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Review

Motivation and reward mechanisms in health behavior change processes

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A B S T R A C T

With increasing prevalence of lifestyle-related chronic diseases worldwide, understanding health behavior change and the development of successful interventions to support lifestyle modification is gaining increasing interest among politicians, scientists, therapists and patients alike. A number of health behavior change theories have been developed aiming at explaining health behavior change and understanding the domains that make change more likely. Until now, only few studies have taken into account automatic, implicit or non-cognitive aspects of behavior, including emotion and positive affect. Recent progress in the neuroscience of motivation and reward systems can provide further insights into the relevance of such domains. In this integrative review, we present a description of the possible motivation and reward systems (approach/wanting = pleasure; aversion/avoiding = relief; assertion/non-wanting = quiescence) involved in behavior change. Therefore, based on established theories encompassing both initiation and maintenance of behavior change, we create a flexible seven-stage behavior change process with three engagement phases (non-engagement, motivational engagement, executive engagement) and relate the motivation and reward systems to each of these stages. We propose that either appetitive (preferably) or aversive motivational salience is activated during motivational engagement, that learning leads to continued behavior and that assertive salience prevails when the new behavior has become habitual. We discuss under which circumstances these mechanisms and reward-motivation pathways are likely to occur and address potential shortcomings of our proposed theoretical framework. We highlight implications for future interventions aiming at lifestyle modification.

1. Introduction

Worldwide, the prevalence of chronic diseases has increased dramatically. The prevalence of diabetes, for instance, has risen from 4.7% (108 million) in 1980 to 8.5% (422 million) in 2014 (World Health Organization, 2016) and the number of patients with diabetes type 2 is estimated to increase from 382 million (in 2013) to 592 million in 2035 (International Diabetes Federation, 2013). The related cost burden is high. For diabetes, e.g., annual costs of type 2 treatment have been calculated to be on average 1.8 times higher than those for other diseases (Ulrich et al., 2016). These tremendous costs on health care systems are being accompanied by disease management efforts applied by the patient, family members and therapists (Ellrodt et al., 1997; Korff et al., 1998; Wagner, 2000). Over and above, comorbidities as well as individual physical and emotional suffering frequently occur (Moussavi et al., 2007; de Ridder et al., 2008; Stewart et al., 1989). It has been estimated that the diabetes type 2 risk is predominantly attributable to lifestyle-related rather than genetic risks (Langenberg et al., 2014) and that 90% of diabetes type 2 cases could be prevented through lifestyle changes (Willett, 2002). Figures for other chronic lifestyle-related diseases like cardiovascular disease, asthma, arthritis and cancer are of similar magnitude (OECD, 2019) and equally call forth interventions to support health behavior change.

Lifestyle changes that have been shown to significantly improve chronic disease conditions such as diabetes include increased exercise, healthier nutrition, reduced alcohol intake and smoking cessation (Knowler et al., 2002; Morris et al., 2019). However, most individuals have difficulties reaching their lifestyle goals. This is no surprise, as lifestyle change consists of a series of personal decisions which frequently involve the foregoing of immediate pleasure in favour of a potential future health improvement (Hall and Fong, 2015; Stroebe et al., 2008, 2013). Nevertheless, engaging the patient in his or her health has become a priority for practitioners, politicians and stakeholders, likewise (Esch, 2018).

Many established social psychological theories on health behavior change are concerned with the determinants of and motives for

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initiation of behavior change (e.g., Bandura, 1989; Cane et al., 2012; Gollwitzer, 1999; Ryan and Deci, 2000), whilst fewer theories take into account the domains that enhance the likelihood of maintaining a new behavior after initiation (Kwasnicka et al., 2016; Prochaska et al., 1988; Rothman et al., 2004; Schwarzer and Luszczynska, 2008; Weinstein and Sandman, 1992).

Among the domains identified are social, biological, psychological, cognitive and environmental factors. A limitation to the theories is their emphasis on behavioral intentions, which involve cognitive processing (Van Cappellen et al., 2018). However, past research has shown that day-to-day health behaviors are often shaped by implicit emotions and autonomous, non-cognitive motives rather than by reflective, cognitive willpower (e.g. Hall and Fong, 2007; Kahneman and Tversky, 1982; Marteau et al., 2012; Sheeran et al., 2013; Strack and Deutsch, 2004). In addition, previous research has shown that health behaviors experienced as pleasant are more likely to be repeated (e.g., Cohn and Fredrickson, 2010; Esch and Stefano, 2004; Fredrickson et al., 2020; Rhodes and Kates, 2015; Woolley and Fishbach, 2017). Overall, the understanding of the underlying mechanisms remains underdeveloped. One promising account is the 'upward spiral theory of lifestyle change' by Van Cappellen et al. (2018), which posits that positive affect experienced during new behavior increases the likelihood of future engagement in that behavior. Recent progress in neuroscience on motivation and reward systems can provide further insights into the relevance of such domains. In particular, three types of motivational states, namely approach motivation, avoidance motivation and assertion motivation, seem to play key – but presumably distinguished – roles during initiation and maintenance of modified health behavior. In this integrative review, we aim at shedding light on those understudied linkages in health behavior change. We do so by integrating the evidence on motivation and reward systems and their underlying physiology, i.e. neurobiology, with behavior change processes discussed in the social-psychological literature. Therefore, we merge established multi-stage health behavior change models into an all-encompassing, comprehensive framework including seven stages of health behavior change. These stages can be comprised into three levels of engagement. We then offer a theoretical framework of the neurobiological mechanisms behind the experiences of approach, avoidance and assertion motivation and relate these mechanisms to various stages of the health behavior change process. Understanding these mechanisms serves as a basis for planning future interventions that aim at lifestyle modification, such as goal-directed (cognitive) behavior change measures or stimulus-driven (non-cognitive) nudging interventions. Finally, we discuss implications for testing the propositions and address limitations of our proposed account.

2. Synthesizing multi-stage behavior change theories

Multi-stage health behavior change theories aim at explaining the various steps an individual has to take – or phases an individual has to go through – in order to take up a new health behavior and make it a habit. A number of those theories (examples below) provide suggestions for the domains relevant to progress along the change process, with different degrees of granularity or evidence. These theories vary in the number of stages proposed and their behavioral focus.

