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# 1118

**Towards an Incentive Saliency Model of  
Intertemporal Choice**

**by**

**Leonhard K. Lades**

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# Towards an Incentive Salience Model of Intertemporal Choice\*

Leonhard K. Lades<sup>†</sup>

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## Abstract

This theoretical paper presents an incentive salience model of intertemporal choice. The model is a variation of the quasi-hyperbolic discounting model. Based on the distinction between ‘wanting’ and ‘liking’, the paper presents one possible explanation of impulsive choices of smaller sooner rewards instead of larger later ones. These impulsive choices are induced by cues that trigger strong motivational ‘wanting’ to obtain smaller sooner rewards, but do not necessarily influence the degree to which the rewards are ‘liked’. Cue-triggered ‘wanting’ can occur when an individual is in a specific need deprivation state, perceives a cue previously associated with an immediately obtainable reward, knows that the cued reward can reduce the current deprivation state, and lacks self-control. By integrating cue-triggered ‘wanting’ into an intertemporal choice model, the incentive salience model allows to predict which rewards elicit impulsive choices of smaller sooner rewards, thus offering an explanation for the domain effect.

Keywords: Intertemporal Consumer Choice; Impulsivity; ‘Wanting’ versus ‘Liking’

JEL classification: B52; D03; D11; D91

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## 1 Introduction

Individuals oftentimes have to choose between obtaining either smaller sooner rewards or larger later ones. Such intertemporal decisions include the trade-offs between small immediate pleasures of smoking or feasting and larger future benefits of good health. Also purchases of not necessarily needed consumption goods provide immediate benefits but might cause financial problems at the end of the month. Oftentimes, these intertemporal decisions are characterized by dynamic inconsistencies: While individuals plan to abstain from smoking, feasting, or consuming goods at the beginning of the month, these plans are often thwarted by urges to smoke, eat, or consume. As a monetary example of a dynamic inconsistency, suppose that some individuals have the opportunity to obtain either €10 today or €11 next week. Suppose furthermore that some of these individuals decide to take the €10 today, because they do not want to wait a week for the extra euro. However, when the same individuals could choose between either obtaining €10 in a year or €11 in a year and one week, almost everybody would choose the €11 in a year and one week. Whereas in the present some of these individuals do not want to wait a week for the extra euro, in the future the same individuals are happy to wait. Hence, as the future becomes present over time, the individuals' intertemporal preferences change towards preferring immediate payoffs.

These dynamic inconsistencies have gained considerable attention in various disciplines such as economics, psychology, and neuroscience. One way to explain dynamic inconsistencies is to assume that decisions between two future outcomes are guided by the reflective decision making system alone, whereas intertemporal decisions with an immediate outcome in the choice set are additionally influenced by the impulsive decision making system (Berns et al., 2007; Strack et al., 2006). Following the distinction between the impulsive system (called System 1) and the reflective system (System 2) (Kahneman, 2003), this paper takes a closer look at the impulsive decision making System 1. Therefore, the paper borrows from recent and influential neuroscientific research by Kent Berridge and colleagues (e.g. Berridge, 1999; Berridge and Aldridge, 2008). This research suggests that sometimes reward 'wanting' and reward 'liking' can become dissociated. Reward is thereby dissociated into a motivational component ('wanting') and a pleasure component ('liking') and both components do not necessarily have to coincide. Based on the insight that 'wanting' and 'liking' can become dissociated, Berridge and colleagues provide a brain-based explanation for impulsive behavior. They argue that under certain conditions cues can trigger motivational 'wanting' peaks without effecting 'liking' reactions. In this paper, we integrate this cue-triggered 'wanting' mechanism into an otherwise standard discounted utility model. The resulting new intertemporal choice model will be called the incentive salience model of intertemporal choice. The incentive salience model offers explanations for some findings that other intertemporal choice models have difficulties to explain. For example, using the incentive salience model one can explain why only certain types of rewards elicit dynamic inconsistencies in the form of impulsive behavior and other rewards

don't (Dittmar and Drury, 2000; Estle et al., 2007; Loewenstein, 1996).

The paper proceeds as follows: In section 2 we present some common models of intertemporal choice and shortly investigate their strengths and weaknesses in explaining impulsive choices of smaller sooner rewards instead of larger later ones. Section 3 draws on neuroscientific findings suggesting that reward 'wanting' and reward 'liking' are two dissociated processes. The section presents the cue-triggered 'wanting' mechanism as a microfoundation of the impulsive decision making system. Evidence for cue-triggered 'wanting' in ordinary human life is presented. The fourth section uses the cue-triggered 'wanting' mechanism to build the incentive salience model of intertemporal choice and discusses the new model. The last section concludes.

## 2 Intertemporal Discounting Models and Impulsivity

Generally, individuals prefer to obtain rewards earlier compared to obtaining them later on. That is, individuals discount the subjective value of a future reward as a function of its delay. The rate with which the reward is devalued per period is called the discount rate ( $q$ ). Suppose that an individual is confronted with the opportunity to obtain either a small reward immediately or a large reward later. The decision which reward to choose depends on the comparison between the value of the immediately obtainable reward and the discounted value of the reward that can be obtained only later on. Accordingly, when this discount rate is very high, odds are good that the individual will choose the immediate smaller reward.

Since Samuelson (1937) presented the basics for the discounted utility model, traditional economics attempts to explain intertemporal decisions sticking to the assumption of a constant discount rate ( $q$ ) reflected by the exponential discounting function. In this model, waiting for a reward for a day from now on discounts the reward with the same discount factor ( $\delta = 1/(1+q)$ ) than waiting for the reward for a day beginning in a month (Frederick et al., 2002). Hence, when an individual prefers to obtain €10 today over €11 next week, the individual also has to prefer €10 in a year over €11 in a year and one week to be accurately modeled by the discounted utility model. However, typically the share of individuals choosing the €10 today is much higher than the share of individuals choosing the €10 in a year. This indicates that at least some individuals have dynamically inconsistent preferences; these individuals are patient (low  $q$ -values) when making plans for the future but impatient (high  $q$ -values) when the potential consumption act approaches immediacy (Ainslie, 2005; Frederick et al., 2002). The discounted utility model with its constant discount rate does not account for such dynamic inconsistencies.

