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The principle of consistency and the cause and function of behaviour

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ABSTRACT

At all levels of information processing in the brain, neural and cognitive structures tend towards a state of consistency. When two or more simultaneously active cognitive structures are logically inconsistent, arousal is increased, which activates processes with the expected consequence of increasing consistency and decreasing arousal. Increased arousal is experienced as aversive, while the expected or actual decrease in arousal as a result of increased consistency is experienced as rewarding. Modes of resolution of inconsistency can be divided into purely cognitive solutions, such as changing an attitude or an associated motor plan, and behavioural solutions, such as exploration, aggression, fear, and feeding. Models and theories consistent with the principle of consistency are numerous, have a long and continuing history, and come from many different scientific fields, such as social psychology, perception, neurocognition, learning, motor control, system control, ethology, and stress. The present paper presents a brief overview of relevant information from these fields of research, while focusing mainly on the implications of the principle of consistency for the understanding of the cause and function of behaviour. Based on this overview, it is proposed that all behaviour involving cognitive processing is caused by the activation of inconsistent cognitions and functions to increase perceived consistency.

1. Introduction

The principle of consistency states that when two or more simultaneously active cognitive structures are logically inconsistent, arousal is increased, which activates processes with the expected consequence of increasing consistency and decreasing arousal. The function of a state of consistency is often assumed to be the avoidance of conflict in the production of behaviour and an increase in effectiveness of that behaviour (Berlyne, 1960; Collins, 1968; Gerard, 1968; Harmon-Jones, 2012; Ramachandran, 1996). A consistent cognitive system is a prerequisite to be able to accurately anticipate what is coming and to be able to adequately react to challenges and opportunities in the environment. In many fields of research concerned with the study of the behaviour of animal and man the principle of consistency has been applied in some form or another. The present paper presents a brief overview of relevant ideas and models from these fields in order to show that theory and research on cognitive consistency can be and have been fruitfully applied to advance our understanding of the cause and function of behaviour.

The term "cognitive consistency" was first used in the field of social psychology (McGuire, 1960) and the application of the principle of consistency has a long and continuing history within that field (e.g., Abelson et al., 1968; Gawronski and Strack, 2012a; Mower White, 1982). Balance theory (Heider, 1946, 1958) is often cited as the first consistency theory in social psychology. It proposes that in evaluations of other people, the valence of related attitudes should be balanced. If person P *admires* person O, then person P should also *like* person O. More often cited is the example that if person P likes person O and person P likes entity X, person O should *also* like entity X. In the original formulation, entity X was described as not being a person, but for instance an event, an idea, or an object. A state of imbalance between the valences of related attitudes was proposed to produce tension and to generate forces towards a state of balance. Although often referred to as the first consistency theory, balance theory was not without precedent and seems to have grown out of Gestalt theory, in particular the principle of closure (Koffka, 1935; Kruglanski and Webster, 1996). The principle of closure describes the tendency of the cognitive system to close open-ended structures and fill in gaps in cognitive representations. Other theories related to cognitive consistency that also predate balance theory are self-consistency theory (Lecky, 1945), which focuses on inconsistencies between the different elements that make up one's personality, and symbolic interactionism (Mead, 1938; Robinson et al., 2006), which proposes that behaviour during social interactions is motivated by the desire to eliminate disequilibrium between actor and environment.

Balance theory was soon followed by other consistency theories, such as symmetry theory (Newcomb, 1953), congruity theory (Osgood and Tannenbaum, 1955), and, most notably, the theory of cognitive

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dissonance (Festinger, 1957). Investigations into cognitive dissonance often involve an inconsistency between existing attitudes and behaviour that is performed by the subject in a certain social context, which could be the presence of a peer group or an authority figure (Festinger and Carlsmith, 1959). Cognitive dissonance is proposed to be an aversive motivational state that activates processes to solve the inconsistency, for instance by altering the attitude so as to make it match behaviour. Since these early years, the principle of consistency has continued to be relevant for theorizing in social psychology, and has been applied to such topics as self-image, social interaction and interpersonal relationships, and decision making (see Cialdini, 2008; Gawronski and Strack, 2012a; Jonas et al., 2014).