A recent systematic review of health behavior change theories that exhibit a particular focus on the maintenance aspect of behavior change has identified five common themes relevant to maintenance: Maintenance motives, self-regulation, resources, habits as well as environmental and social influences (Kwasnicka et al., 2016). All of these themes involve cognitive awareness or effort applied by the individual, except habit. The authors' definition of habit points out the relevance of automatic responses to relevant cues or stimuli, which has been taken into context in only ten of the100 theories reviewed by the authors. Overall, the authors stress a lack of theoretical elaboration on the process of maintenance after initial change present in the literature (Kwasnicka et al., 2016).

In order to integrate neuroscientific advances on the role of motivation systems and endogenous reward mechanisms with social-psychological behavior change theories, we require a theory, which provides a certain granularity of stages but is also practical to use and not too complex. As for none of the existing theories, unambiguous evidence for the effectiveness of theory-based interventions to change health behaviors has been provided (Gourlan et al., 2016; Prestwich et al., 2014), we do not base our elaboration on just one theory. Instead, we synthesize several exemplary theories that (i) have frequently been discussed, applied and tested in the literature and (ii) provide an account of several stages of behavior change, including the aspect of maintenance. Our employed theories vary in their number and definition of stages, but allow a general matching of overlapping phases within a behavior change process. The chosen theories are the Transtheoretical Model of Change (TTM) (Prochaska et al., 1988, 2008; Prochaska and Velicer, 1997), the Health Action Process Approach (HAPA) (Schwarzer et al., 2011; Schwarzer and Luszczynska, 2008), Rothman's theory of maintenance (Rothman, 2000; Rothman et al., 2004, 2011), the Precaution Adoption Process Model (PAPM) (Weinstein, 1988; Weinstein and Sandman, 1992, 2002) and the Rubicon Model of Action Phases (Gollwitzer, 1990). We scanned the definitions of the various stages for overlaps and generated seven stages of a health behavior change process, which are (1) *unawareness*, (2) *awareness*, (3) *contemplation*, (4) *planning*, (5) *initiation*, (6) *continued action,* and (7) *maintenance*. The stages, their definitions and the related stages of the five underlying theories are presented in Table 1.

The stages *unawareness* and *awareness* correspond to the stages unaware of issue and unengaged by issue defined in the PAPM. *Awareness* is in line with the TTM's precontemplation stage, which is defined as "people are not intending to take action in the foreseeable future […]" (Prochaska and Velicer, 1997, p. 39). In the *contemplation* stage, the individual is thinking about changing behavior but has not made any concrete plans to implement the new behavior yet. This stage is derived from the PAPM, the TTM and the HAPA theories and is also part of the Predicisional Action Phase in the Rubicon Model. Having made a decision, the individual enters the *planning* stage and makes concrete plans to implement the new behavior at a certain point in time. This stage has equivalents in the PAPM, the TTM, the Rubicon Model and the HAPA, whereas in the HAPA model, action planning' and coping planning' are listed as separate stages. The *initiation* stage we define as having pursued the desired health behavior for the first time. We suggest this corresponds to actinǵ in the PAPM, implementatioń in the TTM, initiativé in the HAPA, and initial responsé in Rothmańs maintenance model. The actional phasé in the Rubicon model comprises not only *initiation* but also *continued action* and *maintenance*. Whereas most theories define maintenance as the stage following initiation (e.g. PAPM, TTM and HAPA), Rothman et al. (2004) differentiate this stage further. They describe continued response, maintenance and habit, from which derive the *continued action* and *maintenance* stages in our suggested process of health behavior change. As will become more obvious below, the threefold distinction of *initiation*, *continued action* and *maintenance* is important when matching motivation and reward systems to the individual stages. The *continued action* and *maintenance* stages differ by their degree of regularity, i.e., the individual is at the *maintenance* stage when the behavior is carried out on a regular basis rather than infrequently and unregularly as in *continued action*. The *maintenance* stage in our synthesis corresponds also to 'habit formation' defined by Verplanken and Orbell (2003) as a regular and automatic execution of the new behavior. We do not further differentiate 'habit strengths' (Gardner, 2015; Hagger, 2019; Verplanken and Orbell, 2003), as this does not promise added value in the present context. Finally, we also leave aside termination (TTM) and the postactional phase (Rubicon) as they seem irrelevant for our purpose.

In contrast to, for instance, the TTM, these seven stages are not defined as a *linear* process. Instead, stages can be skipped, individuals

Table 1
Seven stage behavior change process.

Stage	Definition	Precaution Adoption Process Model (Weinstein and Sandman, 2002)	Transtheoretical Model (Prochaska et al., 2008)	Health Action Process Approach (Schwarzer and Luszczynska, 2008)	Four Phases of the Behavior Change Process (Rothman et al., 2004)	Rubicon Model of Action Phases (Gollwitzer, 1990)
Unawareness *Non-engagement*	*The individual does not know about the benefits of behavior change*	Unaware of issue				
Awareness *Non-engagement*	*The individual knows about the benefits of behavior change but does not intend to change behavior (yet)*	Unengaged by issue	Precontemplation			Predecisional Action Phase
Contemplation *Motivational Engagement*	*The individual is thinking about changing behavior but has not made any concrete plans to implement the new behavior*	Deciding about acting	Contemplation	Intention *Motivational Phase*		
Planning *Motivational Engagement*	*The individual makes concrete plans to implement the new behavior at a certain point in time*	Decided to act	Planning	Action Planning *Volitional Phase* Coping Planning *Volitional Phase*		Preactional Phase
Initiation *Executive Engagement*	*The individual has carried out the new behavior for the first time*	Acting	Implementation	Initiative *Volitional Phase*	Initial response	Actional Phase
Continued Action *Executive Engagement*	*The individual has carried out the behavior several times*	Maintenance	Maintenance	Maintenance & Recovery *Volitional Phase*	Continued response	
Maintenance *Executive Engagement*	*The individual has carried out the behavior on a regular basis*				Maintenance Habit	
			Termination			Postactional Phase

can experience relapse, do not have to be cognitively involved in reaching a next step, nor do particular steps have to last for a particular duration of time (see Fig. 1 below). In fact, the lack of these features has been one of the main criticisms of the TTM (e.g., Ceccarini et al., 2015; Marshall and Biddle, 2001; Romain et al., 2018; Rosen, 2000).