Along with this insight, the assumption of constant discount rates over time was largely rejected and hyperbolic discounting models as better approximations for intertemporal choice were suggested (Ainslie, 1975; Loewenstein and Prelec, 1992). In these models the discount rates are modeled as functions that are inversely proportional to the delay

( $\theta$ ) so that discount rates decrease with the delay (c.f. Ainslie, 2005).<sup>1</sup> By integrating the assumption that the temporal immediacy of rewards corresponds to relatively high discount rates, the hyperbolic discounting model is able to explain a good part of the dynamic inconsistencies arising from myopic choices of immediately available but smaller rewards. However, hyperbolic discounting provides only a partial account of intertemporal preferences. Numerous studies have observed factors independent of the shape of the discount function that influence the discount rates such that observed discount functions diverge from the benchmarks given by exponential or hyperbolic discounting. So called “anomalies” in intertemporal choice contain the sign effect (gains are more rapidly discounted than losses), the magnitude effect (smaller rewards are more rapidly discounted than larger rewards), and the domain effect (directly consumable rewards such as food and addictive substances are more rapidly discounted than money) (Estle et al., 2007; Frederick et al., 2002). Moreover, the sudden and strong urges that induce impulsive consumption can go beyond what could be modeled by the already myopic discount rates in hyperbolic discounting models (Frederick et al., 2002). In particular, when utilizing hyperbolic discounting, it is difficult to explain the heavily increased discount rates that occur when individuals perceive cues that are associated with rewarding consumption objects, but do not indicate increased availability or proximity of the consumption objects (cf. Ainslie et al., 2010).

To provide explanations for intertemporal choice that go beyond exponential and hyperbolic discounting functions, with increasing frequency it is argued that intertemporal decision making is best explained by conceptualizing the individual as consisting of two distinct decision making systems. On the one hand, System 1 is affective, automatic, impulsive, heavily values the present, and is strongly influenced by situational factors. System 2, on the other hand, is characterized by analytic preferences leading to patient behavior, willpower, and cognition (Berns et al., 2007; Hoch and Loewenstein, 1991; Kahneman, 2003; Loewenstein, 1996; Strack et al., 2006). The common intertemporal choice model in behavioral economics that applies a dual processing framework is Laibson’s (1997)  $\beta$ - $\delta$  model. This model was first proposed by Phelps and Pollak (1968) in the context of intergenerational altruism and was later adapted by Laibson to model intrapersonal dynamic conflicts. The  $\beta$ - $\delta$  model suggests that individuals have two separated discounting factors, corresponding to System 1 and System 2 respectively. The  $\beta$ - $\delta$  model’s discount function is quasi-hyperbolic with discount factors varying discretely over time ( $D(\theta) = 1, \beta\delta, \beta\delta^2, \beta\delta^3, \dots$ ). Practically, this discount function is a discrete variant of the hyperbolic discount function but, theoretically, it implies that there are two exponentially discounting systems guiding individuals’ intertemporal decisions. Whereas the  $\delta$  System 2 discounts all future rewards with a constant rate per period, System 1, reflected by the  $\beta$  parameter, makes a sharp distinction between immediate rewards and future

<sup>1</sup>A simple example for a discount function proposed by Ainslie (1975) would be  $D(\theta) = 1/\theta$  and a more general one suggested by Loewenstein and Prelec (1992)  $D(\theta) = 1/(1 + \alpha\theta)^{\beta/\alpha}$ . As discount rates are defined as  $-D'(\theta)/D(\theta)$ , the discount rates corresponding to both discount functions are  $q(\theta) = 1/\theta$  and  $q(\theta) = \beta/(1 + \alpha\theta)$  respectively. Both discount rates decrease with rising delay.

rewards: when an immediate reward is in the choice set, the reward in the next period is discounted with  $\beta\delta$ , but when both rewards will occur at two successive periods in the future, the later reward is discounted only with  $\delta$  (Laibson, 1997). The utility function reflecting quasi-hyperbolic discounting is given by

$$U_t = E_t \left[ u(c_t) + \beta \sum_{\tau=1}^{\infty} \delta^\tau u(c_{t+\tau}) \right], \quad (1)$$

where  $u(c_t)$  is the utility gained from consumption  $c$  at time  $t$ , and  $\beta$  and  $\delta$  are discount factors both bound between 0 and 1. This model can, for example, explain how preferences change over time from preferring €11 in a year and one week over €10 in a year to preferring €10 today over €11 in a week. The decision for the €10 today is influenced by the impulsive  $\beta$  system in the sense that the €11 in a week are discounted relatively steeply by  $\beta\delta$ . The decision in the future, however, is not influenced by the impulsive decision making system and the €11 in a year and one week are only discounted by  $\delta$  thus making it more likely that these €11 are chosen.

The quasi-hyperbolic discounting model has proven to be useful to explain various cases of intertemporal choice. These contain the choices between watching a highbrow or a lowbrow film (Read et al., 1999), choices between healthy and unhealthy snacks (Read and Van Leeuwen, 1998), early retirement patterns of workers (Diamond and Köszegi, 2003), and contract choices in health clubs (DellaVigna and Malmendier, 2006). Still, some caveats remain in the quasi-hyperbolic discounting model. For example, it is still difficult to give an explanation for the finding that certain rewards (clothes, food items, and addictive drugs) are more steeply discounted than other rewards (e.g. money) (Dittmar and Drury, 2000; Estle et al., 2007). To understand this selectivity, one has to understand why the  $\beta$  system heavily (over-) values the present. It is not entirely clear what the underlying mechanism is that makes the  $\beta$  system act impulsively. If one knew this mechanism, one could understand why it is stronger for some rewards than for others. In other words, a microfoundation of the  $\beta$  parameter is needed.

Two related lines of research that offer potential explanations for the selective existence of low  $\beta$  values are visceral influences (Loewenstein, 1996) and cue-contingent preferences (Laibson, 2001). The microfoundation of the  $\beta$  parameter presented in this paper is strongly related to these two theories. Visceral influences correspond to drive states such as hunger, thirst, sexual arousal, and to some negative emotions such as exhaustion, pain, or fear for physical safety. As part of System 1, these visceral influences often overwhelm other goals stated by System 2 and thus produce short-sighted, impulsive behavior (Loewenstein, 1996, 2000). Although individuals anticipate the influence of visceral factors on their behavior, individuals tend to underappreciate the magnitude of this influence (Loewenstein et al., 2003). The theory of cue-contingent preferences (Laibson, 2001) argues that cues can increase the marginal utility of rewards associated with the cues. For example, the smell of baking cookies is argued to induce hunger in individuals who associate cookies

with eating. Thus, in this framework cues that were previously associated with rewards can change the drive states the individuals are in and thus induce impulsive behavior (Berns et al., 2007).