Although the principle of consistency has been applied most prominently in social psychology, in many other fields of research concerned with the behaviour of animal and man a case can be and has been made for the involvement of mechanisms triggered by inconsistencies between cognitive structures at some level of processing. Most of these ideas and models use different terminology, not referring to cognitive consistency but to for instance "expectancy," "uncertainty," "prediction error," "feedback," or "feed-forward." In the present paper, I will combine relevant information from different fields of research to create an integrated view on the three components that make up the principle of consistency; namely, inconsistent cognitive structures, increased arousal, and processes solving inconsistency (see Proulx et al., 2012). In discussing each component, I will focus mainly on the implications for the understanding of the cause and function of behaviour. Models and ideas were selected from biological and psychological literature on the basis of their application of the principle of consistency in some form or another. They will only be introduced briefly, while more detailed information can be obtained from the references provided. The term "cognitive" will be used to refer to the involvement of mechanisms and processes that act on the level of internal representations of all kinds of concepts (e.g., "schemata," Rumelhart and Ortony, 1977; "scripts," Abelson, 1981) and which, in case of the production of behaviour, mediate between sensory input and the activation of a motor command sent to the musculoskeletal system (Lanz and McFarland, 1995; Zajonc, 1984). In using the term I do not wish to imply – or deny for that matter – the involvement of conscious processing in the detection and resolution of inconsistency. Furthermore, I will treat human and nonhuman subjects alike (Harmon-Jones et al., 2017; Topolinski, 2012), hoping that researchers concerned with the study of the behaviour of either category of subjects will benefit from the ideas and models put forward by those researchers studying the other category.

The first main section of the present paper focuses on the types of cognitive structures that are proposed to be inconsistent in models from a broad range of scientific fields. A brief overview is presented of relevant information from such fields as perception, neurocognition (predictive coding), learning, motor control, system control, and ethology. To exemplify the long and continuing history of these ideas, I will not shun referring to older literature besides including more recent references. In this section, I will pay special attention to the involvement of cognitive inconsistency in the causation of behaviour. The second main section investigates "arousal," which is said to be increased following the detection of cognitive inconsistency. The relation between inconsistency and arousal is described, while the subjective experience of increased arousal is discussed in some detail. As already mentioned, balance theory as well as cognitive dissonance theory refer to this experience as being aversive (Festinger, 1957; Heider, 1958; Proulx et al., 2012), but many other theorists maintain that only larger inconsistencies evoke aversion while smaller inconsistencies are experienced as being rewarding (e.g., Abelson, 1983; Zajonc, 1960). In this section, I will pay special attention to the involved of arousal in the performance of behaviour. The third and final main section briefly investigates some different modes of solving inconsistency. Traditionally, most attention has been paid to cognitive solutions, such as changing an attitude or an associated motor plan, but this section aims to show that behavioural solutions, such as exploration, aggression, fear, and feeding, are just as pertinent. Therefore, less attention will be paid to cognitive solutions and more to the function of behaviour in solving inconsistency. This section is roughly divided according to a categorization of the types of inconsistency based on how the cognitions that are inconsistent with each other were activated: either associatively or directly by an external or internal event. Finally, taking together all the ideas and models from the many different scientific fields reviewed, it is proposed in the discussion that all behaviour involving cognitive processing is caused by the activation of inconsistent cognitions and functions to increase perceived consistency.

2. Inconsistent cognitive structures

The first component in the principle of consistency, which will be investigated in the present section, is the existence of an inconsistency between two or more simultaneously activate cognitive structures. In cognitive dissonance research, this often involves an inconsistency between an existing attitude and behaviour. In relation to the latter it is important to realize that it is not the behaviour as such that is involved in creating dissonance, but rather a cognitive structure representing that behaviour, such as a motor plan. In models concerned with self-image it is generally proposed that people possess self-schemata, which are generalizations about the self that are based on experience and predisposition, and which organize and guide the processing of information related to the self (Bartlett, 1932; Markus, 1977; Rumelhart and Ortony, 1977). Each self-schema should be internally consistent, consistent with other self-schemata, and consistent with what is perceived (Duval and Wicklund, 1972; Higgins, 1987; Lecky, 1945; Rogers, 1956, 1959; Silvia and Duval, 2001). In research on social interactions, people are also proposed to possess schemata, but this time of the expected proceedings of such interactions. Behaviour of a participant in an interaction should match that of the other participants and should be predictable, that is, should adhere to the existing schemata (Afifi and Burgoon, 2000; Berger and Calabrese, 1975; Burgoon and Jones, 1976; Burke, 1991; Cappella and Greene, 1982, 1984; Heise, 1977, 1979; Koster-Hale and Saxe, 2013; Mead, 1938; Robinson et al., 2006). The present section will further investigate which types of cognitive structures are proposed to be inconsistent in models from a broad range of scientific fields other than social psychology, and will show that this may involve the representation, or, schema, of an expectancy activated associatively by the perception of an external or internal event, the representation of the actual perception of such an event, or the representation of a reference value, which may also be considered to be an expectancy. Special attention will be paid to the implications for the understanding of the causes of behaviour.