In addition to the seven stages, we define three phases of engagement, namely (i) non-engagement, encompassing the stages *unawareness* and *awareness*, (ii) motivational engagement, containing the stages *contemplation* and *planning*, and (iii) executive engagement, which includes the stages *initiation*, *continued action* and *maintenance*. The engagement phases are characterized by the level or type of involvement in the new behavior and, as will be discussed below, motivational salience that is of functional necessity to progress along the stages. In this model, individuals are neither actively pursuing a new behavior nor yet motivated to do so at the non-engagement phase, while at motivational engagement, the individual is already motivationally activated. The latter can occur either without the individual being aware of it or with cognitive (conscious) involvement (intention). During the

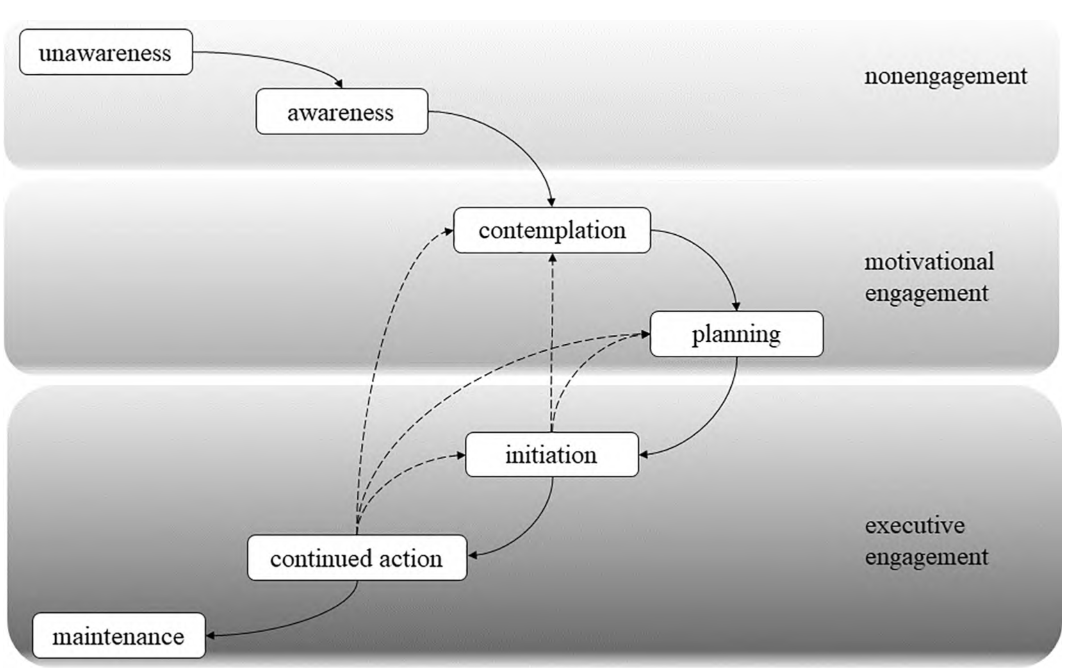

Fig. 1. Seven stage behavior change process.

executive engagement phase, motivation is translated into action and then habituated.

3. Motivation and reward systems

3.1. Three types of motivation

Motivation describes processes that lie at the core of biological, cognitive and social regulation (Esch and Stefano, 2004), including the regulation of intensity of behavior that leads to the attainment of a particular goal or stimulus (Puglisi-Allegra and Ventura, 2012). We define stimuli as concrete physical objects, mental representations or memories of such objects, abstract concepts, or possibilities that are anticipated for the future (Eder and Hommel, 2013; Elliot et al., 2013; Scholer et al., 2013). In relation to health behavior, these stimuli may be physical activity, healthier eating, smoking cessation etc., or the resulting increase in physical fitness, weight loss or other health benefits. The pursuit of stimuli is based on affects (or *basic emotions*, see Ekman, 2005; Ekman and Cordaro, 2011) and can be automatic and occur with or without awareness. When cognitively processed, we may call these stimuli *goals*. Hence, behavior can be stimulus-driven (affective) or goal-directed (cognitive) (Bourgeois et al., 2016).

Motivational salience is the attribute of a stimulus and can be appetitive, aversive (Puglisi-Allegra and Ventura, 2012), or assertive (Esch, 2017; McCall and Singer, 2012). The existing literature does not differentiate between assertive and appetitive motivation; usually, both are considered approach motivation. However, here, we purposely distinguish between the three types of motivational processes (i.e., approach motivation, avoidance motivation and assertion motivation), as they exhibit different physiological/neurobiological processes and we are interested in their distinct roles within health behavior change processes.

3.2. Approach motivation

Approach motivation, or appetitive (incentive) salience, is directed towards stimuli or goals that are associated with positive, hedonic, pleasurable processes (Bozarth, 1994; Elliot et al., 2013; Esch and Stefano, 2004) and functionally associated with the wanting-system, reward expectation, performance and action (Esch, 2017). When approach (appetitive) motivation has led to achievement of the stimulus or goal, a reward is experienced as a pleasurable feeling (which could also remain unnoticed, depending on, e.g., the intensity of the experience). Reward does not lie in the stimulus or goal itself, but in the composite of active psychological and corresponding neurobiological processes that occur in context of positive anticipation (expectation) and as a subsequent reaction to a stimulus or goal (Berridge and Kringelbach, 2008; Schultz, 2015).

Assigning discrete categories of experience to the types of motivational processes is not self-evident. However, it is widely accepted in the literature that individuals continually engage in basic evaluations of stimuli as beneficial or detrimental (Elliot et al., 2013). These evaluations are often characterized as fundamental affective experiences (Cacioppo et al., 1999; Elliot et al., 2013; Lang and Bradley, 2013; Rolls, 2013; Schneirla, 1959). In simple terms, approach motivation emphasizes the expectation of a reward in form of pleasurable feelings, or positive affect, e.g. joy, pleasure and excitement.