This paper's basic strategy to find a microfoundation of the  $\beta$  parameter is to use insights from neuroscientific studies investigating the intertemporal decision maker's brain. Recently, McClure et al. (2004) examined the neural correlates of intertemporal choice for primary and secondary rewards (McClure et al., 2007, 2004). They found that the  $\beta$ - $\delta$  model and the conception of the intertemporal decision maker as being guided by two distinct decision making systems is supported.<sup>2</sup> Utilizing neuroimaging techniques (fMRI), McClure et al. demonstrate that activation in areas that are heavily innervated with the dopaminergic midbrain system (the ventral striatum, the medial orbitofrontal cortex, and the medial prefrontal cortex) is associated with the  $\beta$  parameter, while activation in the lateral prefrontal cortex and posterior parietal cortex is associated with the  $\delta$  parameter. Whereas dopamine related midbrain systems seem to correlate only with impulsive decisions where the sooner reward can be obtained immediately, prefrontal activation occurs in any type of intertemporal decision. Hence, it can be assumed that understanding the role that dopamine plays in the midbrain system will help in finding a microfoundation for the impulsive  $\beta$  parameter. The following section presents research by neuroscientist Kent Berridge and colleagues that elaborates on the role of dopamine in processes related to reward.

### 3 'Wanting' versus 'Liking'

Recent and influential neuroscientific research investigating the neural correlates of reward has made major progress in understanding the motivational and hedonic components of reward (Berridge, 1999). Berridge and colleagues' findings suggest that reward 'wanting' and reward 'liking' are separated processes in the brain. Sometimes individuals 'want' rewards to a higher degree than they 'like' them, and vice versa, 'like' rewards more than they 'want' them. Although consciously, wanting and liking almost always cohere, the unconscious core process of the motivation to pursue a reward ('wanting') and the core process of hedonic pleasure ('liking') can become dissociated, so that 'wanting'-'liking' gaps occur.<sup>3</sup> The core process of motivation, i.e. 'wanting', is the attribution of incentive salience to stimuli or events. This attribution transforms reward stimuli from being just sensory representations in the brain into being desired, attractive, and 'wanted' incentives. Without 'wanting' there would not be any kind of approach behavior. The core process

<sup>2</sup>Though there are also neuroimaging studies that support a unitary discounting system (e.g. Kable and Glimcher, 2007).

<sup>3</sup>The inverted commas indicate the core processes of motivation and hedonic pleasure in the brain. These core processes are different from the conscious perceptions of motivation and pleasure, i.e. wanting and liking without inverted commas. The unconscious core processes of motivation and hedonic pleasure, 'wanting' and 'liking', are necessary but not sufficient conditions for conscious wanting and liking. Whereas the conscious processes of wanting and liking are subjective in nature, the unconscious core processes of 'wanting' and 'liking' can be objectively measured by behavioral or neuroscientific methods.



of hedonic pleasure, i.e. ‘liking’, corresponds to the basic sensory pleasure or experienced utility associated with the receipt of an immediate reward. It is the hedonic activation in the brain that occurs during consumption (e.g. Berridge, 1999, 2007).

	Motivation	Pleasure
Hot/Unconscious System 1	‘Wanting’	‘Liking’
Cool/Conscious System 2	Wanting	Liking

Table 1: Reward dissociations between motivation and pleasure almost never occur at the conscious level. Consciously, individuals almost always want what they like and like what they want. Unconsciously, however, ‘wanting’–‘liking’ dissociations are more likely to occur.

In the brain, ‘wanting’ and ‘liking’ correspond to different neural substrates. ‘Liking’ is caused only in a number of hedonic hotspots in brain structures such as the nucleus accumbens or the posterior half of the ventral palladium (Peciña et al., 2006). Compared to these hedonic hotspots, ‘wanting’ mechanisms in the brain are more numerous and diverse. This was hypothesized to be the “basis for the phenomenon of ‘wanting’ a reward without equally ‘liking’ the same reward” (Berridge et al., 2009, p.69), which is a much more common phenomenon than the reverse, i.e. ‘liking’ without ‘wanting’. It was also argued that incentive salience ‘wanting’ may have evolved earlier in our ancestral history than ‘liking’. Only later in evolution, humans may have learned to ‘want’ what they ‘like’ (Berridge, 2009).

One area that has proven to be especially useful for dissociating ‘wanting’ from ‘liking’ is the dopamine-related mesolimbic brain system (Berridge, 2007). The dopamine-related mesolimbic brain system contains, for example, the ventral tegmental area, the nucleus accumbens (which is part of the ventral striatum), the amygdala, and the medial prefrontal cortex. Recall that this dopamine-related mesolimbic brain system is also the one that the neuroimaging studies testing intertemporal choice behavior found to correspond to the impulsive  $\beta$  parameter (McClure et al., 2007, 2004). In experiments with rats, manipulations of the dopamine-related mesolimbic brain system were shown to be particularly useful for dissociating ‘wanting’ from ‘liking’. In some of these experiments, the effects of dopamine receptor blockades on ‘wanting’ and ‘liking’ sugar rewards were investigated (Ikemoto and Panksepp, 1999). In these experiments, the running speed to a goal box containing sucrose solution and the consumption of the sucrose solution when the rats had already made it to the box were interpreted as ‘wanting’ and ‘liking’ respectively. A reduction of dopamine reception reduced the rats’ running speed, but did not decrease the rats’ intake of the sweet solution. Thus, the neurotransmitter dopamine seems to code how strongly rewards are ‘wanted’, not how much they are ‘liked’.<sup>4</sup> When dissociating reward into motivational and pleasurable components, dopamine is responsible for the motivation

<sup>4</sup>This is contrary to the classical view that sees dopamine as the pleasure neurotransmitter coding ‘liking’. Other researchers argue that dopamine is more important in learning processes signaling prediction errors. For a discussion about the role of dopamine see Berridge (2007).

to pursue rewards rather than how pleasurable rewards are perceived (Berridge, 2007).

What does the ‘wanting’–‘liking’ dissociation have to do with impulsivity? It is striking that both the impulsive  $\beta$  parameter in the intertemporal neuroimaging studies (McClure et al., 2007, 2004) and reward ‘wanting’ correspond to activation of the mesolimbic dopamine system. This indicates that the impulsive  $\beta$  parameter is closer related to ‘wanting’ rewards than to ‘liking’ them. Thus, it might be the case that increased degrees of reward ‘wanting’ lead to the impulsive choices of smaller sooner rewards instead of larger later ones, although the latter are ‘liked’ more (Berridge, 2009; Berridge and Aldridge, 2008). Understanding impulsivity as being characterized by ‘wanting’–‘liking’ dissociations would also correspond to the fact that impulsivity is usually related to the decision making System 1 which does not rely on cognitive deliberation. ‘Wanting’–‘liking’ dissociations are much more likely to occur in hot states than wanting-liking dissociations are likely to occur in cold states (see Table 1). However, if this is the case, what is the mechanism that increases the degree to which immediate rewards are impulsively ‘wanted’?