In research on perception, it has been shown that at one of the lowest levels of processing of perceived events, a feature that differs markedly from surrounding features attracts attention (Desimone and Duncan, 1995; Koch and Tsuchiya, 2006; Treisman, 1986; Wolfe, 2007). This can, for instance, be a bright light, something moving or flickering, a loud noise, or just one red ball amongst many blue ones. The properties of immediately preceding and concurrent perceptions may be said to function as expectancy for the properties of a particular perception, and inconsistency between that expectancy and perceived features increases arousal (Berlyne, 1960; Hebb, 1955). With respect to visual perception, the extraction of separate stimulus features from the complete visual field occurs in parallel, and therefore an inconsistent feature may well not be in the focal centre of the eye. Saccadic eye movements, which bring such features into the focus, are guided and corrected by the representation of the inconsistent feature and continue until the inconsistency between that representation and the actual sensory input from the foveae is resolved (Duhamel et al., 1992; Posner, 1980; Ma et al., 2014). At an even lower level of visual perceptual processing, a level at which cognition cannot be assumed to play a role, retinal ganglion cells appear to predict the local intensity of visual input

based on locations nearby in time and space, and to signal only inconsistencies from these expectancies (Hosoya et al., 2005).

It has long been suggested that perceived events are continuously compared to expected events, which are representations that have been activated as a result of being associated with previous and concurrent perceptions (Clark, 2013; Friston, 2005; MacKay, 1956; Rao and Ballard, 1999). Top-down expectancies pre-sensitize, or, prime, perceptual mechanisms (Chaxel et al., 2016; Higgins et al., 1977; McNamara, 2005), thereby enhancing salience, recognition, and the further processing of perceived expected events while at the same time reducing salience and processing of other information (Bar, 2009; Dunovan et al., 2014; Gilovich, 1991; Kosslyn and Sussman, 1995; Laming, 1979; Treisman and Gelade, 1980). Facilitated processing of a perceived expected event has been referred to as "fluency" (Winkielman et al., 2012). Motor mechanisms have also been shown to be pre-sensitized by top-down expectancies when an expected event is associated with a motor plan (i.e., when it is motivationally significant), which reduces the time to respond effectively to a perceived event (Bolles and Fanselow, 1980; Jepma et al., 2012b; Näätänen, 1971). Thus, expectancies facilitate detection, recognition, and the further processing of perceived events, and guide behaviour, thus ensuring that information relevant for the functioning of a subject is processed and acted upon quickly and efficiently.

With regard to the relationship between perception and expectancy, von Helmholtz (1867/1962) proposed that perception is affected as much by bottom-up information from sensory receptors as it is by associatively activated top-down expectancies, and could be described as a process of schema-based inference (Minsky, 1975). In decision making, this results in processing that is biased in favour of information that is consistent with existing schemata, and is observed as biased information seeking, confirmation bias, and precommitment bias (Bond et al., 2007; Brownstein, 2003; Hogarth and Einhorn, 1992; Fraser-Mackenzie and Dror, 2009; Jonas et al., 2001; Montgomery, 1983, 1994; Nickerson, 1998; Simon et al., 2004). Related to biased information processing are the "halo effect," "anchoring," and "stereotype confirmation." In the halo effect, a subject forms a general impression of a concept which subsequently colours the judgment of the constituent properties or in which the judgment of one property colours the judgment of another (Thorndike, 1920). In anchoring, a subject's judgment is biased towards an initially provided piece of information (Tversky and Kahneman, 1974), and in stereotype confirmation, perception, encoding, and retrieval of information confirming a pre-existing judgment is enhanced compared to refuting information (Maass et al., 1989; Sanbonmatsu et al., 1994; Sherman et al., 2012). In pathological cases, schema-based inference may even result in subjects blatantly misinterpreting perceptions to be consistent with existing cognitive structures. For instance, inconsistent information may be denied or distorted, as in anosognosia (Ramachandran, 1996), and actions initiated by one part of the brain may be misinterpreted by another part as consistent with information available to that part without having access to the information of the part that initiated the action, as in split-brain research (Corballis, 2003; Gazzaniga and LeDoux, 1978). However, all this does not mean that inconsistent information will always be made to fit existing schemata; on the contrary, conspicuous inconsistent information may be learned and remembered better than consistent information, dependent upon the particular situation (Pezdek et al., 1989).

