rewards in nongame contexts, the empirical findings of gamification have been mixed. For example, positive effects of gamified in-class activities (gamified quizzes with points and a team leaderboard) on intrinsic motivation have been documented (Sailer & Sailer, 2021), but gamification (e.g., points, badges, visualized goal progress) was also found to undermine participation in an e-learning task (Amriani et al., 2013). Aggregating the results of two studies, Bitter et al. (2022) showed that removing pay significantly decreased intrinsic motivation, whereas removing gamification elements (e.g., points, feedback) did not; however, differences between the two effects (pay vs. gamification) were not statistically significant. In general, the interpretation of the findings of studies on gamification is complicated by the fact that the effects of different (extrinsic) game elements are usually not tested separately. Instead, scholars often pit gamified versions, which include a variety of elements (e.g., badges, points, but also competitive and cooperative game elements, storytelling, use of avatars), and nongamified versions against each other (see also Ratinho & Martins, 2023).

To conclude, both negative and positive effects of extrinsic rewards on motivation have been proposed, and there is empirical support for both perspectives. Our aim is not to dwell on the differences between these two lines of research but rather to reconcile contrasting viewpoints and move beyond dichotomies. We do so by drawing on the reward-learning framework of knowledge acquisition (Murayama, 2022; Murayama et al., 2019), which we briefly describe in the following section.

2. The reward-learning framework of knowledge acquisition

The reward-learning framework of knowledge acquisition (Murayama, 2022; Murayama et al., 2019; Murayama & Jach, 2024, see Fig. 1) explains how individuals initiate and sustain learning processes. The framework incorporates ideas from interest theories in educational psychology (e.g., Hidi & Renninger, 2006; Sansone & Thoman, 2005; Wigfield & Eccles, 2002) in reward-learning models. The framework builds on and expands such reward-learning (or reinforcement-learning) models (Dayan & Niv, 2008; Montague & Berns, 2002), which outline that behavior is guided by the rewarding value of the behavior that is computed and updated by means of reinforcement processes (see also Fitzgibbon et al., 2020; FitzGibbon & Murayama, 2022).

In the traditional reward-learning models, extrinsic rewards (e.g.,

[1] In SDT, even though extrinsic rewards are presumed to be generally maladaptive for motivation, it is important to add that the theory also suggests that the effects are more nuanced. Specifically, extrinsic rewards can have positive effects to the extent that they affirm competence (e.g., positive feedback; Deci et al., 1999; Patall & Zambrano, 2019; Ryan & Deci, 2020).

[2] For example, the contrast effect account suggests that the removal of rewards creates a relative contrast with the time when rewards were provided, disrupting engagement in the task (Hidi, 2016).

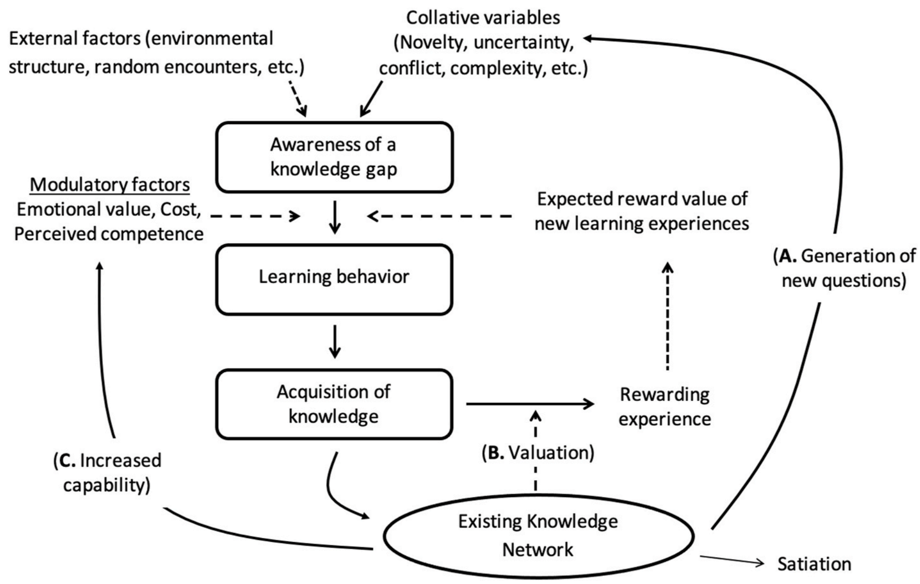

Fig. 1. *The Reward-Learning Framework of Knowledge Acquisition*
Note. Figure adapted from Murayama (2022).

food or money) reinforce behaviors (e.g., Berridge, 2000). The same principle can be applied to interest-based learning—a person can be voluntarily engaged in learning because knowledge acquisition is inherently rewarding and is often accompanied by subjective positive emotions, which strengthen learning behavior even without explicit tangible rewards (e.g., Bernacki et al., 2021).

Fig. 1 describes this phenomenon. In the first place, an individual experiences a subjective feeling of curiosity about knowledge acquisition when they become aware of a gap in their knowledge about a specific topic (Loewenstein, 1994). Awareness of the knowledge gap makes the individual expect the rewarding value of new information, which triggers learning (information-seeking) behavior (e.g., Gottlieb et al., 2013; Gottlieb & Oudeyer, 2018; Renninger & Hidi, 2022). Specifically, the brain generates reward signals linked to learning and the acquisition of information (Berlyne, 1960; Gottlieb et al., 2013; Gottlieb & Oudeyer, 2018; see also Renninger et al., 2024, for a discussion in the context of interest development). In fact, being curious about anticipated information elicits activity in the brain's dopaminergic system, the brain's chief reward system (Gottlieb et al., 2013; Gottlieb & Oudeyer, 2018; Gruber & Ranganath, 2019; Kang et al., 2009). Once the knowledge is acquired, the individual experiences a feeling of reward, and this rewarding experience reinforces future learning behavior (it increases the expected rewarding value of new learning). This concept is represented in the internal loop in Fig. 1. Thus, both extrinsic rewards (which traditional reward-learning models focus on) and intrinsic rewards (which the reward-learning framework of knowledge acquisition focuses on) are governed by the same reward-learning principles (see also Fitzgibbon et al., 2020; Gruber & Ranganath, 2019).