### 3.1 Cue-Triggered ‘Wanting’ in Rats

One particular mechanism that leads to ‘wanting’ elevations without influencing either the actual hedonic impact in the brain (‘liking’) or liking expectations is cue-triggered ‘wanting’. Cue-triggered ‘wanting’ describes strong motivational peaks that are evoked by certain reward cues (Berridge and Aldridge, 2008). These motivational ‘wanting’ peaks were first shown in rat experiments (Wyvell and Berridge, 2000, 2001). In these experiments, rats were trained to work for sugar rewards. The rats learned that by constantly pushing a lever they could obtain some sugar pellets. In separated training sessions, the rats learned that a certain auditory cue predicted the sugar pellets. After these two training sessions Berridge and colleagues activated some rats’ dopamine systems by amphetamine micro-injections. In the actual experiment, these rats as well as a control group of rats without activated dopamine systems were tested for their motivation to work for rewards in absence as well in presence of the auditory sugar cues. In these testing sessions, the rats did not obtain any rewards anymore. It turned out that the auditory sugar cues induced motivational ‘wanting’ peaks, but only for those rats with activated dopaminergic midbrain systems. In rats with normal mesolimbic activation, the same cues had only mild effects on the motivation to acquire the sugar rewards. Also an activated mesolimbic dopamine system alone did not make the rats work harder. In absence of the auditory cues no difference between the two rat groups was found. Additionally, the authors found that ‘liking’ expressions (measured by typical facial reactions such as rhythmic lip-licking movements) did not differ for the two groups of rats. The authors conclude from these experiments that for cue-triggered ‘wanting’ to occur, two situational factors have to coincide. First, as a physiological factor, the rat has to be in a state of mesolimbic activation. Second, as a psychological factor, the rat has to perceive a cue that was previously associated with an immediately obtainable reward. When both situational

factors coincide, cue-triggered ‘wanting’ induces the rat to work irrationally hard for the cued reward (Berridge and Aldridge, 2008).

To explain these findings, Berridge and colleagues argue that the association of the cue with a reward attributes the cue with dopamine-driven incentive salience (‘wanting’). This incentive salience imbues the cue with strong motivational power. It makes the cued reward highly ‘wanted’. With activated mesolimbic brain structures this attribution is stronger than without such activations. Moreover, incentive salience increases the motivation to pursue the reward, but leaves the actual pleasure experience of the reward untouched. Activation of the dopaminergic midbrain system does not change how much rats ‘like’ sugar rewards. Therefore, the authors argue that at moments of motivational ‘wanting’ peaks, rats with activated mesolimbic dopamine systems ‘wanted’ the cued sugar rewards to a higher degree than they ‘liked’ them.

However, an alternative interpretation of these findings would not allow to conclude that ‘wanting’ and ‘liking’ are dissociated at the moment of the motivational ‘wanting’ peaks. It might be the case that the sugar cues momentarily increased the liking expectations of the sugar rewards. Then cue-triggered ‘wanting’ would simply be the result of cue-triggered increases of reward expectations, and ‘wanting’ and liking expectations would cohere. To disentangle cue-triggered ‘wanting’ from cue-triggered changes of liking expectations, Tindell et al. (2005) conducted a related rat experiment. In this experiment, two consecutive cues predicted a sugar reward. An auditory cue was followed 10 seconds later by a click cue and one more second later by a sugar pellet. Whereas the auditory cue signaled everything that followed, the click cue was redundant and added only little new information. Tindell et al. therefore argue that the auditory cue corresponds mostly to liking expectations, the click cue carries the greatest incentive salience ‘wanting’, and the sugar pellet itself reflects actual ‘liking’. Using this experimental paradigm, the authors investigated when ventral pallidum neurons fired the most.<sup>5</sup> The authors found that ordinarily, ventral pallidum neurons code liking expectations, i.e. fire with the auditory cue. However, when the rats’ mesolimbic dopamine systems were activated by sensitization or amphetamine administration, the activation of ventral pallidum neurons shifted towards the click cue (‘wanting’) and away from the auditory cue (liking expectations). This shift took place only when the click cue predicted temporally close rewards, implying that cue-triggered ‘wanting’ depends on the immediacy of the cued rewards. Moreover, behavioral hedonic ‘liking’ reactions were not changed by the sensitizations or amphetamine administrations. Tindell et al. conclude from these findings that the activation of the mesolimbic dopamine system increases cue-triggered ‘wanting’, but does not change the effect that cues have on liking expectations. Hence, the motivational ‘wanting’ peaks triggered by cues are not mediated by momentary increases of cue-triggered liking expectations. When the click cues were perceived, the rats with activated mesolimbic brain areas ‘wanted’ the immediately available sugar rewards to an irrational high degree, i.e. to a degree that

<sup>5</sup>The ventral pallidum is the chief target of mesocorticolimbic circuits and is crucial for reward ‘liking’, ‘wanting’, and expected liking (which is the result of reward learning).

did not rationally match their liking expectations. As the activation of the mesolimbic dopamine system selectively increased the incentive salience of cued rewards that were temporally close, this behavior can be interpreted as impulsive rat behavior (Berridge and Aldridge, 2008; Tindell et al., 2005).

Summing up the evidence found in these rat experiments, the synergy of (1) the activation of rats' mesolimbic brain systems, and (2) the perception of certain reward cues can induce cue-triggered 'wanting' characterized by 'wanting'–'liking' dissociations. In other words, when rats with activated dopamine midbrain regions perceive cues that are associated with immediately obtainable rewards, the rats impulsively 'want' the cued rewards to a higher degree than they expect to like them.

### 3.2 Cue-Triggered 'Wanting' in Humans

Humans, of course, are not rats. Human behavior is much more complex than rat behavior could ever be. Hence, to explain impulsivity in humans, the cue-triggered 'wanting' mechanism has at least to be adjusted. Nevertheless, also certain similarities between human and animal behavior can be assumed, especially for human behavior that is governed by the impulsive decision making System 1. This system is unconscious, lacks cognitive deliberation, and might well mimic behavior found in animal experiments, at least to a certain extent. Humans, just like other animals, have brain dopamine systems that interact similarly with cues and can foster impulsivity. In humans, states of mesolimbic activation frequently correspond to need deprivation states such as hunger, thirst, and drug addiction. Thus, cue-triggered 'wanting' can be seen as mostly consistent with and supportive of the theory of visceral influences (Loewenstein, 1996). Most of the visceral factors that Loewenstein mentions are related to dopamine activation in the brain, so that cue-triggered 'wanting' might be one specific mechanism of how visceral factors induce impulsivity in intertemporal choices (Berridge, 2002). Additionally to these basic visceral factors, many emotional situations that can either be rewarding or stressful activate mesolimbic circuits (Berridge and Aldridge, 2008). Hence, human cue-triggered 'wanting' might not be confined to rewards that satiate physiological needs. The neural structures that correspond to higher cognitive rewards are similar to the brain structures that correspond to basic rewards. Primary rewards such as food, as well as more abstract rewards such as art, money, and social rewards elicit activity in the same neural structures (Montague et al., 2006). Therefore, it is likely that besides physiological need deprivation states, also psychological need deprivation states can interact with cues and induce cue-triggered 'wanting'. These cues can occur in many different ways. Generally, every stimulus that can be perceived somehow has the potential to become a cue triggering 'wanting'. Also the perception of a reward itself can trigger impulses. In ordinary human life, cues perceived in, for example, television home shopping channels are potential triggers to increase 'wanting' over 'liking'. Moreover, in humans cognitive representations of rewards can be enough to interact with activated dopamine systems and thus induce impulsive behavior