The concepts of motivation have underlying core physiological mechanisms occurring in brain areas that are distinct from other sensory or cognitive areas (Esch, 2017; Kringelbach, 2005). The mechanisms related to approach motivation are commonly described within the explanation of the approach motivation and reward system, which is embedded in the central nervous system (CNS). A crucial part of the CNS approach motivation and reward system are nerve cells that have their origin in the ventral tegmental area (VTA) (Esch and Stefano, 2004, 2010). These nerve cells send projections to the frontal brain, mostly to the nucleus accumbens (NAC) (Nestler, 2001; Nestler, Malenka, and Hyman, 2001). Via the mesolimbic pathway, the neurotransmitter dopamine, which is essential to this system, is connecting VTA and NAC during first pairing of the stimulus with the reward or when there is a stimulus that predicted reward in the past (Berridge, 2007; Smith et al., 2011), i.e., "dopaminergic activity promises positive feelings" (Esch, 2017, p. 75). The NAC signals the desire to obtain a reward and the level of effort to do so, i.e. it determines appetitive motivational salience. In addition, reward is measured and regulated by the VTA-NAC pathway; it signals the other brain centers how rewarding an activity is (Esch and Stefano, 2004). The intensity of expected reward, consequently, determines how likely an individual is to remember and repeat it (Esch and Stefano, 2010). The hippocampus, as part of the (para)limbic system, serves as the "front gate" for experiences to be recognized and remembered (Esch and Stefano, 2004; Nestler and Malenka, 2004).

In addition, with the help of the amygdala, the assessment of experiences as pleasurable or detrimental occurs within the endogenous reward system, which also helps generating links between an experience and other stimuli (Esch and Stefano, 2010; Nestler, 2001; Nestler, Malenka, and Hyman, 2001). Such information is processed by the mesocortical dopamine pathway in the frontal cortex, which is key to calculating the "costs" (disadvantages) over the likelihood of reward, considering "costs" and risks of reward pursuit. Here, the ultimate behavior is consequently determined (Esch and Stefano, 2010).

3.3. Avoidance motivation

Aversive motivational, or negatively-valenced fearful salience, is related to the avoidance of threat and punishment (as an opponent to receiving reward) and related to the fight-flight-freeze system (i.e., stress physiology, stress response) (Bozarth, 1994; Esch, 2017; Esch and Stefano, 2004; Seymour et al., 2007). It is usually being triggered by a frightening or challenging stimulus and compels a motivated response of avoidance, i.e., getting away from unpleasurable conditions. Punishment, which is associated with a reduction of response strength (passive avoidance) can further be distinguished from negative reinforcement, associated with enhancing response strength (active avoidance) (Schultz, 2015). Hence, in comparison to active fear reactions (fight or flight) as a result of a fearful stimulus, more passive freezing reactions can also occur (Berridge, 2018). The negative affects linked to avoidance motivation are, for example, anxiety, fear and disgust (Cacioppo et al., 1999; Elliot et al., 2013; Esch, 2017; Hirschberg and Manning, 2015; Lang, 1995; Watson et al., 1999). Functionally embedded in the stress system, avoidance motivation is associated with increased sympathetic activity, including the release of cortisol, (nor-)adrenaline, as well as, e.g., opioids and vasopressin (Esch, 2017), and rooted in the lower limbic system, mainly the amygdala and the hypothalamus (pituitary gland).

When real or imagined threat is anticipated, two central signaling pathways are activated. One is via the hypothalamus, which receives its impulses from cortical, subcortical, limbic and brainstem areas, to the pituitary gland, where hormones are secreted into the blood that lead to the release of cortisol from the adrenal cortex. Cortisol is particularly responsible for providing energy for 'fight and flight' (Esch, 2017). The other pathway is via the sympathetic autonomous nervous system. Here, too, the hypothalamus, but above all the brainstem and the catecholamine systems, play a major role. Nerve impulses are transmitted from here to the peripheral organs and the adrenal medulla. From there, the stress hormone adrenaline (or noradrenaline) is released. This second pathway is the faster, more immediate one and it particularly affects the circulatory and organ functions (Esch, 2017). The aforementioned freeze reaction is functionally embedded in the amygdala circuitry (LeDoux, 1998).

The outcome of successful passive or active avoidance behavior can result in relief, which is a positive, low-arousal basic emotion/affect (Krisam et al., 2017; Levenson, 2011) that can be caused by an expected or unexpected change consistent with the motive. At the point of relief, the aversive stimulus is absent (Deutsch et al., 2015). Hence, psychologically, relief results from the reduction of the impact of a negative stimulus and can be experienced as relaxation and/or reward, i.e., '*no stress*'.

Physiologically, relief is experienced, e.g., when the influence of the amygdala (i.e., stress) is reduced (Esch, 2017). Here, we see a strong relation between approach and avoidance motivation systems. In functional magnetic resonance imaging (fMRI)-based studies, it has been shown that the same brain areas are activated during both relief and other positive affects (Kim et al., 2007; Sangha, 2015).

3.4. Assertion motivation

The majority of research on motivation and reward has not distinguished between behavior driven by approach versus assertion motivation. In fact, they are often confounded or merged with each other (McCall and Singer, 2012), even though they exhibit different neurobiological processes, are rooted in partly distinct brain areas, and have different behavioral consequences. Assertion motivation, or assertive salience, is associated with the 'non-wantinǵ system, with inaction, acceptance or contentedness, homeostasis and quiescence; it describes the motivation to maintain a certain condition or state (Esch, 2017; McCall and Singer, 2012), and its associated positive valence is contentment. Thereby, assertion motivation differs from approach motivation in terms of related affective qualities (Esch, 2017; McCall and Singer, 2012). Assertion motivation can also be distinguished from approach motivation with respect to automatic responses and behavioral outcomes; assertion motivation is characterized by the absence of any noticeable action, because of implicit or reflective consent with the current state, for example, a newly habituated health behavior. This consent with the current state can be experienced as "perfectly happy", or content, inducing no intention to change it or move away from it, or approach towards something/somewhere else.

Functionally embedded in the parasympathetic autonomous nervous system, the assertive motivational state is linked to increased parasympathetic or vagus nerve activity, hence associated with a physio-psychological down-regulation, and states of relaxation. At the level of neurotransmitter systems, assertive salience is associated with endogenous opiates, oxytocin, acetylcholine, serotonin, as well as endocannabinoid signaling (Esch, 2017). Notably, the assertion motivation system is not, as compared to approach and avoidance motivation systems, characterized by an activation of dopaminergic activity. Rather, it is due to the absence or inhibition (decrease) of dopamine why individuals feel no drive or striving to change, generate or avoid new experiences through changed behavior. Brain areas involved during the activation of assertive motivation are, e.g., the midbrain, the vagus areas, cingulum, hippocampus and ventral striatum, as well as the hypothalamus and the pituitary gland.

