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On clickbaits and evolution: curiosity from urge and interest

Ohad Dan[1], Maya Leshkowitz[1] and Ran R Hassin[2]

Recent years have witnessed a multi-disciplinary surge in the scientific study of curiosity that is characterized by a deep schism. Gap theories conceptualize curiosity as a pressing drive that needs to be satiated, much like hunger or thirst. On the other hand stand theories that conceptualize curiosity as a central component of long-term learning and maximization of reward. Both approaches treat curiosity as unidimensional and tend to neglect its temporal dynamics. The new model proposed here conceptualizes curiosity as a bi-dimensional psychological phenomenon, where one factor is the urge to approach information, and the other is an evaluation of how interesting it might be. These factors define a space, in which one can locate different states, people, and species. Crucial to the model is the postulation that the factors are characterized by different temporal dynamics, that create interesting challenges to rational behavior. The model allows us to cross the schism and account for the two basic approaches to curiosity under the same roof.

Addresses
[1] Department of Cognitive Sciences and The Federmann Center for the Study of Rationality, The Hebrew University of Jerusalem, Jerusalem, Israel
[2] James Marshall Chair of Psychology, The Department of Psychology and The Federmann Center for the Study of Rationality, The Hebrew University of Jerusalem, Jerusalem, Israel

Corresponding author: Hassin, Ran R (ran.hassin@huji.ac.il)

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How do un-played episodes of thought-provoking podcasts relate to finding out what happens in the YouTube video *Everyone LAUGHED AT HIM but You Won't Believe What Happens Next*? And what do the unread books on our shelves have to do with figuring out how is Lady Gaga doing these days? On the face of it, each of these examples contrasts behaviors that have little to do with each other. The new theory of curiosity we develop here, however, suggests that these behaviors naturally emerge from the factors that shape our curiosity and from their temporal dynamics. Curiosity, the theory predicts, may lead to systematic breaches of rationality, that are more prevalent today than they have ever been in the history of humans. The theory also suggests that we can be curious about topics we find quite boring, and that we can lack curiosity towards issues we find interesting. Confused? We hope you won't be when you are done reading this short paper.

In one of the most dramatic revolutions in the history of our species, the knowledge we gathered throughout history is, quite literally, at the tip of our fingers [1]. If the volume of information consumption stayed constant, this dramatic shift in the availability of knowledge would have merely increased convenience. Yet, as our excessive use of smart devices shows [2,3], it did not. Recent evidence suggests that we search, check our inboxes [4], prey social media [5], read Wikipedia [6,7], and consume information, practically all the time [8]. As a result, epistemic curiosity, the drive to find out information, has gained unprecedented presence and importance in our lives.

Following Berlyne's seminal work [9,10], curiosity has received much scientific attention in the psychological [11], educational [12••] and, more recently, neuroscientific literatures [13,14]. It became clear that in some contexts, curiosity leads to dangerous and reckless behaviors [15–17]. In others, it is associated with negative feelings (e.g. Refs. [18–20]). Yet, by and large, curiosity is considered a desired feeling that should be cultivated. Indeed, trait curiosity is associated with life satisfaction, happiness and improved problem solving [21,22], professional [23,24] and academic success [25,26], and with higher levels of creativity [23,27–29].

Recent years have witnessed a multi-disciplinary surge in the scientific study of curiosity, that is beautifully reflected in the scope and breadth of contributions to this special issue. These exciting developments are characterized by a deep schism. Gap theories [30••,31•,32••,33] conceptualize curiosity as a pressing drive that needs to be satiated, much like hunger or thirst. Accordingly, much of the literature in this tradition uses the itch to know answers to trivia questions as its basic tool. As Marvin *et al.* [34] argue, this type of curiosity bears family resemblance to impulsivity, in that it assumes a need to know in the *here and now*. Clickbaits (*You Won't Believe What Happens Next*) operate on this kind of curiosity.

On the other hand of the schism stand theories that focus on curiosity's role in enhancing learning and maximizing

rewards. Curiosity in these frameworks emerges from a (quasi) rational process, that allows efficient epistemic exploration [11,12••,35••,36]. It contributes to growth and adaptation of organisms by steering knowledge acquisition processes towards information that helps short-term, long-term and longer-term goals [32••,37].