Importantly, while highlighting the similarities, the reward-learning framework of knowledge acquisition also suggests the critical difference between interest-based engagement and engagement based on extrinsic rewards. Specifically, the framework indicates that interest-based engagement has inherent and unique mechanisms that make the engagement more *sustainable* for a prolonged period of time. The critical fact is that humans always accumulate or update knowledge by learning new things. This knowledge accumulation plays a crucial role in explaining the sustainment of interest-based engagement (Paths A-C in Fig. 1, thus forming an external loop).

First, the acquisition of knowledge motivates people to acquire more knowledge because, with more knowledge, individuals tend to become more aware of further knowledge gaps that they did not notice before. This awareness thus triggers more learning behavior because, the more you learn, the more you become aware that there are many things that you do not know yet (Path A, "generation of new questions").

Second, accumulated knowledge can increase awareness of the importance of a topic because, the more you learn, the more value you can see in the topic you are learning about (Path B, "valuation").[3] Realizing the importance of a topic further enhances the value of new knowledge, as the value of new information varies as a function of how well individuals can connect new information with existing knowledge.

Lastly, the accumulation of knowledge increases individuals' perceived competence because, the more you learn, the more you feel that you have the competence to learn even more about the topic (Path C, "increased capability"). This means that the acquisition of knowledge makes it easy for learners to seek and comprehend newer information.

These three pathways create a positive feedback loop in the knowledge acquisition process, increasingly generating internal rewards over a prolonged period of time. Once the positive feedback loop has been established, people can engage in learning in a sustainable manner (i.e., *self-boosting effect*; Murayama, 2022; Murayama et al., 2019). Research has shown that people with a high level of interest have a strong commitment to learning for a long period of time (Renninger & Hidi, 2015, 2016). The framework can explain this phenomenon on the basis of reward-learning principles. This long-term engagement, often coined as individual interest (Renninger & Hidi, 2015, 2016), can be interpreted as the whole reward-learning process in Fig. 1.

3. Enjoyment of learning as an intrinsic reward

Educational researchers tend to use the term reward to refer only to extrinsic incentives (e.g., food, money; Murayama et al., 2019). However, if a reward is something that strengthens behavior, there is no point in limiting the definition of rewards to extrinsic incentives. For example, positive experiences from the pleasure of engaging in a task, curiosity, or knowledge attainment (Deci & Ryan, 1985; Murayama, 2022) should also influence learning behavior (e.g., if learning a topic brings a person joy, they will be more inclined to learn about the topic

[3] There may also be instances in which enhanced knowledge about a specific topic makes an individual realize that this topic may not be important (for them), which could stop further knowledge acquisition processes.

again), even and should be conceptualized as intrinsic rewards. One important point of the reward-learning framework of knowledge acquisition is that rewards can be conceptualized as positive internal feelings that arise from the learning process or from knowledge acquisition itself (i.e., intrinsic rewards).

Extrinsic rewards (e.g., money) and intrinsic rewards (e.g., enjoyment from learning) are of course different *types* of rewards. But critically, they are, at least in part, based on the same reward-learning *processes*, which strengthen and motivate learning behavior.[4] In fact, neuroscientific research has shown that different types of rewards (extrinsic and intrinsic) are processed in the same brain network, the so-called reward network, particularly in the ventral striatum (e.g., Berns et al., 2001; Campbell-Meiklejohn et al., 2010; Daniel & Pollmann, 2012; Delgado et al., 2005; Han et al., 2010; Knutson & Greer, 2008; McCabe et al., 2013; Murayama et al., 2015; O'Doherty et al., 2001; Tricomi et al., 2006; Valentin & O'Doherty, 2009), suggesting that intrinsic and extrinsic rewards rely on a common reward-learning system (for a more thorough discussion of neuroscientific research on motivation and rewards, see Hidi, 2016; Hidi & Renninger, 2019; Murayama, 2019). In fact, it does not make a lot of sense to assume that humans have different systems for processing intrinsic and extrinsic rewards separately (especially in the downstream of the reward process) because extrinsic and intrinsic rewards are most often intertwined in real-life learning contexts.

For example, say a student really enjoys programming and constantly seeks to expand their knowledge base and learn new skills, in line with the self-boosting effects described above. At the same time, students may learn these skills with the intention to pursue a career in programming and earn a lot of money. Here, knowledge acquisition still serves as an intrinsic reward, but the engagement is also driven in part by extrinsic rewards (e.g., monetary rewards) in the long run.