Neurocognitive theory and research show that any mismatch between perceived and expected events produces a prediction error (Den Ouden et al., 2012; Heilbron and Chait, 2018; Rao and Ballard, 1999; Spratling, 2008). This error evokes orientation (Sokolov, 1960), which facilitates perceptual and associative learning, thereby making expectancy match perception. Learning theory predicts that learning will continue as long as there is an inconsistency between perceived and expected events, and that the speed of learning is dependent upon the size of the prediction error (Bush and Mosteller, 1951; Pearce and Hall, 1980; Rescorla and Wagner, 1972; Sutton and Barto, 1987). At a neural level, learning entails an increase in synaptic strength when two neurons are repeatedly active at about the same time, and a decrease when neurons are active at separate times (Brown et al., 2009; Hebb, 1949; McClelland and Rumelhart, 1981). The learning rule for increasing or decreasing the weight of the connection between neurons or groups of neurons in neural networks is generally proposed to contain an error-correction rule similar to that applied in learning theory (Ludvig et al., 2012; Read and Simon, 2012). When a consolidated memory trace is activated, and there is a discrepancy between the content of that memory and perceived events, "reconsolidation" may occur in which new information is added to the existing memory (Ecker, 2015). If that new information is misleading and was not part of the original event that is represented by the activated memory trace, this may result in "false memory" (Laney and Loftus, 2013; Loftus and Palmer, 1975; Straube, 2012). By integrating new information into existing memory traces, cognitive structures are updated continuously and the cognitive system remains consistent at all times (Dayan et al., 2000; Gottlieb et al., 2013).

According to Sokolov (1960), orientation occurs whenever sensory input does not match the "neuronal model" of some anticipated event. Orientation is the first stage of exploration (Berlyne, 1960), and, consistent with the ideas of Sokolov, the exploration system has been proposed to be activated by inconsistencies between perceived and expected events (Berlyne, 1954; Inglis, 1983; Loewenstein, 1994; van Kampen, 2015). Indeed, with respect to "scientific curiosity," James (1890/1950, p. 430) already wrote that "The philosophic brain responds to an inconsistency or a gap in its knowledge […]," and Berlyne (1954, 1960) proposed that curiosity functions to gather information in order to fill that gap, or, to update expected events to make them match perceived events (Inglis, 1983; Loewenstein, 1994). Berlyne (1960, 1971) recognized three major variables playing a role in the causation of exploration; namely, psychophysical variables (intensity and conspicuousness), ecological variables (positive and negative reinforcers), and collative variables. The latter are called "collative" because they involve a comparison between different stimuli or features. These collative variables are complexity, uncertainty, conflict, and novelty (including change, surprisingness, and incongruity; Berlyne, 1960). Berlyne's analysis of exploration subsequently influenced the analysis of the perception of music (Huron, 2006; Keller and Koch, 2008), of art in general (Berlyne, 1971), and of landscape perception (Purcell, 1986).

Inconsistencies between perceived and expected events are not only proposed to evoke exploration, but also aggression and fear (Archer, 1976, 1988, 2009; Hinde, 1970; Salzen, 1962, 1970; van Kampen, 2015). Hebb (1946, 1949) proposed that at a neural level, exploration, aggression, and fear are all evoked when a perceived event disrupts temporally and spatially organized cerebral activities ("phase sequences"); that is, the sequence in which neuronal models ("cell assemblies") are activated as determined by experience and predisposition. Based on an extensive review of the available data, Archer (1976) concluded that the variables involved in the causation of both aggression and fear can be categorized into four groups; namely, intensity (or, more specifically, pain), novelty, frustration, and conditioned stimuli (see also Adolphs, 2013; Berkowitz, 1989; Dollard et al., 1939; Gray, 1987). Archer (1976) also proposed that "all the situations involve the common property of a discrepancy between observed and expected stimulation" (p. 231).