4. Stimulus-driven and goal-directed behavior

The activation of all three types of motivation results from stimuli. These may originate either from external or internal sources likewise, can be short- or long-term in duration, and may be strong, medium, or weak in their intensity. Hence, a stimulus can activate automatic processes and lead to behavior without the individual having noticed the stimulus. This behavior we call stimulus-driven behavior. Has the stimulus been cognitively processed and has therefore been changed into a goal, the resulting behavior can be called goal-directed behavior. This distinction has mainly been discussed in the psychological literature. Here, we aim to integrate such psychological explanations of behavior with the aforementioned neurobiological understandings of motivation and reward processes in order to provide a ground for illustrating the role of motivational processes in behavior change and substantiate the non-linearity of the behavior change process.

It has been largely accepted in the psychological literature, that goals can be divided into controlled goals, which involve a reflective/cognitive process, and autonomous goals (Miquelon and Vallerand, 2006), which are, in essence, unnoticed stimuli. Both are able to elicit appetitive, aversive or assertive salience via reward expectations.

As explained above, appetitive salience is usually being triggered by stimuli and is experienced as a temporary increase in the desire to obtain an associated reward, i.e., positive affect (Berridge, 2012, 2018; Flagel and Robinson, 2017; Robinson et al., 2014). As explained, the encounter of the stimulus can occur unnoticed by the individual. Hence, appetitive salience can be activated independently of whether the stimulus is cognitively processed or not. In this way, appetitive salience may, even without cognitive involvement (planning), proactively lead to action and engagement (Berridge, 2018; Carver, 2009; Kruglanski et al., 2014; Ryan and Deci, 2000).

Goal direction (striving), on the other hand, is typically based on declarative memories and cognitive expectations of outcomes related to a behavior (Berridge, 2018). Goal-directed behavior, thus, usually involves an intention or plan that leads to the achievement of the goal. Whilst appetitive salience is physiologically embedded in the lower limbic level, i.e., mainly the amygdala, the upper limbic level, i.e., orbitofrontal and ventromedial cortex (Esch, 2017; Roth, 2009), are involved when stimuli are cognitively processed and goals are formed. Hence, stimulus-driven behavior can occur without the involvement of the upper limbic level. Both unnoticed stimuli and cognitively processed stimuli (goals), can lead to the same action and engagement. However, in goal-directed behavior, the individual is consciously involved in the process and, as explained below, undergoes several additional stages of a behavior change process.

Parallely, aversive salience can lead to affective fear (stimulus-driven) reactions or cognitive (goal-directed) avoidance reactions. Behaviors resulting from assertion motivation can also be stimulus-driven or goal-directed. A simplified graphic representation of stimulus-driven and goal-directed behavior is depicted in Fig. 2.

5. Relating motivation systems to behavior change processes

In the following, we link the stages of behavior change synthesized above with the different types of motivation and reward systems, thus highlighting the role of positive affect, and providing a rationale for the relations we aim to establish.

5.1. Non-engagement

The seven stage health behavior change process described above entails three phases of engagement. We suggest that during the first, non-engagement phase, which includes the stages *unawareness* and *awareness,* all types of motivation to change a behavior are yet absent. Progressing from *unawareness* to *awareness* solely requires an acquisition of information – or generation of knowledge – about the health improving potential of a behavior change

5.2. Motivational engagement

The new information gathered during the non-engagement phase can serve as a stimulus activating motivational salience, thus "transferring" the individual into the motivational engagement phase. Here, the stage following *awareness* is the *contemplation* stage at which the individual, in case the stimulus has been noticed, may consider advantages and disadvantages, feasibility and potential gains from a behavior change. The intensity of the reward expectation plays a major role in the *contemplation* stage.

The *contemplation* stage is crucially determined by the type of motivational salience activated by the stimulus. Individuals may be either content with the current state, i.e., assertive salience is activated, or prefer a change, i.e., appetitive or aversive salience is activated. If assertive salience is activated, the prospect of maintaining the current