Whereas the programming example captures the rewards in different time frames, it is also possible for extrinsic and intrinsic rewards to become intermingled in a single session. Consider a student who plays a serious game (i.e., a videogame developed for educational purposes, Deterding et al., 2011) about the history of the Roman Empire (e.g., Viccari et al., 2024). The game helps the student discover existing knowledge gaps (e.g., What were relations like between the Romans and Barbarian tribes?), and the student derives great excitement from the process of acquiring knowledge about the Roman Empire, setting in motion a positive feedback loop of knowledge acquisition. At the same time, not only does completing missions in the game contribute to intrinsically rewarding knowledge acquisition, but it is also coupled with the receipt of extrinsic rewards (e.g., trophies, medals, or badges). From the outside, one may be tempted to conclude that extrinsic rewards drive game play behavior and motivation, when, in fact, it is very difficult to isolate "pure" intrinsic or extrinsic motivation and their interplay with intrinsic and extrinsic rewards (see also Kidd & Hayden, 2015).

In a school setting, grades can even be both intrinsic and extrinsic rewards. Whereas many regard grades as extrinsic rewards, depending on the level of interest in the subject, learners sometimes perceive grades as a way to gauge their own learning progress (see also Renninger & Hidi, 2022), which is a critical source of intrinsic rewards (Ten et al., 2024).[5] In alignment with the discussion, many motivational constructs proposed in the past literature arguably have elements of both intrinsic and extrinsic rewards (see, e.g., attainment value from Expectancy-Value Theory, Eccles & Wigfield, 2020; see also Pekrun's Generalized Expectancy-Value Theory of Motivation, Pekrun, 1993).

Of course, this is not to say that intrinsic and extrinsic rewards are always intertwined as internal experiences. There are cases where these two types of incentives compete with each other when the context clearly distinguishes them (e.g., undermining effect; Deci et al., 1999). We will discuss this point later. But as illustrated above, in real-life contexts, it is often difficult to separate these incentives in people's internal experiences.

4. Beyond the dichotomy: whether rewards have positive effects or not

The discussion of rewards has focused a great deal on the question of whether rewards have positive or negative consequences (e.g., Cameron et al., 2001; Deci & Ryan, 1985; Harackiewicz et al., 1984; Lepper et al., 1973). Here, we argue that researchers should not care about this dichotomy. For instance, whereas most researchers would agree that, in learning contexts, intrinsic rewards (and intrinsic motivation) are inherently positive, the picture is likely more differentiated. For instance, Shin and Grant (2019) compared intrinsic motivation and performance across multiple tasks and showed that employees with the highest maximum intrinsic motivation in one task exhibited lower average and minimum performance across other tasks as well as greater variability in performance across tasks. In a second study, working on a highly intrinsically motivating initial task led to worse performance on a subsequent task if the second task was uninteresting but not if it was interesting (Shin & Grant, 2019). The authors concluded that the intrinsic rewards of working on an extremely interesting task are likely to create contrast effects with respect to other less interesting tasks, thus negatively affecting performance on these other tasks (see also Grant & Schwartz, 2011; "too much of a good thing").

These findings indicate that dichotomies (e.g., extrinsic rewards are bad, intrinsic rewards are good) fall short of capturing the complexities of dynamic (motivated) human behavior. Further, Shin and Grant's (2019) findings take on new meaning when considering principles of the reward-learning framework of knowledge acquisition (Murayama, 2022; Murayama et al., 2019). In fact, a person cannot be interested in everything (see the *selectivity principle* of the reward-learning framework of knowledge acquisition; Murayama, 2022; see also Fastrich et al., 2018; Ozono et al., 2021); and over the course of development, individual differences in intrinsic motivation can underlie idiosyncrasies in educational and career choices and determine individual life paths. More precisely, such individual differences exist with respect to which tasks and activities are subjectively perceived to generate intrinsic rewards (see also Kruglanski et al., 2018), thus allowing for the unfolding of self-boosting effects (Murayama, 2022) and the development of domain-specific competencies and competence beliefs (e.g., Wan et al., 2021). We provided just one example, but the point is that there is a need to move beyond the dichotomy. To do so, we next introduce motivation transformations.

5. Motivation transformations

The dynamics of intrinsic and extrinsic rewards are complex, but the extension of the reward-learning framework of knowledge acquisition discussed herein to account for extrinsic rewards suggests the following possibility (see also, e.g., Renninger & Hidi, 2022): Extrinsic rewards (and the expected value of extrinsic rewards) can be used as an "entry point" for engagement, by helping learners jump-start the positive feedback loop of the internally rewarding process (Murayama, 2022; Murayama et al., 2019). We call this process *motivation transformation*. To make the point clear, we expanded the initial figure to incorporate extrinsic rewards in learning contexts (Fig. 2). Here, we added extrinsic rewards as the consequence of learning behavior. Fig. 2 thus aims to

[4] We mean they are managed in the same system downstream in the process. In fact, if they are processed in completely different systems, organisms have difficulty making decisions when two types of rewards are present (Levy & Glimcher, 2012). In the upstream stages of the process (e.g., visual or sensory processes), however, they can be processed differently.

[5] Awareness is a key factor. We believe it is highly context-dependent; for example, when grades are explicitly highlighted in a learning environment, learners are more likely to become aware of the presence of extrinsic rewards.