(Berridge, 2002). However, as humans live in a much more complex world, perceive many cues at each point in time, and are driven by various need deprivation states, a third factor has to be added to understand impulsivity in ordinary human life. This third factor captures the knowledge about which goods are appropriate to satiate which needs, and can be called consumption knowledge. Consumption knowledge implicitly or explicitly contains the subjective knowledge or beliefs about which goods satiate which needs. For example, only when exhausted individuals implicitly or explicitly know that eating a specific food item increases their energy degree, respective food cues will induce cue-triggered ‘wanting’. However, even when need deprivation states, reward cues, and consumer knowledge coincide and increase the motivation to obtain immediate rewards, in humans this increased motivation does not necessarily induce impulsive decisions. Humans are not totally prone to their urges. By the use of willpower, humans can control themselves and neutralize the impulsive motivations. Self-control, however, is a resource that can get depleted so that urges tend to influence decisions more frequently (Baumeister et al., 1998; Vohs and Faber, 2007). Self-control has to be considered as a fourth factor to understand (non-)impulsivity in human beings.

This paper’s basic claim is that cue-triggered ‘wanting’ can explain why individuals impulsively choose smaller sooner rewards instead of larger later ones. Cue-triggered ‘wanting’ might essentially be the (or more likely: one) mechanism causing the impulsivity reflected by the  $\beta$  parameter in quasi-hyperbolic discounting models (Berridge and Aldridge, 2008). Thus, it might explain how the impulsive System 1 in the various dual system models generates impulsive behavior. Cue-triggered ‘wanting’ is one way to explain why, in ordinary human life outside the experiment, individuals consume cued goods in an impulsive fashion. Thus, cue-triggered ‘wanting’ explains why impulsive consumption occurs particularly when individuals are deprived of specific needs and additionally perceive cues that are associated with consumption goods known to be able to satisfy the respective currently deprived needs. Cue-triggered ‘wanting’ can be seen as a “brain-based explanation of why hyperbolic discounting especially describes the choices of sensitized addicts, the inebriated, or even ordinary people who are in a momentary “hot” state that recruits mesocorticolimbic circuits” (Berridge, 2009, p. 393). Strong need deprivation states such as hunger, drug addiction, and sexual deprivation correspond to activation in the mesolimbic brain system and thus can induce strong and sudden urges to consume, for example, food items and drug-like products (Berridge, 2002; Berridge and Aldridge, 2008).<sup>6</sup> In the following we review some of the growing evidence for ‘wanting’–‘liking’ distinctions and cue-triggered ‘wanting’ in humans.

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<sup>6</sup>Note that even if unconscious ‘wanting’ that exceeds unconscious ‘liking’ may be the reason for many impulsive decisions, on the conscious level wanting and liking do not necessarily have to be perceived as dissociated. Individuals may often rationalize their behavior to themselves in the sense that they explain their urges by, for example, arguing that they always expected to like the impulsively bought rewards. Also note that cue-triggered ‘wanting’ is different from miswanting (Gilbert and Wilson, 2000). Whereas in miswanting individuals wrongly expect to like rewards, cue-triggered ‘wanting’ can make rewards ‘wanted’ although these are not even expected to be liked.

### 3.3 Evidence for ‘Wanting’–‘Liking’ Dissociations and Cue-Triggered ‘Wanting’ in Humans

Support for the dissociation between ‘wanting’ and ‘liking’ in human impulsive decisions comes from several neuroscientific studies. Cue-triggered ‘wanting’ was related to the growing rates of obesity and binge eating (Berridge et al., 2010). In this encompassing line of research it is argued that when an individual is hungry, a cue of an immediately available food item triggers strong and impulsive ‘wanting’ reactions. Food cues are argued to induce hungry individuals to impulsively ‘want’ food to a higher degree than they expect to like the same food item in the moment of the impulse. The cumulative evidence is consistent with the hypothesis that mesolimbic dopamine mediates the incentive salience of food and influences ‘wanting’ to eat (e.g. Berridge, 1996; Berridge et al., 2010; Finlayson et al., 2007; Lemmens et al., 2011). Cue-triggered ‘wanting’ was also used to account for the fact that drug addicts perceive extremely strong cravings when they encounter drug-related cues, although these addicts usually do not expect to like the drugs (Robinson and Berridge, 1993, 2008). In the incentive salience theory of addiction, drugs are argued to cause long lasting sensitization in mesolimbic brain regions containing the dopaminergic pathway. In other words, drugs put the brain into a state of permanent mesolimbic activation. Hence, it can be explained why impulsive and addictive relapse, even after a long phase of abstinence where no withdrawal syndromes are present anymore, is frequently the result of encounters with drug cues (Robinson and Berridge, 1993, 2008).<sup>7</sup>

Also in behavioral studies, the ‘wanting’–‘liking’ distinction was related to human (impulsive) behavior (Dai et al., 2010; Kahneman et al., 1997; Litt et al., 2010). Kahneman and colleagues, for example, distinguish between four types of reward utility: remembered utility, experienced utility, predicted utility, and decision utility (Kahneman et al., 1997). The first three types of utility refer to remembered liking, actual ‘liking’, and expected liking, and decision utility roughly corresponds to ‘wanting’ (e.g. Berridge, 2002; Berridge and Aldridge, 2008). Litt et al. (2010) find that ‘wanting’ and ‘liking’ can be driven in opposite directions when people experience failure in pursuing desired outcomes. Individuals who perceived a failure to obtain an attractive reward showed increased willingness to pay for this reward, i.e. ‘wanted’ the reward more. However, these individuals also happened to ‘like’ the reward less and more often traded it away. Thus, the authors argue that failure to obtain a reward can enhance reward ‘wanting’ but at the same time reduce the pleasure this reward provides. Additionally, the authors find that such ‘wanting’–‘liking’ dissociations are especially present for cool-headed individuals who score low on affect intensity measures. Litt et al. (2010) argue that in individuals with high affect intensity the strong negative emotions evoked by the failure to obtain the reward had a stronger influence on reward ‘wanting’ than it had in cool-headed individuals. Hence, this study highlights that although ‘wanting’ and ‘liking’ are dissociable, they can and often do influence each