Interestingly, although these views are very different from each other, they hold (explicitly or implicitly) the view that curiosity is a uni-dimensional phenomenon. This assumption means that knowing one's 'location' on the dimension's axis is tantamount to knowing one's curiosity. Similarly, knowing this 'location' also allows scientists to predict the effects of curiosity on behavior.

In the new model we develop here we propose, in contrast, that curiosity is a bi-dimensional psychological phenomenon. The first factor, the *urge to approach* information, is 'hot' [38]. The second factor — an *evaluation* of how interesting the information might be, is 'cold'. These factors allow us to model, under the same conceptual roof, the two basic approaches to curiosity sketched above. They also define a space, in which one can locate different curiosity states, people and species. Crucial to the model is the postulation that the factors are characterized by different temporal dynamics. Urge tends to rise and decline relatively fast, whereas interest is much slower to change. These dynamics create interesting challenges to rational behavior.

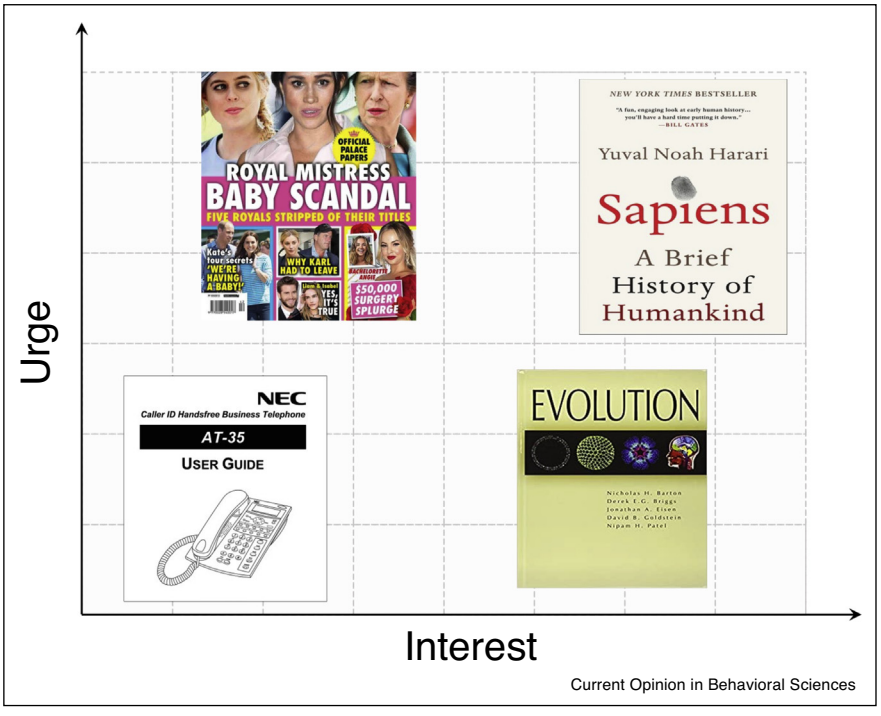
In the following sections we introduce the model, relate it to existing literatures and derive novel predictions. We end by discussing the implications of our theory to individual differences, context effects, and the ontogenesis and phylogenesis of curiosity.

The two dimensions of curiosity

Curiosity from **UR**ge and **I**nterest (*CURI*) is a parametric model, in which two continuous factors determine how curious we become when we realize that we can learn a unit of information, K, in a certain context and framing. Conceptually the dimensions are orthogonal, and they define a two-dimensional curiosity space (see Figure 1).

The first factor is the urge to approach K. Urge is best described as 'hot' [38], motivational, and emotional. It follows the dynamics of 'hot' systems, that is – it tends to rise and decline quickly. Urges may arise from various motivations that include anxiety reduction (e.g. deprivation-type curiosity [39]), and enjoyment (e.g.

Figure 1



An illustration of the 2-dimensional curiosity space.
CURI proposes that curiosity has two dimensions, Interest and Urge. Here we illustrate the dimensions with intuitive, daily examples (that cannot and should not work for everyone). Gossipy tabloids articles may be characterized by high Urge but low Interest; a lengthy science book (on, e.g. evolution) may stimulate a lot of Interest but little Urge. Popular scholarly books may elicit both Interest and Urge. User manuals for landline phone may stimulate little Urge and little Interest.