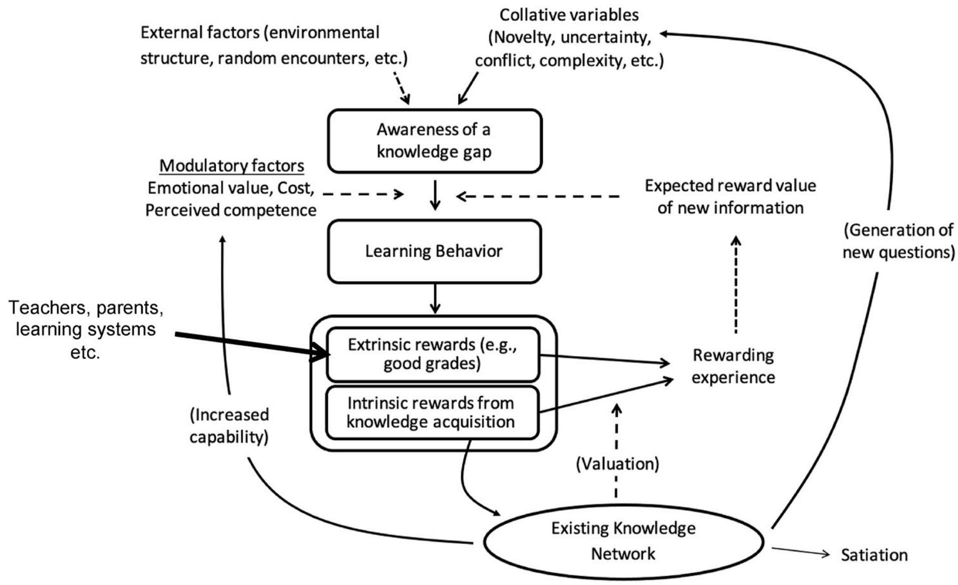

Fig. 2. Extrinsic Rewards as the "Entry Point" That Helps Jump-Start the Process of Intrinsically Rewarding Knowledge Acquisition
Note. Extrinsic rewards are incorporated into the process depicted in Fig. 1. The arrow from the right indicates that extrinsic rewards are exogenously provided (e.g., by teachers, parents, or learning systems). For details on different aspects of the figure not described here (e.g., valuation, increased capability), see the description of Fig. 1.

clarify the integration process of intrinsic and extrinsic rewards.[6]

Critically, this self-boosting effect occurs only when the knowledge-acquisition process has been started up, and learners accumulate a certain amount of knowledge (Murayama, 2022). However, learners (e.g., school students) are not always motivated to learn (Hidi & Harackiewicz, 2000), for example, because they are not interested in a subject or task or because they do not see the value of learning something. This lack of motivation prevents self-boosting recursive loops from being established, as the rewarding process of knowledge acquisition is not even initiated, or, if it is initiated, it is very fragile (i.e., it is easily disrupted and stops) and is thereby not sustainable. The framework supposes that learning serves as an intrinsic reward, but if learners do not start learning, there is no way for them to experience intrinsic rewards.

In such situations, extrinsic rewards can be a useful tool that can get learners to engage in the learning process in the first place (see Fig. 2). Hence, extrinsic rewards initially support learners' motivation to engage in learning behavior (internal loop), and the learning behavior that is initiated helps learners acquire knowledge. As learners develop knowledge—for whatever reason (e.g., just to get stickers)—more opportunities to experience internal rewards from learning arise, and thus, their learning behavior is sustained on the basis of the internal rewards. In other words, extrinsic rewards may function as a way for learners to jump-start the positive feedback loop of knowledge acquisition. In this way, motivation that was initially based on extrinsic rewards in a sense transforms into motivation that is later based on intrinsic rewards (i.e., motivation transformation; Fig. 3).

This idea is still theoretical, and there is not much empirical evidence to support it. To illustrate, however, in a previous study, participants were promised bonuses for the next task they would work on. They inferred that this task would be less pleasant and expected to be less motivated than if they had not been offered a bonus (Woolley & Fishbach, 2021; as cited in Fishbach & Woolley, 2022). Nonetheless, when measuring their experience, it was revealed that those offered a bonus enjoyed the task more, and they connected this feeling of excitement with the task (but see Sheldon et al., 2010, for contrasting findings).

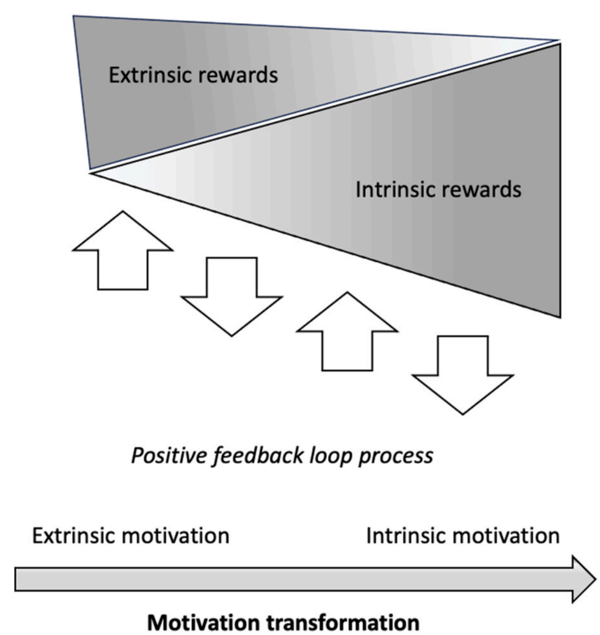

Fig. 3. The motivation transformation process.

Another interesting finding from the study was that people actually seemed to have an awareness of this motivation transformation, but they did not have the right belief about *how* motivation changes (i.e., inaccurate metamotivational belief; see Scholer et al., 2018). In fact, prior to the task, the prospect of receiving a bonus suggested to the participants that the task would not be intrinsically motivating. Hence, people who initiate a (learning) activity because of the prospect of receiving an external reward may underrate the affective and motivational value arising from the knowledge acquisition process initiated by external rewards (see also Hatano et al., 2022; Kuratomi et al., 2023; Murayama et al., 2016).

[6] For interested readers, we also refer to Murayama (2022), where the process of engagement based on extrinsic rewards is illustrated in Fig. 1A.