<sup>7</sup>For an economic application of the incentive salience theory of addiction see Bernheim and Rangel (2004)

other. Dai et al. (2010) investigate impulsive preferences towards human faces and find that individuals have two types of impulsive preferences towards identical faces in identical contexts. These two types are face likability and face incentive value, corresponding to ‘liking’ and ‘wanting’ respectively. The authors find that under some conditions ‘wanting’ to look at a face (operationalized as an impulsive desire to visually consume the face in a key press task) differs from ‘liking’ the face (operationalized as the hedonic response to a face in form of an immediate emotional experience in an evaluative movement assessment). Dai et al. find that individuals’ ‘liking’ reactions to the aesthetic features of male and female faces are independent of the viewers’ gender. But regarding ‘wanting’, the viewer’s gender plays a role. Male participants ‘want’ to visually consume physically attractive female faces to a significantly higher degree than female viewers ‘want’ to look at attractive male faces. These differences occur only for ‘wanting’, not for ‘liking’. To explain this, the authors propose that the sexual drive is stronger in men than in women, and that this drive unfolds strong additional influence on the incentive value (‘wanting’) but not on ‘liking’ the attractive opposite gender faces.

## 4 The Incentive Salience Model

In this section we integrate the cue-triggered ‘wanting’ mechanism into an otherwise standard discounted utility model. More precisely, we suggest that the impulsive decision making System 1 is essentially characterized by cue-triggered ‘wanting’. Compared to the quasi-hyperbolic discounting model, we substitute the  $\beta$  parameter by the cue-triggered ‘wanting’ mechanism. We will call the new model the incentive salience model of intertemporal choice. This model is inspired by the neural computational model presented by Zhang et al. (2009) which, however, had other aims and another focus.

In the incentive salience model, the motivation to acquire a reward is determined by two components. The first component is the pleasure that a reward is expected to offer. When individuals expect an object to be pleasurable, they will be motivated to obtain it. This is in line with standard expectancy value models where individuals want to consume those products they expect to like. The influence of expected liking on the motivation to consume is the result of standard reinforcement learning mechanisms. The motivation to consume is upgraded every time an individual recognizes that the pleasure the object offers is different from what the individual has expected it to be.<sup>8</sup> Hence, the incentive salience value ( $\bar{V}$ ) of a rewarding object ( $c_t$ ) that is pleasurable ( $r(c_t) > 0$ ) is given by the expected future hedonic pleasure ( $\bar{V} = E_t[\sum_{i=0}^{\infty} \delta^i r(c_{t+i})]$ ), where  $\delta \in [0, 1]$  is the discount factor. This component of the incentive salience model corresponds to the standard discounted utility model.<sup>9</sup>

<sup>8</sup>In each period, pleasure estimates  $\hat{V}$  are based on computing a prediction error  $\gamma$  and correcting any experienced deviation of  $\hat{V}$  from consistent successive periods:  $\gamma_t = r_t + \delta \hat{V}(s_{t+1}) - \hat{V}(s_t)$ . Using this prediction error, the estimated pleasure  $\hat{V}$  is updated.

<sup>9</sup>As an alternative modeling approach, it would be possible to use a hyperbolic discounting model instead of the discounted utility model as the first component of the incentive salience model. However,

The second component that additionally determines the motivation to acquire rewards is situationally imposed cue-triggered ‘wanting’. Cue-triggered ‘wanting’ can increase the motivation to obtain an immediately available reward independent of pleasure expectations and learning mechanisms. As seen in section 3.2, cue-triggered ‘wanting’ can occur when individuals (1) are currently in a need deprivation state, (2) perceive a cue associated with an immediately obtainable reward, (3) know or believe that the cued reward is able to reduce the current need deprivation state, and (4) do not control themselves perfectly. The need deprivation state is reflected by  $\eta_t$ .  $\eta_t < 0$  indicates oversaturation (such as when the individual has eaten too much), and  $\eta_t > 0$  represents deprivation (for example hunger). In this paper, we will focus on the latter case. The perception of a cue is captured by the binary variable  $s_t$ , which is zero when no cue is perceived and unity in case of a cue perception. The explicit or implicit knowledge about which goods are appropriate to satiate which needs is captured by consumption knowledge ( $k_t; 0 \leq k_t \leq 1$ ). Self-control ( $SC_t$ ) that can neutralize the urges to impulsively obtain immediate rewards is bound between zero and unity ( $0 \leq SC_t \leq 1$ ). Perfect self-control corresponds to  $SC_t = 1$ .

Hence, when individuals are in a need deprivation state ( $\eta_t > 0$ ), perceive a cue ( $s_t = 1$ ) that indicates the immediate availability of a pleasurable reward ( $c_t$ ), and know or believe that the need deprivation state can be reduced by the cued object ( $k_t > 0$ ), cue-triggered ‘wanting’ increases the motivation to acquire the object. This increased motivation can induce behavioral changes when individuals do not perfectly control themselves ( $SC_t < 1$ ). The simplest way to formalize cue-triggered ‘wanting’ is by a multiplicative function ( $s_t \cdot k_t \cdot \eta_t$ ). When the product of the three variables is greater than zero, cue-triggered ‘wanting’ adds additional motivational power to the cued reward. The motivation to obtain an immediately available reward including cue-triggered ‘wanting’ is depicted by  $r(c_t)(1 + s_t \cdot k_t \cdot \eta_t)$ , and the difference from  $r(c_t)$  is the consequence of cue-triggered ‘wanting’. By the use of self-control, however, the effect of cue-triggered ‘wanting’ can be neutralized ( $r(c_t)(1 + s_t \cdot k_t \cdot \eta_t \cdot (1 - SC_t))$ ), so that the motivation to obtain rewards again coheres with pleasure expectations. Without cue-triggered ‘wanting’ or with perfect self-control, there is a one-to-one relationship between the expected pleasure and the motivation to consume. When decisions are influenced by cue-triggered ‘wanting’, however, this coherence is suspended.