The principle of consistency has also been proposed to play a role at several hierarchical levels within the motor system. Activated motor plans, which control the order in which motor commands are projected onto the musculoskeletal system, are only executed when preconditions are met whilst postconditions are not, and execution persists until the inconsistency between perception and goal is resolved (Clark, 2013; Cooper and Shallice, 2000; Diedrichsen and Kornysheva, 2015; Kilner et al., 2007; Miller et al., 1960). Even in routine behaviour, the cue activating the motor plan must somehow relate to an inconsistency

between perceived and desired conditions. At a lower level in the motor control hierarchy, the execution of motor commands is monitored by comparing the expected proprioceptive and exteroceptive feedback of the action (the "efference copy") with the actually perceived feedback (Grush, 2004; Shipp et al., 2013; Todorov, 2004; von Holst, 1954; von Holst and Mittelstaedt, 1950/1971). Prediction error is subsequently used to adjust the motor command or even the motor plan (Bach et al., 2014; Wolpert et al., 2003). This basic principle is suggested to be valid also for routine and involuntary actions (von Holst and Mittelstaedt, 1950/, 1971). At an even lower level of motor control, a level at which cognition cannot be assumed to play a role, it has been proposed that neural control of muscle length and tension is based on feedback to the spinal cord from muscle spindle receptors and Golgi tendon organs, respectively, and that this input is compared to expected length and tension in order to reduce inconsistency (Cools, 1981; Houk, 1979; Houk and Rymer, 1981; Kistemaker et al., 2013).

Motor control is often treated as an example of a control system (Schneider, 2001). Control theory originated in the field of engineering and looks at the same principle as the one underlying consistency theory from a different perspective (Powers, 1978; Sirgy, 1987; Wiener, 1948). In control theory, a central comparator is proposed to compare the input of the current state (perception) to some reference value, often referred to as "goal" or "expectancy" (Sirgy, 1987), although it may also be referred to as an "adaptation level," formed through experience and predisposition (Helson, 1947, 1948). Inconsistency between input and reference value generates an error signal. This signal may be sent to an effector where it triggers output intended to increase consistency, or it may trigger a learning process intended to adapt the reference value (Kalman, 1960). While consistency theory looks from the perspective of the inconsistency between input and reference value, control theory considers the feedback loop in which the output of a system is fed back to that system as the essential component. Control theory has been applied in many subdisciplines within psychology, sociology, and ethology (Carver and Scheier, 2012; Schneider, 2001; Sirgy, 1987) and to behaviour systems such as exploration, aggression, fear, affiliation, and drinking (Bischof, 1975; Toates, 1975; Wiepkema, 1977). The central comparator mechanism has also been applied to more specific forms of behaviour, such as the incubation and nesting behaviour of the herring gull (Baerends, 1976) and the optomotor response of the crab *Carcinus* (Horridge, 1966).

Control theory is closely related to the concept of "homeostasis," a term coined by Cannon (1929). This concept refers to the tendency of a system to maintain a steady state, just as the cognitive system is proposed to tend to consistency. Behaviour and homeostasis have often been linked (Hogan, 1980, 2017; McFarland, 1970), and the work of Cannon on homeostasis strongly influenced the drive theory of motivation as developed by Hull (1943, 1951). Hull proposed that all forms of behaviour are energized by a non-specific drive to action which is caused by the absence or shortage of essential commodities or conditions; that is, by a deviation of the current situation from some reference value. Such a state of "need" was proposed to evoke prior associations, or "habits," in order to reduce the need and return to a state of equilibrium. Thus, for instance, foraging and feeding are caused by hunger in case of a shortage of required nutrients, and drinking is caused by thirst in case of a shortage of fluids. Originally the concept of homeostasis was used only for physiological processes preserving a constant internal environment, such as body temperature and blood pressure (Bernard, 1878; Cannon, 1929; Carpenter, 2004; Modell et al., 2015). Accordingly, homeostasis involved in consistency is perhaps better regarded as the maintenance of an optimal level of arousal than as the maintenance of consistency as such.

In summary, the principle of consistency has been applied to all levels of information processing in the brain, from perceptual mechanisms to central mechanisms and to motor mechanisms (see also Hogan, 2017). The production of behaviour following a certain perception will often involve inconsistency at more than one level. For instance, first a subject is confronted with an unexpected sensory event (inconsistency at perceptual level), second, after a search of the memory system the event is recognized but is associated with an ambiguous meaning (inconsistency at central level), and third, after an action has been decided upon, the expected sensory feedback differs from the actual feedback (inconsistency at motor level). The cognitive structures involved in inconsistency may be an expectancy, a representation of an actual internal or external perception, or some reference value (which may also be considered to be an expectancy). Inconsistency between cognitive structures has been proposed to be involved in the causation of many types of behaviour; such as, social interaction, affiliation, decision making, exploration (including orientation), aggression, fear, feeding, and drinking.