6. Undermining effect after the motivation transformation

After people establish a positive feedback cycle, extrinsic rewards can still help sustain engagement to some extent (as noted earlier, there is no "pure" intrinsic motivation), but extrinsic rewards can also disrupt the positive feedback loop process if they are too salient. Such a disruption manifests as the undermining effect (Deci, 1975; Deci et al., 1999). "If the reward is one too many—the person is already motivated and does not expect this reward, it might undermine IM [intrinsic motivation]" (Fishbach & Woolley, 2022, p. 345, brackets added). When confronted with explicit extrinsic rewards, people may start reasoning ("Is this why I am engaging in the activity?"), which diverts attention and disrupts the self-reinforcing cycle of knowledge acquisition (see also, e.g., Iten et al., 2018; Kammermann et al., 2024). In other words, when extrinsic rewards are made salient after the positive feedback loop has been established, the relative salience of internal rewards may be diminished. As a result, learners experience smaller rewarding feelings from learning after the extrinsic rewards are removed (in comparison with before the extrinsic rewards were introduced). Similarly, Kruglanski et al. (2018) emphasized that when another goal (e.g., an extrinsic reward) is brought into the realm of an already intrinsically motivated activity, under certain circumstances, the reward can dilute the perceived fusion between an activity and its goal, thus decreasing intrinsic motivation.

The undermining effect can thus be integrated into our account of extrinsic rewards in the context of the reward-learning framework of knowledge acquisition. One important point of divergence from the traditional account of the undermining effect is the scope of time. Specifically, the undermining effect has often been studied as a phenomenon that occurs within a short time frame (e.g., Deci et al., 1999; Esteves-Sorenson & Broce, 2022). By contrast, the reward-learning framework of knowledge acquisition discussed the role of extrinsic rewards in the development of longer-term learning engagement as it unfolds in naturalistic learning settings, highlighting that the effects of extrinsic rewards are not dichotomized (i.e., good or bad) but that the effects depend on the time and context. For some learning activities to ultimately turn into (more) intrinsically rewarding learning experiences, providing extrinsic rewards may be the key to motivating students to become engaged in the first place. For this to happen, extrinsic rewards should not be stopped too early but should not be prolonged. Also, to the extent that extrinsic rewards do not discount the (established) positive rewarding experiences that come from learning, extrinsic rewards can be a good aid for sustaining long-term engagement (see also Renninger & Hidi, 2022), especially when the positive feedback loop cycle gets stuck (e.g., facing a challenge in understanding learning materials). Extrinsic rewards could have complementary or additive effects, depending on the status of students' learning and knowledge.

The argument that extrinsic rewards can be beneficial for unmotivated learners is not entirely new. In fact, ideas relating to "motivation transformations" have been suggested in several theoretical frameworks (e.g., Hidi & Harackiewicz, 2000; Zimmerman, 1985). For instance, the four-phase model of interest development (Hidi & Renninger, 2006) distinguishes between *situational interest*, which captures momentary rewarding experiences that are externally triggered, and *individual interest*, which describes a person's relatively enduring predisposition to reengage with a certain kind of content. Hidi and Renninger (2006) outlined how situational interest can provide a basis for individual interest to emerge. The reward-learning framework of knowledge acquisition explains *how* this interest develops through reward-learning processes.

Similarly, SDT specifies that there is a continuum of extrinsic motivation types that differ in their levels of self-determination. This continuum ranges from *external regulation*, where behaviors are performed to satisfy external demands or to obtain externally imposed reward contingencies, to *integrated regulation*, where the reasons for actions are internalized, even though the behavior is still extrinsically motivated, as it is carried out for its presumed instrumental value (e.g., Ryan & Deci, 2000). Individuals can transition from one type of extrinsic motivation to another. However, one critical assumption of the theory is that even if extrinsic motivation becomes more internalized, it is never transformed into intrinsic motivation. Intrinsic motivation is always considered to be a separate form of motivation that is located on a continuum that is distinct from that of extrinsic motivation (Ryan & Deci, 2000, 2020). In other words, SDT would say that extrinsic motivation cannot be transformed into intrinsic motivation (i.e., motivation from enjoyment). The reward-learning framework of knowledge acquisition takes a different stance. Intrinsic and extrinsic rewards have the same kind of reward processing, which implies that individuals can transform one type of motivation into the other (Murayama, 2022; Murayama, 2019; see also Hidi, 2016; see also *common currency* in reinforcement learning models, Montague & Berns, 2002; Niv & Schoenbaum, 2008).

7. Critical (transmitting) factors

We have made a case for the potential utility of extrinsic rewards to facilitate motivation: Extrinsic rewards can be used as an entry point for getting people engaged in learning. Of course, however, the dynamics we laid out for intrinsic and extrinsic rewards are very simplistic. Reality is always more complicated, and various factors are in operation in learning contexts. Here, we discuss factors that may transmit motivation transformation processes and that should be empirically tested in future work using the reward-learning framework of knowledge acquisition to better understand the potential utility of extrinsic rewards and motivation transformations.

First, whether the acquisition of knowledge creates more knowledge gaps (i.e., one prerequisite for establishing the positive feedback loop) depends on aspects such as the nature of the task, the knowledge acquired, and the structure of learner's prior knowledge (Prenzel, 1992; Renninger & Hidi, 2022).[7] For example, short, self-contained trivia questions might not spark further interest in exploring the topic (Murayama, 2022). The same likely applies to a task such as finding the way to a train station. In these cases, learners acquire a simple answer, and there is little room for the knowledge to be developed further. However, when learners have strong prior knowledge about the question (e.g., the learner happened to know the topic of the trivia question very well) or have the intention (goal or reason) to gather further knowledge (e.g., the person just started living in the city and looked for a train station to learn about the city), the situation is likely to be different. The role of knowledge or the task structure and the development of curiosity are important points for future inquiry. In addition, there are large interindividual differences in which topics (and how many) spark a person's curiosity about knowledge acquisition, which would be interesting to explore.