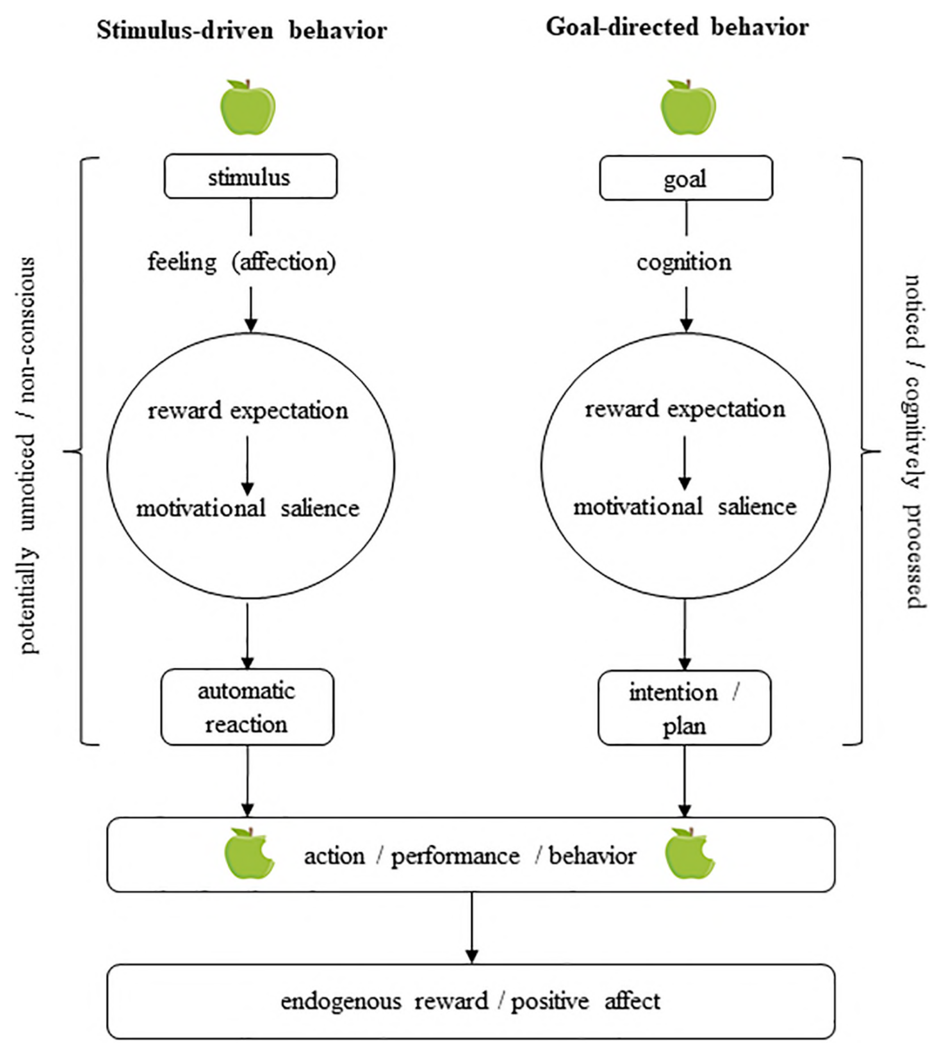

Fig. 2. Simplified representation of stimulus-driven and goal-directed motivation.

state is associated with positive valence of calm, quiescence and/or relaxation as a result of the release, e.g., of endogenous opiates, oxytocin and related neurotransmitters, and parasympathetic activity. Behavioral inaction is the result and, consequently, the behavior change process comes to an end. If the stimulus, however, leads to the activation of appetitive or aversive salience, then information is processed by the mesocortical dopamine pathway in the frontal cortex and a preference for a new behavior is set (Esch and Stefano, 2010). From here, the motivated individual transfers to the next stage.

On the seven stage behavior change process, as defined here, the next stage is *planning*, which is a cognitive, goal-driven action (see Fig. 2): thinking, reflecting, and evaluating, involving the upper limbic level. During the *planning* stage, the individual is motivationally – but not yet executively – engaged in the behavior change process. Theoretically, this stage is independent of whether appetitive or aversive salience is activated, as, presumably, both types of motivational salience lead to similar or corresponding behavioral actions. The perceived urgency may differ, though, but there has not been, to our knowledge, any research on these potential correlations, so far. Yet, below, we discuss the role of positive and negative framing of stimuli and goals.

The cognitive action of *planning* is driven by motivational salience, and may result in an intention, or a set of intentions (plan). Whilst part of the motivational engagement phase, the *planning* stage can involve preparatory physical actions, for example, the purchase of running shoes allowing the implementation of the new behavior (i.e., exercise). We assume that *planning*, due to its cognitive action, can only occur in goal-driven behavior, and not in solely stimulus-driven behavior. Hence, the *planning* stage could be skipped in a stimulus-driven behavioral change process.

The *awareness* and *contemplation* stages also do not necessarily require the cognitive involvement of the individual. In fact, each or all of these stages assigned to motivational engagement could be skipped, when the encountered stimulus and activated motivational salience remains unnoticed. Remember that we did not define a linear process, but a model that allows for "jumps" and "relapse", and discussed that approach or fear/aversion mechanisms can be activated without the individual being aware of it (see stimulus-driven behavior in Fig. 2).

5.3. Executive engagement

The first stage of the executive engagement phase, *initiation*, is the behavioral consequence of a response-outcome mechanism, i.e., the individual is actively responding to the appetitive or aversive motivational salience resulting from the encounter (and processing) of a stimulus. The *initiation* stage follows directly the *awareness* stage when the stimulus and the related motivational salience activated remain unnoticed. The *initiation* stage follows upon the *contemplation* or *planning* stage when the stimulus has been cognitively processed and resulted in a goal, intention, or even a plan.

The initial action results from the expectation of pleasurable feelings such as joy and excitement (positive stimuli) or relief (avoidance of negative stimuli). The assessment of experiences as pleasurable or unpleasurable occurs within the endogenous reward system (e.g. amygdala), which also includes generating links between an experience and other stimuli. Given the expectation of a positive experience is met, such experience inhibits a memory of the experience, and leads, consequently, to an expectation of reward from the same action, so that the action is likely to be reiterated (Van Cappellen et al., 2018), known as reward responsiveness (Carver and White, 1994). Recording memories of experience, including where, when and with whom it occurred, happens with the involvement of the hippocampus (Esch and Stefano, 2004), i.e., learning takes place (Esch and Stefano, 2010; Nestler, 2001; Nestler, Malenka, and Hyman, 2001). This learning process can lead to reciprocal effects: Over time, associations between positive affect and stimuli predictive of it, and memories of it, may endow those stimuli with appetitive salience, making them more likely to capture attention in the future (Van Cappellen et al., 2018; Fredrickson and Joiner, 2018). Such stimulus–response associations are characteristic of operant learning, i.e.. behavioral learning by doing – trial and error –, as opposed to classical or linear learning (Guo et al., 2016). When those stimuli are subsequently encountered, their heightened salience triggers approach or avoidance behaviors (Van Cappellen et al., 2018), and we speak of response-outcome associations (Guo et al., 2016). Hence, learning directs behavior towards the expected outcomes.

We can contrast rewards being positive reinforcements against punishment producing negative learning or reinforcement (Berridge, 2018). The experience of negative affect resulting from punishment increases the expectation of punishment when the negative stimulus (threat) is encountered repeatedly, leading to passive and/or active avoidance behavior (LeDoux, 1998). In terms of health behavior, for example, the experience of weight gain through sedentary behavior may represent such punishment, experienced as negative affect like fear of even more weight gain, or detrimental health consequences. Vice versa, the experience of weight loss through an increase in exercise behavior acts as positive reinforcement likely to elicit a repetition of physical activity.

The experience of reward does not depend on whether the stimulus was cognitively processed as a goal or not. The intensity of the reward may, however, be stronger when the stimulus was pursued with cognitive involvement. The activation of endogenous reward through initiating of the new behavior activates a learning process through the association between the new behavior and the positive affect experienced. As a consequence, reward expectancy increases, i.e., the aforementioned reward responsiveness (Carver and White, 1994) may lead to *continued action*. *Continued action* strengthens the response-outcome association between pleasantness and the stimulus predictive of it, and the same stimulus is more likely to capture attention in the future (Van Cappellen et al., 2018; Fredrickson and Joiner, 2018).