3. Arousal

When two or more simultaneously active cognitive structures are inconsistent, arousal is increased. Generalized arousal (Moruzzi and Magoun, 1949) consists of cortical arousal (the release of neuromodulators in the brain), activation of peripheral endocrine systems (the release of peripheral hormones into the blood stream), and activation of the sympathetic autonomic nervous system (e.g., increased heart rate, blood pressure, and respiration; LeDoux, 2012, 2014). In general, increased arousal results in increased overall vigilance and behavioural reactivity, and more specifically, increased cortical arousal enhances selective attention, facilitates information processing, and induces the synaptic plasticity necessary for learning (LeDoux, 2012; Ranganath and Rainer, 2003). The amount of arousal is dependent upon the size of the inconsistency, the type of cognitive structures involved, and the specific context. These factors also determine the composition of arousal; that is, the relative amounts of cortical, endocrine, and autonomic arousal. The present section describes the relation between cognitive inconsistency and arousal, paying special attention to the perception of increased arousal as either aversive or rewarding, and to the involvement of arousal in the performance of behaviour.

One of the neuromodulators of which the release is increased during cortical arousal is dopamine (Horvitz, 2000; LeDoux, 2012; Schiff and Plum, 2000), a monoamine that has been shown to be involved in the causation of numerous forms of behaviour. Dopamine levels are increased during appetitive behaviour aimed at obtaining rewards (e.g., eating, drinking, and sexual behaviour), during aversive and defensive behaviour avoiding stressful and harmful stimuli, and also during exploratory, social, and maternal behaviour (Floresco, 2015; Kakade and Dayan, 2002; Lorrain et al., 1999; Montague et al., 1996; Robinson et al., 2011; Salamone et al., 1997; Stanwood and Zigmond, 2000; Zabik et al., 1993). Dopamine has also been shown to modulate attention (Lee et al., 2010), to play an important role in learning (Gruber et al., 2014; Wickens et al., 2007), and it has been proposed to signal the size of the prediction error included in many models of learning (Glimcher, 2011; Montague et al., 1996; Schultz et al., 1997). However, cortical arousal consists of a complex interaction between several neurotransmitters, and discussing only one of those cannot be considered representative of that whole complex (e.g., Schiff and Plum, 2000). For instance, whereas dopamine is suggested to increase proportionately to the size of the violated expectancy, acetylcholine has been suggested to increase after the perception of expected uncertainty, coming from familiar but unpredictable events, while noradrenalin increases after the perception of unexpected uncertainty, coming from unfamiliar and unpredicted events such as novelty and surprise (Yu and Dayan, 2003).

Several studies have shown that cognitive inconsistency also increases autonomic arousal. This was found for cognitive dissonance (e.g., Martinie et al., 2013), social interaction (Mendes et al., 2007; Patterson, 1976), decision making (Mann et al., 1969; van Harreveld et al., 2009), and even the rather trivial inconsistency of anomalous colours of the suits of playing cards (Sleegers et al., 2015). Increased

autonomic arousal has also been associated with the performance of exploration, aggression, and fear (Berlyne, 1960; LeDoux, 2014; Novaco, 2000; "fight-or-flight," Cannon, 1915; McCarty, 2000). Thus, for both cortical and autonomic arousal there are strong indications that they are both related to cognitive inconsistency and are both involved in the performance of behaviour.

The experience of increased arousal as a result of inconsistency is often described as aversive (Elliot and Devine, 1994; Festinger, 1957; Proulx et al., 2012). However, it is also well-known that organisms at times deliberately look for or even create inconsistencies and increased levels of arousal, for instance during entertainment (Abelson, 1983; Zajonc, 1960), play behaviour (Baldwin and Baldwin, 1977; Bonawitz et al., 2012; Špinka et al., 2001), and, in a more extreme form, during sensation-seeking (Zuckerman, 1994). Why would one deliberately seek to increase arousal by looking for the unknown and the uncertain if it were aversive? This apparent contradiction can be resolved by assuming that there a two processes involved in the causation of behaviour that increases arousal. First, the perception of a moderately aversive discrepant event, and second, the anticipation of its rewarding resolution, which, combined, is experienced as excitement (Jepma et al., 2012a; Kagan, 1972, 1974; Keller et al., 1994; Loewenstein, 1994). Berlyne (1960, pp.198–200) referred to the drop in arousal that terminates slight and transitory jumps in arousal as pleasurable "arousal jags," and proposed that these would occur only in case of both moderately increased arousal and anticipated relief. A similar two-process explanation has been offered for the positive affect experienced after expected punishment is withheld and after expected reward is exceeded; that is, in the overall experience, negative affect as a result of the violated expectancy is outweighed by the positive affect associated with the outcome of the event (Noordewier et al., 2016).