Second, effort should be considered. While learning often occurs automatically with daily practice (e.g., learning one's native language), in many formal learning situations, knowledge acquisition is effortful and costly, and so is establishing the self-boosting feedback loop inherent in the reward-learning framework. In the literature, effort has often been considered something aversive that people tend to avoid (e.g., Kool & Bootvinik, 2018; Shenhav et al., 2017). However, more and more studies have suggested that the inherent value of effort can be increased through reinforcement. For example, rewarding participants for exerting cognitive effort increased their motivation to engage in effortful tasks without any prospects of gaining additional extrinsic rewards (Clay et al., 2022). Moreover, because effort is likely to lead to better outcomes, effort can turn into a secondary reinforcer and become

[7] Further boundary conditions exist, as the likelihood of these processes also depends, for example, on aspects of the context (e.g., in a threatening environment in which learning is performed due to external pressure, learning is likely stopped once there is no longer any threat of punishment).

increasingly intrinsically rewarding (see also *learned industriousness*; Eisenberger, 1992).

We thus argue that extrinsic rewards can "train" effortful mental engagement so that it becomes natural—and rewarding in and of itself—to exert mental effort (Clay et al., 2022; Lin et al., 2023). There is indeed evidence that effortful tasks activate the reward network in the brain (Boehler et al., 2011; Sakaki et al., 2023; Ulrich et al., 2014). This activation, in turn, helps to start up the self-boosting effect of knowledge acquisition. Relatedly, in education, there is a long-standing recommendation that students should be rewarded for their efforts and not their abilities or achievements (e.g., Mueller & Dweck, 1998; Zentall & Morris, 2012). Interestingly, it has also been proposed that environmental uncertainty can create challenging situations that prompt information seeking and increased effort, a phenomenon that may have its roots in nonhuman animals and could serve as a foundation for the development of intrinsic motivation (see Anselme & Hidi, 2024).

These effort-based features also figure prominently in game contexts, in which continual efforts are rewarded (e.g., Granic et al., 2014). Further, it is possible to think about daily life examples that support the proposed "effort transmission" within motivation transformation processes. For instance, changing habits (e.g., working out regularly vs. staying on the sofa) requires effort. Extrinsic rewards may be useful in the beginning; for example, it may help you get started with a new fitness program if you are rewarded (or you reward yourself) with a nice pair of new running shoes or a new shirt after sticking to the fitness program for 1 week. However, over time, you may start to enjoy your workouts and to exert yourself (see also, e.g., "runners' high"), and your need for extrinsic rewards may diminish or even disappear. In fact, Acland and Levy (2015) found that offering incentives for exercising increased exercise behavior even after the incentives were removed.

Third, motivation transformation may be better achieved by integrating elements from the means-end fusion theory of intrinsic motivation (Kruglanski et al., 2018; Kruglanski, 2000; see also Fishbach & Woolley, 2022). Means-end fusion theory presumes that the greater the perceived association (fusion) between an activity and its end, the more the activity is experienced as intrinsically motivated (Kruglanski et al., 2018). According to means-end fusion theory, extrinsic rewards can enhance the total value attached to the activity. This added value then "trickles down" or transfers to the activity, thus boosting its interest value or appeal (Fishbach et al., 2004; Kruglanski et al., 2018; for a computational approach, see Melnikoff et al., 2022). The same applies to the use of gamification, when learning content is wrapped up in game elements that are enjoyable and offer added value that can be carried over to the learning activity (e.g., Birk et al., 2016).

Similarly, it has been discussed that extrinsic rewards can add meaning to an activity, and this meaning is related to the development of intrinsic motivation (see also Sansone & Smith, 2000). The reward-learning framework of knowledge acquisition also refers to values or valuation: Accumulated knowledge makes individuals realize the importance of a topic, which further increases the reward value of new knowledge (Murayama, 2022; see also Hidi & Renninger, 2006). Hence, extrinsic rewards may lead people to value a learning activity more; and acquiring knowledge while engaging in the activity (initially, because external rewards were provided) becomes intrinsically rewarding, resulting in a "double valuation" that underlies motivation transformation. Future research in which experience sampling is applied within and across learning situations could explore how learners come to value or devalue specific learning activities by testing influences of extrinsic rewards on developmental trends and dynamic shifts in self-reported valuation.

Fourth, social aspects should also be considered. In many learning situations in which extrinsic rewards play a role, significant others (e.g., teacher or parents) who provide or promise rewards are involved too. Social factors, including interactions and relationships with teachers and parents, can be powerful sources of academic motivation (Bardach et al., 2020; Burgess et al., 2018; Ojanen et al., 2010). Games also include social elements, and it has been suggested that, in digital learning environments (e.g., videogames), learners can develop strong attachments to virtual avatars or other game characters. Furthermore, collaborative gaming technologies can help motivate students in educational gaming contexts (e.g., Granic et al., 2014; Szolin et al., 2023).