The overall motivation to acquire a reward that occurs when individuals perceive a cue that is associated with the consumption object is reflected by  $V(s_t)$ . This motivation is determined by both the discounted liking expectations ( $\bar{V} = E_t[\sum_{i=0} \delta^i r(c_{t+i})]$ ) and the combined effects of the current drive state  $\eta_t$ , the consumer knowledge  $k_t$ , the cue  $s_t$ , and non-perfect self-control ( $SC_t \leq 1$ ). The motivation to consume a given reward is

$$V(s_t) = E_t \left[ r(c_t)(1 + s_t \cdot k_t \cdot \eta_t \cdot (1 - SC_t)) + \sum_{i=1} \delta^i (r(c_{t+i})) \right]. \quad (2)$$

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as this paper’s focus is on the integration the cue-triggered ‘wanting’ mechanism, we chose to stick to the simplifying assumption of the discounted utility model (see discussion in section 4.1).



where  $\delta \in [0, 1]$  is a constant discount factor. In the incentive salience model, cue-triggered ‘wanting’ ( $s_t \cdot k_t \cdot \eta_t > 0$ ) reflects the influence of the impulsive decision making System 1. Cue-triggered ‘wanting’ increases the motivational weight put to immediate rewards relative to future rewards. The decision making System 2 is reflected by self-control ( $SC_t$ ) as well as the part of the incentive salience model that mimics the discounted utility model. When the individual does not perceive a cue ( $s_t = 0$ ), has no consumer knowledge ( $k_t = 0$ ), is not in a need deprivation state ( $\eta = 0$ ), or has perfect self-control ( $SC_t = 1$ ), the model simplifies to the standard discounted utility model. When one of these conditions holds, decisions are solely the result of the reflective decision making System 2. On the other extreme, when degrees of deprivation become very high, the impulsive System 1 can become the dominant driver of decisions. In these cases the deprivation state  $\eta$  gets so great, that the relatively small values of discounted future rewards have almost no influence on the decision anymore. Also self-control might be negatively influenced by very strong deprivation states. Very hungry individuals, for example, can’t prevent themselves from eating. In this paper, however, we take self-control as an exogenously given variable. For most decisions deprivation states are not strong enough to completely override cognitive deliberation. On the other hand, also the cognitive System 2 is not strong enough to completely neutralize urges occurring in the impulsive System 1. Hence, it seems best to model intertemporal decisions as being made by both systems simultaneously as it is done in equation (2).

As seen in section 2, in intertemporal decision models impulsivity is commonly described by very high discount rates (i.e. low discount factors) in intertemporal trade-offs where an immediate option is in the choice set. Correctly measured discount factors imply that there is indifference in this intertemporal trade-off. In the incentive salience model, indifference in the trade-off between obtaining a reward now or in the next period is characterized by  $E_t[r(c_t)(1 + s_t \cdot k_t \cdot \eta_t \cdot (1 - SC_t))] = E_t[\delta r(c_{t+1})]$ . The term reflecting cue-triggered ‘wanting’ ( $s_t \cdot k_t \cdot \eta_t$ ) occurs at the left-hand side of this equation. This reflects that cue-triggered ‘wanting’ increases the motivational value of the immediately obtainable reward, and does not decrease the discounting factor with which future rewards are discounted. Impulsivity can be seen as the desire for immediate gratification on top of the impatience that is already measured by the discount rate  $\delta$ .

The distinction between impulsivity and impatience scrutinizes the usefulness of taking a single discount rate for measuring either impulsivity or impatience. A single discount rate lumps together impatience and impulsivity. However, as it is possible to measure and manipulate deprivation states, consumer knowledge, cues, and self-control, distinguishing between impatience and impulsivity is possible when applying the incentive salience model in experiments. The incentive salience model suggests observing  $\eta_t$ ,  $k_t$ ,  $s_t$ , and  $SC_t$  to predict degrees of impulsivity arising from cue-triggered ‘wanting’. These predictions can easily be formulated in hypotheses that can be tested in rather standard intertemporal choice experiments. For food rewards, for example, impulsivity can be measured as the difference between the presumably constant discount factors of satiated individuals and

the immediate discount factors of hungry individuals.

#### 4.1 Discussion

Comparing the incentive salience model (equation 2) with Laibson's (1997) quasi-hyperbolic discounting model (equation 1), it becomes obvious that both models have essentially the same functional form (Zhang et al., 2009). The  $\beta$  parameter in the quasi-hyperbolic discounting model is substituted by the cue-triggered 'wanting' mechanism. Cue-triggered 'wanting' might essentially be the (or more likely: one) mechanism causing the impulsivity reflected by the  $\beta$  parameter in the quasi-hyperbolic discounting model. This conjecture is in line with neural data. The neural correlates of both parameters reflecting impulsive decisions (i.e.  $\beta$  in the quasi-hyperbolic discounting model and  $\eta_t$  in the incentive salience model) involve active dopaminergic midbrain structures (the ventral striatum and the medial prefrontal cortex) (Berridge, 2007; McClure et al., 2007, 2004). However, only the incentive salience model provides a brain-based explanation for the fact that the impulsive desires to obtain smaller sooner rewards occur. While in the quasi-hyperbolic discounting model the  $\beta$  parameter reflects ad hoc values that are chosen to fit the data, the incentive salience model allows to predict impulsive choices even before they occur. This predictive capacity is the major advantage of the incentive salience model compared to other models of intertemporal choice. In the rest of this section we present some further advantages of the incentive salience model, explain some modeling decisions, and show some implications of understanding impulsivity sometimes characterized by 'wanting'-'liking' dissociations.

Compared to other models of intertemporal choice, a further advantage of the incentive salience model is that it offers an explanation for the domain effect (different types of reward elicit different degrees of delay discounting). Certain rewards like food items, drinks, and drug-like rewards are discounted more steeply than, for example, money (Estle et al., 2007). All these rewards are able to satiate deficiency needs that, when deprived, activate the mesolimbic dopamine system. Rewards that are related to, for example, cognitive needs that do not correspond to mesolimbic activation are unlikely to be chosen impulsively. For example, it is rather unlikely to perceive a strong urge to buy basic body care. Hence, the incentive salience model adds a motivational perspective to the behavioral economic literature on intertemporal choice. Rather than solely focusing on how individuals choose impulsively, with the incentive salience model one can go beyond this decision theoretic perspective and also predict what the rewards are that tend to be chosen in an impulsive fashion (Witt, 2010). This allows, for example, a structured investigation of when self-commitment devices are sensible, thus complementing the research focusing on how self-commitments work in well specified cases.

This motivational focus is also the reason for our simplifying choice of using exponential discounting of future rewards to describe the cognitive System 1. A more realistic alternative would be to use hyperbolic discounting of future rewards. In hyperbolic discounting models preferences can dynamically change from larger later rewards to smaller sooner

ones without impulsivity being involved. In these models, individuals are impatient in the present and patient when making plans for the future, and these changing degrees of impatience can result in dynamic inconsistencies (Ainslie, 1975). These changing degrees of impatience, however, are usually assumed to be equal for all reward domains. Impulsivity, which is reward specific, could then be seen as the extreme desire for immediate gratification on top of the already myopic preferences modeled by a hyperbolic discounting function. However, as one of the paper's major aims is to explain the domain effect by integrating the cue-triggered 'wanting' mechanism into an intertemporal choice model, adding changing degrees of impatience as an alternative explanation for dynamic inconsistencies could cause unnecessary complexity. Related to this point one should keep in mind that cue-triggered 'wanting' explains impulsivity rather than changing degrees of impatience. The incentive salience model thus accounts only for those dynamic inconsistencies that are the result of impulsivity. Consequently, the incentive salience model can explain the finding that different types of rewards elicit different degrees of delay discounting only to the extent that impulsivity plays a role in these intertemporal choices.