Trying to solve a puzzle, reading a novel or poetry, watching a movie or a magician's show, and looking at visual art and listening to music, all these activities have been proposed to induce inconsistency and to increase arousal, and all these activities are experienced as exciting and, after resolution, as pleasurable (Berlyne, 1960, 1971; Hebb, 1949; Huron, 2006; Keller and Koch, 2008). Anticipated resolution is essential in causing these activities, but the actual resolution determines how we look back on the total experience. If we are unable to solve the puzzle, or watch or read the unravelling of a murder mystery, we are left with a feeling of dissatisfaction, disappointment, or frustration. Besides anticipated resolution, many exciting events share the characteristic that the inconsistency is also anticipated to be inconsequential; that is, it is not expected to be followed by a harmful event or by the increase of some need, and it does not evoke conflicting behavioural tendencies. This means that we engage in behaviour increasing inconsistency and arousal primarily when the expected difference in motivational consequences between solving and not solving the inconsistency is low, while the expected probability of resolution is high (e.g., Carver and Scheier, 1990). Still, the actual resolution of inconsistency and subsequent decrease in arousal is paramount for the overall experience to be positive.

Resolution of inconsistency and the associated decrease in arousal has a positive valence. You feel happy when you are hungry and eat a good meal, when you are threatened and make the threat disappear, and when you finally solve that mind-boggling puzzle. Even hurting someone that has wronged you may lead to positive feelings (Bushman and Huesmann, 2010), just as winning a fight may do (Archer, 1976). Neurophysiological research has indeed shown that dopamine levels decrease during and after resolution of inconsistency, while serotonin levels increase, a relation that has been found for instance for feeding (Breisch et al., 1976; Lam et al., 2010), sexual activity (Lorrain et al., 1999), and aggression (Nelson and Trainor, 2007; Seo et al., 2008).

Resolution of inconsistency and decrease in arousal may be accompanied by smiling and laughter, and unexpected consistency may put a smile on one's face (Topolinski et al., 2009). Both behaviour patterns have been interpreted as social displays communicating relieved tension and functioning as appeasement to disarm social tension (Ramachandran, 1996; Sroufe et al., 1974; van Hooff, 1972). Humans also smile and laugh about humorous situations, which has indeed been explained as a result of the resolution of an inconsistency that was created within a certain context of associatively activated schemata and which was resolved within an unexpected different context (Mower White, 1982). Laughter as a result of malicious pleasure may be the result of two subsequent processes. First, arousal increases due to the activation of the same brain mechanisms ("mirror neurons") that are activated when the subject would be in the very same unpleasant situation as a perceived conspecific and which are also involved in empathy (Di Pellegrino et al., 1992; Olsson and Phelps, 2007; Rizzolatti and Craighero, 2004), and second, the relief of tension after the realization that it was not you it happened to.

Acute stress, which occurs immediately after the perception of a stressor, is associated with increased arousal (Belujon and Grace, 2015; Bremner et al., 1996; Guilliams and Edwards, 2010). This is not surprising, as acute stress is actually the same as the fight-or-flight response (Cannon, 1915; McCarty, 2000), or, the normal reaction to the perception of a relatively large cognitive inconsistency. According to Ursin (1988; Ursin and Eriksen, 2004), when the inconsistency between expected events ("set value") and perceived events ("actual value") cannot be resolved satisfactorily, this results in chronic stress and sustained high levels of arousal, for instance increased levels of cortisol. Chronic stress was defined by Toates (1995) as a "chronic state that arises only when defense mechanisms are either being chronically stretched or are actually failing" (p. 3), which ultimately leads to somatic disease and illness. In order to cope with stress, homeostatic set values might be adjusted temporarily or more permanently, a process that has been termed "allostasis" (Ganzel et al., 2010; Sterling and Eyer, 1988). An example is increased blood pressure after the perception of a stressor. However, even though it is clear that the systems involved in arousal are dysregulated during chronic stress, reports on whether arousal is increased or decreased are inconsistent. More research is needed to understand when for instance cortisol levels are either increased or decreased (Guilliams and Edwards, 2010; see also Bremner et al., 1996), although cortical as well as autonomic arousal often appear to be decreased (Belujon and Grace, 2015; Moret and Briley, 2011; Lucini et al., 2005).