Accordingly, when motivation transformations are referred to as "the way people can transform one type of motivation into another" (Murayama, 2019, p. 141), taking social factors into consideration can lead to an expansion of this description so that it becomes "the way others help us transform one type of motivation into another", whereby the involvement of others serves as an additional rewarding factor. This involvement could take various forms, such as interest contagion (e.g., Burgess et al., 2018), value transmissions (e.g., Kurdi et al., 2022; Parrisius et al., 2020), challenge contagion (e.g., Ogulmus et al., 2024), and modeling effects (e.g., Bandura, 1977). For instance, if others deem a learning activity relevant (as signaled by the reward they provide to the learner), initially uninterested learners may engage in the activity (because they want to get the reward *and* because they infer that the activity is perceived as important by other people they care about). The engagement with the activity then sets in motion the self-boosting cycle of knowledge acquisition.

It would be interesting to empirically test this assumption in real-life learning contexts, for example, by combining self-reports of motivation with information about social relations (e.g., social network data) to understand when, how, and for whom social closeness to the provider of extrinsic rewards facilitates motivation transformations. Relatedly, future studies could experimentally manipulate whether another person assigns extrinsic rewards to learners, whether learners assign these rewards to themselves, or whether extrinsic rewards are externally provided, but without the involvement of another person. Such a set-up allows researchers to study the role of social factors for motivation transformations and to examine potentially differentiated effects of different assignment scenarios for different periods of motivation transformation processes. For instance, whereas unmotivated learners may initially be particularly likely to benefit from the involvement of others in the reward provision process, rewards provided by others may also be perceived as more controlling than self-assigned rewards, especially at later stages of successful motivation transformations (but see Hidi, 2016, for a critique of the notion that extrinsic rewards are controlling).

Finally, extrinsic rewards can increase the likelihood that individuals will try to self-regulate their interest, that is, they will purposely attempt to make an uninteresting activity more interesting (Sansone & Smith, 2000; Sansone & Thoman, 2005). Such interest-enhancing strategies can involve, for example, making studying more enjoyable by turning it into a game or focusing on the fun aspects of a task (e.g., Wolters & Benzon, 2013). Over time, the use of interest-enhancing strategies (and not extrinsic factors) enhances persistence with and the resumption of activities (see Sansone & Thoman, 2005; Wolters, 2003; Wolters & Benzon, 2013; Yun & Park, 2020). This perspective is interesting, as it highlights the active role of the learner, acknowledges that intrinsic motivation can be part of the process of pursuing extrinsic rewards, and understands motivation transformation as embedded in a self-regulatory system in which extrinsic and intrinsic parts work sequentially over time (Sansone et al., 1992; Sansone & Smith, 2000).

On a related note, many games are designed in an interest-enhancing way, which underlies their effects on motivation and engagement. However, here, the interest-enhancement stems, to a large part, from the game itself instead of being self-initiated by the learner (as in Sansone's interest-enhancing self-regulation strategies). In addition to diary studies that allow researchers to examine learners' spontaneous use of interest-enhancing self-regulation strategies following extrinsic rewards, experimental tests of the effects of different isolated strategies in game and nongame contexts could offer important insights.

8. Limitations and future research directions

Of course, the reward-learning framework of knowledge acquisition is a general framework, rather than a theory that makes precise predictions, and empirical studies of the herein discussed factors transmitting motivation transformations in the context of the reward-learning framework of knowledge acquisition are currently lacking. Thus, there are clear practical limitations.

For example, whereas answering the question "When should we start providing extrinsic rewards?" seems more straightforward (e.g., "provide rewards to children who are initially not motivated to learn"), it is more challenging to find an answer to the question "When should we stop providing extrinsic rewards?" One reason is that the latter question may hinge strongly on a better understanding of motivation transformation processes and learning contexts. For instance, is it possible to identify a clear end point in that, from this point on, extrinsic rewards exert negative effects on intrinsic motivation because motivation transformation has been "successfully completed"? Or is there a transition period in which positive extrinsic reward effects fade out and then slowly start unfolding negative effects? How do these scenarios vary within and between individuals and motivation transformation processes? Further, does motivation transformation necessarily have to come to an end, or can there be ongoing and mutually reinforcing motivation transformations? Specifically, are there situations in which extrinsic and intrinsic (knowledge-acquisition-related) rewards can be coupled over extended periods of time, even when initially unmotivated students have already become motivated?

The framework does not offer a definite answer to these questions. However, gamification may provide such a context in which intrinsic and extrinsic rewards can co-occur over extended periods of time, as here, extrinsic rewards (e.g., points, medals) and intrinsically rewarding knowledge acquisition processes that derive from game play (e.g., enjoying acquiring knowledge about the Romans in a history videogame) are often intricately interwoven within the game (e.g., receiving points and medals for completing a mission that provided opportunities to expand one's knowledge).

Further, motivation transformations are not one-dimensional and do not operate solely within one activity. Consider the example of a videogame on Barbarian tribes in the Roman Empire developed for history classes, as it provides rewards for completing missions *and* it sparks students' interest. Consequently, students may start reading about the Roman Empire in their free time when no rewards are provided, while they may also continue to play the game and reap the game's rewards without harming their motivation. This example raises the possibility of motivation transformation generalization effects.

Another layer of complexity is related to individual differences. Motivation transformation is very likely to be subjected to many individual difference factors. For example, in the first year at university when students find themselves in a new place surrounded by people they do not know yet, social processes may be more effective motivation transformation mechanisms than later in a student's academic career. And some individuals do, in general, gain more from social interactions than others, thus making it more likely that, in general, social factors provide a more useful motivation transformation resource for them.