Refs. [11,18,20,39]). Other factors that give rise to urges include potential threat, arousal, basic and social needs such as sex, affiliating and belonging, as well as short and long-term goals [37]. Urges are especially quick to decline once the motivational hunger is satisfied (e.g. Ref. [40]), or when K, or the motivation to find out what K is, are no longer in the focus of conscious attention (e.g. due to distraction).

The second factor, Interest, is 'cool,' cognitive and more abstract, and it reflects an evaluation of the potential contribution of K to one's knowledge regarding one or more of her epistemic concerns. Importantly, contribution is measured in subjective psychological units, not in bits (e.g. Ref. [41]). The larger the potential contribution and the more central the epistemic concern, the larger the interest in K. Like other 'cold' phenomena, interest's temporal dynamics are relatively slow, and they mainly reflect one's progress in- and shifting-of areas of epistemic concern (broadly defined). For short durations (specifically, those that characterize most psychological experiments) one can assume that interest is fixed.

A terminological point is in order here. The terms *interest and urge* are loaded with multiple meanings for multiple audiences. This is unfortunate, yet inevitable. We therefore chose to capitalize them — Interest and Urge — to highlight the technical nature of their use here.

Inherent to CURI is the postulation that curiosity is a prioritizing tool, allowing organisms to prioritize attention, motivation, thought and behavior [42•]. Epistemic curiosity drives animals to learn their environments (be it physical, social, or cultural); adapt to changes, and prepare for the future. In humans, it is also the engine behind the sciences and the arts [43,44]. Given these functions, combining a hot, short-term and relatively short-sighted determinant, with a cold, longer-term, broad determinant, offers an efficient and flexible prioritizing mechanism. It allows prioritizing in the here-and-now, while taking the past and future into account.

Eq. (1) describes the relationships between Urge, Interset, and Curiosity, as well as the temporal dynamics of curiosity:

$$C(t) = I + \pi * e^{-\lambda t} \quad (1)$$

where C(t) is curiosity at time t after learning about the opportunity to find out K, I is the Interest associated with K, π denotes the Urge induced by K, and λ is the rate of Urge decay ($I, \pi, \lambda \geq 0$). Illustration of various temporal dynamics of Urge, Interest and curiosity are depicted in Figure 2.