However, the incentive salience model's ability to explain the domain effect hinges on a critical assumption that should be mentioned here. The incentive salience model assumes that each deprivation state, say  $\eta_{it}$ , increases the motivation to obtain its corresponding reward  $r(c_{it})$  instead of any other reward  $r(c_{jt})$  with  $i \neq j$ . In other words, there are distinct  $\eta$  values for hunger, thirst, or drug addiction (Zhang et al., 2009). For example, when an individual is hungry, the sight of a pizza delivery car might trigger a 'want' to eat a pizza, while the sight of a glass of water does not increase the 'want' to drink in hungry individuals. However, it is not yet evident if specific need deprivation states can indeed induce impulsive choices only of those rewards that are able to satiate the currently deprived needs. It was shown that cross-domain spillover effects of 'wanting' can occur. Compulsive gamblers, for example, may also show other addictions (Zhang et al., 2009), male participants exposed to erotic pictures have a higher 'want' for money (Van den Bergh et al., 2008), and a salient need for distinctiveness increases the 'want' to eat (Berger and Shiv, 2011). Hence, mesolimbic activation of dopaminergic brain systems induced by one of these need states might also increase the motivational value of any other cue. This would correspond to the idea that dopamine reflects a motivational "common currency" in the brain (c.f. Berger and Shiv, 2011). Future research should clarify to which extent deprivation states indeed induce higher 'wanting' only in the specific domains corresponding to the current need deprivation states.

Besides offering one possible explanation for the domain effect, the incentive salience model also allows accounting for parts of the magnitude effect (smaller rewards are more rapidly discounted than larger rewards). In the incentive salience model, current need deprivation states are decisive for the occurrence of strong desires for immediate gratification. Small rewards should be sufficient to reduce these current need deprivation states. Thus, the proportion of the reward that is needed to reduce the current need deprivation state is larger in smaller rewards than it is in larger rewards. For example, smokers in need

of a cigarette might show higher discount rates for a single cigarette than for a carton of cigarettes, because a single cigarette is sufficient to reduce the craving. As a complementary explanation for the magnitude effect one can argue that the cognitive System 2 tends to dominate decisions where large rewards are at stake. When only small rewards are at stake, controlling oneself is less important and the impulsive System 1 might dominate the choices.

Another simplifying assumption the incentive salience model makes is that short-term fluctuations of need deprivation states effect only impulsivity. The effects of fluctuating need deprivation states on reward ‘liking’ and pleasure expectations are not modeled, i.e.  $r(c_t)$  is independent of  $\eta_t$  both in the present and in the future. Thus, it is implicitly assumed that the individuals’ pleasure expectations are extrapolations of the pleasures that respective rewards have offered in the past. In real life, however, need deprivation states effect the pleasure that rewards provide and this effect can also be anticipated. For example, food tastes better when hungry and individuals know that. However, the effects of need deprivation states on the pleasure components of reward do not explain impulsivity. Impulsivity, defined as spontaneous, automatic, and without a lot of reflection (Rook, 1987), can better be explained by cue-triggered ‘wanting’. As the paper investigates dynamic inconsistencies arising from impulsivity, it seems justified to simplify in the sense that pleasure is not influenced by fluctuating need deprivation states.

Finally to conclude the discussion of the incentive salience model, some implications of understanding impulsivity as being characterized by ‘wanting’–‘liking’ dissociations are stressed. First, the ‘wanting’–‘liking’ distinction might explain why individuals underappreciate the effects that visceral states have on current and future behavior (Loewenstein et al., 2003). While consciously, rational individuals almost always want what they like and like what they want, unconsciously ‘wanting’–‘liking’ distinctions can occur. Most individuals are not aware of these unconscious distinctions and thus it is hardly possible for them to anticipate preference reversals leading to choices of smaller sooner rewards. ‘Wanting’–‘liking’ dissociations may thus partly explain why individuals are naive about future self-control problems (O’Donoghue and Rabin, 1999). Second, ‘wanting’–‘liking’ distinctions might explain why individuals oftentimes regret their impulsive choices. Situational factors, for example, in the store might increase how much consumer goods are ‘wanted’ without changing how much the same goods are ‘liked’. Purchasing a product without actually ‘liking’ the product sufficiently to make the purchase happen under normal circumstances is likely to induce regret. Such regret might then decrease discount factors in subsequent intertemporal decisions (Raeva et al., 2010). However, the idea that impulsive purchases can be characterized by ‘wanting’–‘liking’ dissociations raises serious doubts about the applicability of the revealed preference approach to impulsive choices. Third, ‘wanting’–‘liking’ distinctions may help understanding why certain needs are particularly difficult to be satiated. Economically, this is of particular interest with regard to higher order needs. David Nettle in his book “Happiness: The science behind your smile” argues that a slight rise of one’s income or social status might be enough to engage the

wanting-system, but not enough to induce higher degrees of pleasure or happiness (Nettle, 2005, p.129).

## 5 Concluding Remarks

This paper presented the incentive salience model of intertemporal choice. This model follows dual process theories in distinguishing between an impulsive decision making System 1 and a reflective decision making System 2. The incentive salience model focuses on the impulsive system in that it integrates a brain-based explanation for impulsivity into an otherwise standard discounted utility model. Drawing on the dissociation of reward into ‘wanting’ and ‘liking’ components, the paper argued that impulsive choices of smaller sooner rewards instead of larger later ones are induced by a mechanism called cue-triggered ‘wanting’. Cue-triggered ‘wanting’ occurs when need deprived individuals perceive cues that are associated with rewards known to satisfy the currently deprived needs. If not controlled by cognitive efforts, cue-triggered ‘wanting’ can induce impulsive choices of smaller sooner rewards instead of larger later rewards, although the latter are ‘liked’ more. The paper suggested to observe need deprivation states, consumer knowledge, cues, and (lack of) self-control and to use these observations to test predictions regarding impulsivity made by the incentive salience model. Besides this predictive capacity, the incentive salience model offers possible explanations for the domain effect (certain types of reward elicit steeper discount rates than others) and the magnitude effect (smaller rewards are more rapidly discounted than larger rewards). Moreover, implications of understanding impulsivity as characterized by ‘wanting’–‘liking’ dissociations were presented.

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