Moreover, differences in prior learning experiences and interests and trait- and state-level differences in curiosity, reward sensitivity, and mental health (and their dynamic interactions) can come into play, among many other factors. Blain et al. (2023) recently found that affective aspects of mental health were associated with sensitivity to intrinsic but not extrinsic (monetary) rewards. They also showed that the sensitivity to intrinsic rewards was domain-general, and they concluded that individuals with high reward sensitivity will engage in a variety of intrinsically rewarding activities. Eventually, they will find those they excel at, whereas low sensitivity individuals will not (Blain et al., 2023). Expanding on this point, some individuals may find it easier to engage in or may be more susceptible to (certain) motivation transformations. Some individuals may even actively seek out situations that provide opportunities for motivation transformations (i.e., self-regulated motivation transformations), a situation that will serve as a training bed for internally rewarding knowledge acquisition and will boost learning, motivation, and domain-specific performance across the life span. We hope that future research will adopt designs and statistical methods that can capture motivation transformations at high levels of temporal granularity, ideally across contexts, and that allow peak reward effects to be estimated (e.g., Hecht and Zitzmann, 2020, 2021). We additionally envision computational approaches that can formalize motivation transformation mechanisms.

9. Potential practical implications

By itself, a theoretical framework, as presented in the current article, is not sufficient to allow researchers to confidently derive strong practical recommendations. Robust empirical evidence is needed before concrete recommendations on motivation transformations can be derived. Keeping this current limitation in mind, we nevertheless discuss potential practical implications that can be further expanded and refined later, pending the availability of the respective empirical evidence.

The links between extrinsic rewards and motivation are presumably dynamic and situationally sensitive. (They are likely also developmentally sensitive to some extent, even though developmental differences were not the focus of our work.) We thus propose that personalized reward provision systems that consider the roles of different types of rewards for different tasks and different students in different moments of the knowledge acquisition process may hold promise. Although personalization does not depend on the use of technology, many technological solutions that could aid in personalizing reward provision are currently available for personalized learning (Bernacki et al., 2021; Dumont & Ready, 2023; Spitzer et al., 2024). These technologies include new developments around hybrid human-artificial intelligence (AI) learning technologies with a combined responsibility between the system and the teacher (Molenaar, 2022). Despite the potential that technology holds, the involvement of "real" teachers with rich pedagogical knowledge, high levels of diagnostic competence, and close and trustful relationships with their students (see also Bardach et al., 2024) are likely the keys for initiating motivation transformations, as technologies alone may fall short of recognizing the complexities of these processes. Moreover, to assess students' motivational changes in motivation transformations, self-reports are still indispensable for gaining insights into learners' mental states (e.g., Pekrun, 2020). However, self-reports could be complemented by behavioral motivational traces that can be unobtrusively collected (e.g., from log files, eye tracking) and automatically scored and fed back to teachers using AI.

Also, in gaming contexts, state-based personalization, which considers patterns in players' motivation over time and can involve game-based rewards, has been discussed as a promising route for engaging learners (e.g., Birk et al., 2016; Dumas Reyssier et al., 2023) that needs further investigation. Overall, before any practical implementation, we need to gain clarity on how to tailor rewards to learners' motivational states and the stages of the internally rewarding knowledge acquisition process. Such tailoring will require a change in thinking but also in research approaches so that they better reflect real-life complexities and the dynamic nature of rewards and motivation ("right award at the right time").

10. Conclusions

Should teachers and parents worry about rewarding children for learning? Do extrinsic rewards in educational videogames harm intrinsic motivation? Here, we have argued that instead of continuing the search for a definite answer (extrinsic rewards are beneficial vs. harmful for intrinsic motivation), it would be much more advantageous to move beyond this dichotomy, in both real-world learning and virtual (e.g., gaming) contexts. Specifically, as highlighted in the extension of the reward-learning model of knowledge acquisition discussed in this article (Murayama, 2022; Murayama et al., 2019; see also Murayama & Jach, 2024), rewards need to be conceptualized in terms of both extrinsic and intrinsic incentives, and their effects can be intertwined and are more complex than often assumed. Our proposal is that extrinsic rewards can be useful for initiating the internally rewarding process of knowledge acquisition in an early stage. At the same time, salient extrinsic rewards may actually harm motivation when learners have already established the positive rewarding cycle of knowledge acquisition.

To conclude, albeit the question of how extrinsic rewards affect intrinsic motivation has long been debated, we think that it is an auspicious time to conduct research on rewards and motivation, particularly on motivation transformations. Historically, the motivational role of extrinsic rewards has been downplayed due to the undermining effect. This may be true, but when extrinsic rewards are used in an appropriate manner, they can enhance intrinsic motivation. Future research should thus examine the motivation transformation effect more systematically. Stated differently, giving children gold stars and stickers and letting them play educational videogames that offer extrinsic rewards is not "good" or "bad." Extrinsic rewards have their place in the intrinsic motivation space. Let us now continue to figure out how and move beyond dichotomies.

CRediT authorship contribution statement

Lisa Bardach: Writing – review & editing, Writing – original draft, Visualization, Conceptualization. **Kou Murayama:** Writing – review & editing, Writing – original draft, Visualization, Conceptualization.

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Lisa Bardach's research focuses on the role of individual differences (e.g., motivation, personality, self-regulation, cognitive abilities) and their interplay in learning contexts. She is also interested in how schools approach cultural diversity and in social inequities. Further, she conducts research on digital learning.

Kou Murayama's research focuses on a number of overlapping questions about how motivation works in human functioning. One of the central themes of his recent work is to understand how humans are autonomously motivated to seek and gain knowledge (motivational state often called "interest" or "intrinsic motivation") and how we can apply this idea to educational settings.