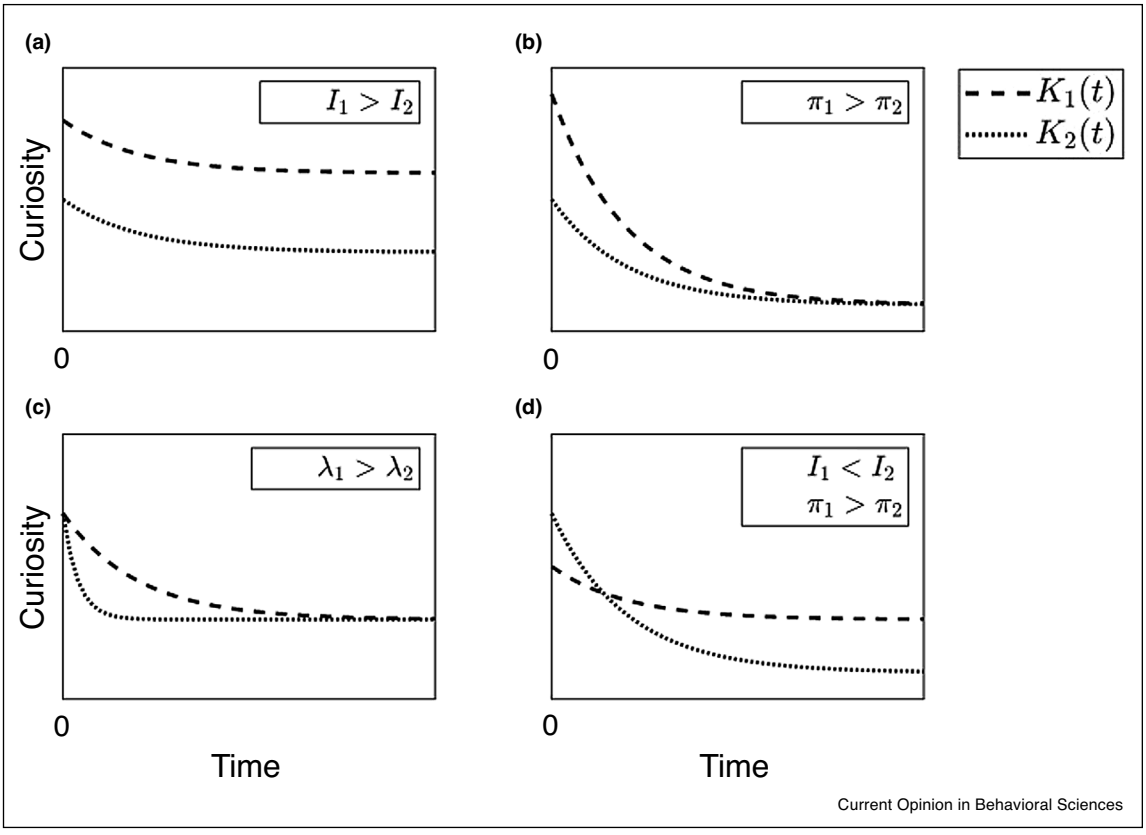
Implications and predictions

When Interest and Urge go hand in hand, all is well. We passionately pursue information on topics we find interesting. The troubles begin when they do not, giving rise to two major types of discrepancies. One, when we feel an urge to find out information about a topic characterized by relatively low interest (it may even be utterly boring). Two, when the Interest associated with a topic is relatively high, yet we do not feel an urge to engage with it. The scholarly books in our Kindles, that we buy yet never get to read, may provide evidence for the latter. Our insight into the whereabouts and deeds of various famous athletes is a strong testimony of the former (at least for the authors, who confess to having no interest in sports or athletes whatsoever).

Yet, when Interest and Urge diverge, peculiarities may arise. Interestingly, the model predicts systematic choice reversals over time (Figure 2d). To see why this is the case, consider two topics, X and Y, each has its own coefficient values of Urge (π^X, π^Y) and Interest (I^X, I^Y). Assume that $\pi^X < \pi^Y$ and $I^X > I^Y$. For illustration purposes, consider X as a new discovery about the ontogeny of theory of mind, where Y is the reason that drove the royal couple Harry and Meghan to leave their royal lives behind (or: You won't believe how THIS led Harry and Meghan to leave the palace). Suppose we were to offer you to read about one of the above – which topic would you choose? We suspect that for some readers of this paper, the former topic is Interesting but is not accompanied by strong Urge (i.e. high I and low π), while the latter topic is of little Interest, yet it stimulates some Urge (i.e. low I and high π). A short time after the presentation of the choice, before Urge declines, curiosity may be higher for Y than for of X ($C^Y_{t=0} > C^X_{t=0}$). As a result, one might be more likely to choose to see the information regarding the British royals. But consider, instead, that one is asked to take time before making a decision. By then Urge may have subsided considerably. When $I^X > I^Y$, and given enough time (T) for decay, one is more likely to choose to read about the new discovery of theory of mind ($C_{t=T^Y} < C_{t=T^X}$). Generally, quick decisions for the here-and-now tend to be more Urge based (finding out about the royals) than slow and distant decisions. Such preference-reversal is irrational and may lead us to use one of the most valuable resource at our disposal, time, on information that is of little interest to us.

We have recently tested this prediction [45]. In one study subjects were presented with pairs of questions, and were asked to choose one question to which they will see the answer. In one condition, participants were told that they will get the answers immediately. In another, a week later. Some questions were pretested to be higher on Urge and low on Interest (e.g. "What is the color of the white house toilet paper?"); others were high on Interest yet low on Urge (e.g. "How feasible would it be to

Figure 2



The CURI model.
Each line in each panel describes the temporal dynamics of curiosity towards items K_1 (dashed line) and K_2 (dotted line). The items are characterized by the model's three parameters: I (Interest), π (Urge), and λ (Urge decay rate). In each panel, K_1 and K_2 have the same values for parameters that are not indicated in the legend, for example, in panel (a) the items differ in their I value (as indicated in the legend) but share π and λ values. **(a) Different Interest**, $I_1 > I_2$. Curiosity to both items decay at the same rate and at any point in time, curiosity towards K_1 is greater than towards K_2. **(b) Different Urge**, $\pi_1 > \pi_2$. Curiosity to both items decay at the same rate, however since K_1 is associated with greater Urge it arouses more curiosity at time 0. After enough time has passed, curiosity to K_1 and K_2 is only determined by their Interests, which here are identical. **(c) Different decay rate**, $\lambda_1 < \lambda_2$. Though they begin and end with the same curiosity, K_2' s Urge decays faster and so it will arouse more curiosity throughout the process. **(d) Preference reversal**, $I_1 > I_2, \pi_1 < \pi_2$. Because of the relatively high Urge of K_2 at time 0, curiosity towards it is higher. As time passes, Urge of both K_1 and K_2 decays. Then, since K_1 is characterized by a higher Interest, curiosity towards it becomes higher than towards K_2.

colonize Antarctica?"). Consistent with CURI, a between-condition comparison revealed preference reversal: people prefer to read the answers to high Urge questions now, but they prefer to see answers to high Interest questions later.