In sum, approach motivation emphasizes the expectation of a reward in form of pleasurable feelings, or positive affect (Esch, 2017), and is reiterated when the expectation is met (Van Cappellen et al., 2018) because of a learning process. Therefore, approach motivation processes most likely lead to repetitions of initiated new behaviors, given that the new behavior induces a similar, or greater, intensity of endogenous reward as compared to the old behavior. However, the autoregulatory nature of approach motivation entails impactful – but potentially fading – reward intensity, since the very same behavior, by pure repetition and then habituation, will pay less reward over time when no reinforcement cues are built in. In fact, approach motivation characterizes intense but limited reward experiences in that they are self-terminated by their very nature – as they would otherwise lead to addictive behavior, or a weakening and then attenuation of the desired behavior change (Esch and Stefano, 2004). Similarly, learning processes result from the successful avoidance of a negative stimulus, with potentially fading positive valence (relief) from repeated avoidance behavior as a reaction to the same negative stimulus (Deutsch et al., 2015).

Hence, the likelihood of repetition, and thereby the progress into the *continued action* stage, depends on the intensity of endogenous reward that is experienced from the new behavior in comparison to the reward experienced from old behavior.

After frequent repetition of the stimulus-driven or goal-directed behavioral action, the individual finally enters the *maintenance* stage. The continuous operant learning process leads to the formation of habit (Schultz, 2015). This implies that habits cannot be learned with a one-time performance but develop from repetition of behavior (Schultz, 2015), i.e., sequence of trial and error, pursued during a goal-directed or stimulus-driven learning phase. At this final *maintenance* stage, the behavior is repeated on a regular basis.

At this stage, we suggest that the assertion motivation and reward system is active, i.e., the now habitually performed behavior is driven by assertive salience. The experience of contentment, quiescence or calm during the activation of the parasympathetic nervous system, and other down-regulatory pathways, motivates to maintain the new behavior, meaning that a 'non-wanting' of further behavior change prevails.

All in all, whilst no motivation system is yet activated during the non-engagement phase, either approach or avoidance motivation drive preparatory behavior during the motivational engagement phase. Both types of motivation are likely to lead into the executive engagement phase. Learning through the experience of reward happens throughout the executive engagement phase, reiterating approach and avoidance behaviors until assertion motivation is activated at the maintenance stage.

6. Implications for health behavior change interventions

Throughout the discussion above, we have made a difference between stimuli and goals. This differentiation plays a crucial role when determining which factors influence behavior change and when developing behavior change interventions. Whilst motivational salience and goal striving often go together (Berridge, 2018), the differentiation made is important, because motivational salience may remain unnoticed by the individual. When these stimuli, cues, or triggers are intentionally applied in an environment to drive behavior of individuals or groups, they are also called nudges (Thaler and Sunstein, 2008). Nudging involves affective components of decision-making, which makes the desired behavior motivationally more attractive – with freedom of choice still persisting – and its implementation playful or intrinsically rewarding. Nudges, such as advertisements or food placements, increase appetitive or aversive salience, and hence lead to a temporary increase in the desire to obtain an associated reward, or getting relief from an unpleasant stimulus or situation. As the intensity of expected reward determines how likely an individual is to remember and repeat it (Esch and Stefano, 2010), nudges can further be used as reinforcement strategies (Kahneman, 2011; Kahneman and Tversky, 1979). Frequently applied reinforcement strategies in the context of health behavior are, for example, point systems (gamification).

More recent work has demonstrated that the formation of goals, and therefore goal-directed behavior, can also be primed (i.e., influenced) by motivational stimuli (Bargh et al., 2001; Custers and Aarts, 2010). In particular, Aarts et al. (2008) have suggested an affective/motivational account of the aforementioned goal-pursuit in which motivational cues, e.g., nudges, strengthen goal activation and maintenance, even when this occurs outside of an individual's awareness (Chiew and Braver, 2011). Autonomous goal formation (i.e., the formation of goals without the individual cognitively building them) occurs, for example, because other peoples' goals can be 'contagious', i.e., goals can be developed without notice, for example, through social comparison (Custers and Aarts, 2005; Custers and Aarts, 201). Hence, understanding the development and role of motivational salience in the behavior change process allows to develop suitable nudges that direct people's behaviors into their desired direction. Whilst this exemplifies an interdependent approach, individuals can nudge themselves. Considering the findings of fruit placement experiments (Hansen et al., 2016; Wansink et al., 2011), for example, an individual is likely to eat more fruit when a bowl with fresh fruit is placed where one regularly passes by and looks at routinely, compared to when fruit is placed in a more hidden space. This type of priming, as one form of nudging, is likely to increase the awareness of fruit and thereby the probability to grapping and eating more of it.

Another aspect relevant to behavior change intervention planning is the aspect of positively versus negatively framed goals (or nudges), which determines whether appetitive or avoidance motivation is activated. In our elaboration of the relation between motivation and behavior change, we refrained from distinguishing between positive and negative health behaviors so far. This is in contrast to some previous studies, e.g., Van Cappellen et al. (2018), who discuss only physical activity and healthy eating as positive health behaviors. We claim, in accordance with a number of studies, that the *framing* of a stimulus or goal crucially determines success, and also well-being and other psychological outcomes related to the pursuit/achievement of a goal or the habituation of a new behavior (e.g., Coats et al., 1996; Roney et al., 1995). In our context, the way the stimulus or goal, i.e., the preferred (result of the) health behavior, is framed is of critical relevance. The framing of the stimulus or goal determines the type of motivational process involved. For example, for an individual who wants to quit smoking, the goal can be framed positively as "I want to live smoking-free", which inherently elicits appetitive salience because of the expectation of living free from the urge to smoke. In contrast, the negative framing "I want to stop smoking" intends to the same behavioral outcome but more likely leads to the elicitation of avoidance salience, since relief from something that is labeled unpleasant and should thus be avoided would be expected. Similarly, for an individual who wants to increase his or her level of physical activity, a positive frame "I want to exercise more" (approach motivation) can be distinguished from a negative frame "I want to sit less" (avoidance motivation).

As explained above, motivation emphasizes the expectation of a reward in form of pleasurable feelings, or positive affect (Esch, 2017). Therefore, motivation and reward processes most likely lead to repetitions of initiated new behaviors. For doing so, the 'context' of the new behavior, and how it originally was achieved, have to be remembered as well, besides the behavior itself; this, too, has to be marked (labelled) with a positive emotion, or affect, and stored in the brain (memory), so it can later be recalled more quickly from memory, and the behavior then, finally, successfully repeated.