Two additional implications are worth mentioning. First, CURI postulates that Interest and Urge give rise to a rather unified feeling of curiosity, a feeling that we use as input for decisions. This means that, by and large, people will intuitively tend to confuse Interest, Urge, and Curiosity. Second, CURI assumes that the values of Urge and Interest are context and frame-dependent [41]. Thus, contexts and frames that highlight, nurture, and enhance urges (e.g. stress or intoxication) will lead to more urge-based curiosity, while those that are cooler, cognitive, and abstract (e.g. libraries, universities, workplaces) will tend to veer us towards Interest-based curiosity.

Going beyond computed curiosity

So far, the parameters of the model were K-specific (i.e. characterizing curiosity towards K), but it is conceivable that the same framework may be used to characterize individuals. For example, people whose average Interest is greater than that of others, are more likely to learn about a variety of topics they find interesting (but see the discussion on variance below). Those who have stronger Urges are more likely to learn many details about topics they generally find less interesting. They are also more

likely to be distracted by clickbaits, emails, and other less-interesting but rather urge-arousing information. Similarly, average differences in λ will distinguish between people whose Urges decay quickly and those for whom epistemic Urges tend to be more long lasting (see Ref. [34]).

Another interesting set of implications emerges from the potential role of context in determining the value of the model parameters. Lower variance between contexts means more consistent behavior across situations, whereas larger variance characterizes people who are more strongly affected by factors outside of the model (e.g. social surrounding). Following the groundbreaking work of Mischel [46,47], it seems likely that many of the interesting differences between people lie not in their averages, but rather in their context-trait interaction.

Taking the model one step further, one may be able to use it to characterize different stages of human life and different species of animals. It seems reasonable to assume a positive correlation between an animal's cognitive complexity on the one hand, and its non hard-wired Interest on the other. If this is indeed the case, then CURI predicts that the less developed the cognitive system, the more salient a role will Urge play in the determination of curiosity. Since Urge tends to ascend and descend rather quickly, organisms whose curiosity is largely determined by Urge are likely to experience short bouts of curiousity. These organisms, are less likely to develop long term plans, arts and sciences.

To place our model in a broader context, we draw the reader's attention to the family resemblance between CURI and a host of approaches from across the cognitive sciences. These include Metcalfe and Mischel's hot and cool systems for self-regulation [38], Kent Berridge's liking versus wanting [48], delayed discounting (specifically time-inconsistent models, such as hyperbolic discounting [49,50]), and classical social-cognitive models that view attitudes as comprising of both affective and cognitive components [51]. There are also notable similarities to dimensional models of emotion [52]. Thinking about curiosity not in isolation, but rather in the wider context of these models, may shed new light on the nature of curiosity, pave new ways for its investigation, and better situate it within related cognitive processes.

An afterthought: back to clickbaits

To come a full circle, consider the example with which we opened the paper. What really happened next to the individual in *Everyone LAUGHED AT HIM but You Won't Believe What Happens Next*? Some of you may have been curious and already found out. Others didn't. But as of 8/2020, twenty million viewers have. Even assuming that only 50% of them actually saw the video, humanity invested 500,000 hours, or over 62,500 full days of work in it. These numbers illustrate a simple point: clickbait economy is worth billions of dollars because it leads us to give companies our most valuable resource – time (see Ref. [53]). CURI suggests that clickbait economy works partly because curiosity is bi-dimensional, and (con)fuses Interest and Urge. This understanding may also pave the way for dealing with epistemic urges.

Our environment is information-rich in ways it has never been before. This abundance gives epistemic curiosity an unprecedented role in our lives. This historic development offers many opportunities for meaningful growth – for individuals and societies alike. Understanding the underlying factors of curiosity will not only advance our science, it will allow us to better navigate our way in this new, fascinating and challenging world.

Conflict of interest statement

Nothing declared.

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