Even though both approach and avoidance motivational salience increase attention and motivational meaning, we believe that approach rather than avoidance motivation is the preferred motivational process when it comes to health behavior change. This preference over the activation of avoidance motivation is due to the implication of negative affect, active coping responses and sometimes even defensive attacks associated with avoidance motivation (Higgins, 2006), as well as the activation of sympathetic activity including the release of stress hormones such as cortisol and (nor-)adrenaline. In addition, the brain's plasticity, and thus medium-to-long-term structural change of the behavioral memory, increases with positive affect expectations (e.g., dopamine), increased curiosity, trust and operant learning. In contrast, avoidance (learning) is based on short-term survival principles, i.e., the expectation of threat or punishment builds up rather linear mechanisms and tends to set up on short-term and familiar (standard) mechanisms because of the speed of processing threat. Consequently, plasticity is rather reduced under chronic avoidance motivation, as stress, for example, causes the hippocampus to shrink (Sevinc et al., 2019, 2020).

Our preference is in accordance with other authors. For example, the 'upward spiral theory of lifestyle change' explains that, to the extent that positive affect is experienced during a new health behavior, it creates autonomous motives for that activity, i.e., it increases appetitive salience for stimuli associated with this behavior (Van Cappellen et al., 2018). The experience of positive affect builds a row of endogenous 'vantage', e.g., biological, cognitive, physical and social, resources (Fredrickson, 2013; Pluess and Belsky, 2013), such as physical health and resilience. These render individuals more sensitive to subsequent positive experiences. In addition, while approach motivation is resource-building (Fredrickson, 2013), avoidance motivation has been shown to be resource-depleting (Elliot et al., 2013). The low-arousal affect of relief at the point of successful avoidance is, as we argue, presumably not able to compensate the negative affects experienced during the activation of aversive salience and constant threat expectation. In addition, positive affect experienced during physical activity appears to be especially important in this regard (Van Cappellen et al., 2018; Rhodes and Kates, 2015), as they act as reinforces.

Hence, approach motivation rather than avoidance motivation contributes positively to the individual's overall well-being, and the initiation of change. We suggest that behavior change interventions should thus focus more on positive stimuli and positively framed goals rather than evoke fear and threat through negatively framed stimuli and goals.

7. Limitations

The lack of research on the role of motivation in health behavior change has led us to the idea of linking social-psychological behaviour change theories with modern understanding of motivation and reward mechanisms discussed in the neurobiological literature. Due to a number of varying theories and models present in the literature, the proposed nexus is one of potentially different ways of explaining the complex relationships present in human behavior. Especially the differentiation between automatic/non-cognitive and reflective/cognitive aspects of human behavior is predominantly discussed by psychologists, and a one-to-one overlap with neurobiological models is not expedient. The models we have chosen represent frequently discussed, modern views of behavior and motivation. We do not claim, however, to provide an all-inclusive model. Especially the increasingly popular dual-process models (Hall and Fong, 2015; Kahneman and Tversky, 1982; Strack and Deutsch, 2004) are directly related to the proposed account and can be considered as the essential base of the discussion, even though they have not been elaborated on in this article. These have been left out of the discussion here, because they do not particularly focus on motivation and reward per se, but on general implicit / non-conscious domains or resources potentially affecting behavior (change). In addition, a number of other behavior change models could have been used to synthesize the seven stage behavior change process. However, as it was more important to us to develop a general, basic behavior change process, rather than an all-encompassing, elaborated, evermore valid model. Instead, we suggest that its validity needs to be tested empirically.

Future research is also necessary in order to verify the propositions made regarding the role of the different types of motivation at various stages of a health behavior change process. An empirical investigation involving individuals who aim at changing their health behavior(s) would be fruitful in this regard.

Another limitation is the rather superficial presentation of positive and negative affects which are at the core of motivation and reward mechanisms. Clearly, different emotions/affects play distinct roles in the determination of motivational salience and reward intensity. A higher level of granularity would have rendered the presentation of the proposed relationships overly complicated. We hope for future research analysing these details further.

Finally, it is important to note that motivation as a single domain is not sufficient for lasting behavior change. An individual, we argue, requires a number of resources in order to become and stay engaged, i.e., progress from one stage to the next within the individual change process. These other domains could not be depicted in the present account in order to keep matters simple, yet still comprehensive.

8. Conclusion

A large number of health behavior change interventions have been developed, implemented and evaluated. Usually, these interventions focus – often without explicitly stating it – on one of many domains that individuals seem lacking in order to initiate or maintain health behavior change. Thus, deficits instead of resources, or positive motivation and reward, predominate. Efforts have been made to comprise those domains, or resources, into one framework with domain categories in order to provide an understanding for researchers and intervention developers. Van Cappellen et al. (2018) pose that a limitation to existing theories is their emphasis on cognitive domains. In addition, frequently cited health behavior change models propose a *linear* progress along stages that involve cognitive involvement. Day-to-day health behavior is, however, often determined by affects and autonomous, non-cognitive motives rather than by reflective, cognitive willpower. Understanding the role of endogenous resources, such as motivational salience, in addition to cognitive resources, provides an additional set of opportunities for understanding human behavior and developing interventions for effective behavior change.

We have thus provided a synthesis of behavior change models as a basis for discussing the role of motivation and reward processes within health behavior change initiation and maintenance. This synthesis serves as a basis to relate different aspects of motivation and reward mechanisms to individual stages of behavior change process.

In the course of this work, we have introduced three motivation and reward processes, namely approach, avoidance and assertion motivation. A further differentiation between non-cognitive – sometimes also referred to as non-conscious – and cognitive (conscious) motivational processes allowed for a distinction between stimulus-driven and goal-directed behavior change. We discussed at which stage of behavior change stimuli and goals as well as the three types of motivation and reward processes are relevant and provided an account of the underlying physiological/neurobiological processes.

We suggest that, in addition to domains like social, psychological and environmental, already discussed in the literature, also automatic, affective or "non-conscious" domains and processes inherent in human behaviour – especially neurobiological motivation and reward processes – play crucial roles in behavior change and yet critically affect human well-being.

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