A state of boredom has often been associated with both increased levels of arousal (Berlyne, 1960; Bench and Lench, 2013) as well as decreased levels (Hebb, 1955; Mikulas and Vodanovich, 1993), or even with both (Elpidorou, 2018). This inconsistency can be resolved by assuming that autonomic arousal is increased during boredom (London et al., 1972; Ohsuga et al., 2001), while cortical arousal is decreased. The decrease in cortical arousal may be the result of reduced levels of information processing in the brain. A low level of cortical arousal will create an inconsistency with the optimal level of arousal formed through experience and predisposition, and which has also been referred to as the expected and the preferred level (Inglis, 1983, 2000; McClelland and Clark, 1953), and is similar to the reference value in control theory. This inconsistency increases autonomic arousal and subjects will engage in activities expected to increase information processing by looking for or actively creating inconsistencies. Examples are sensation-seeking, play (Hughes and Hutt, 1979), and even aggressive behaviour (Bushman and Huesmann, 2010). Subjects with a higher optimal level of cortical arousal need more stimulation to maintain this expected level, and have been found to be more prone to seeking novelty, variety, emotional stimulation, and the reinforcement of food and drugs (Dellu et al., 1996; Zuckerman, 1994).

When a subject is engaged routinely in motivationally significant activities such as feeding, but the level of motivation is not very high, an "exploration bonus" may be added to the performed behaviour to keep arousal at the optimal level. This "exploration bonus" consists of employing less familiar behavioural patterns and selecting less familiar targets, which allows for the discovery of more optimal ways of doing

things and of alternative stimuli supporting consummatory behaviour (Inglis, 2000; Inglis and Langton, 2006; Kakade and Dayan, 2002; Sutton, 1990). Thus, when subjects are hungry, but not very hungry, they will not maximize energy intake, but instead increase cognitive activity and arousal by seeking moderately different food items at moderately different locations. In reinforcement learning, the search for an optimal balance between goal-directed behaviour and the gathering of information is referred to as the trade-off between exploitation and exploration (e.g., Daw et al., 2006).

Although more research is needed into how the composition of generalized arousal is affected by the type of cognitive structures involved in inconsistency and the specific context, especially in the case of chronic stress and boredom, it is also clear that cognitive inconsistency increases arousal and that this increase is experienced as being aversive. Furthermore, the existing data also indicates that the expected or actual decrease in arousal as a result of increased consistency is experienced as rewarding, while the combination of a moderate increase in arousal and its anticipated decrease is experienced as excitement. Arousal has been shown to be involved in the performance of many types of behaviour; such as, social behaviour, maternal behaviour, sexual behaviour, exploration, aggression, fear, feeding, and drinking. This broad range suggests that arousal may be involved in the performance of behaviour in general (see Hebb, 1955; LeDoux, 2012). If this is the case, and an increase in arousal always has a negative valence, the performance of behaviour should somehow always be associated with some amount of negative affect. Indeed, a century ago Craig (1918) already proposed that appetites as well as aversions are a "state of agitation," and that appetites (e.g., hunger) cease as a result of the consumption of an "appeted" stimulus (e.g., eating food), while aversions (e.g., fear) cease when the "disturbing" stimulus has ceased (see also Mowrer, 1938). Cognitive inconsistency will therefore lead to approach of an object when consummatory behaviour involving that object is expected to increase consistency, whereas it will lead to avoidance of an object when that object is the cause of the inconsistency and when the perceived probability that consummatory behaviour will increase consistency is low.

4. Solving inconsistency

When arousal is increased as a result of an inconsistency between two or more simultaneously active cognitive structures, processes are activated with the expected consequence of increasing consistency and decreasing arousal. The present section briefly discusses some different modes of resolving inconsistency, paying special attention to the function of behaviour in increasing consistency, as opposed to the cognitive solutions that usually receive most attention. The section is roughly divided according to a categorization of the types of inconsistency based on how each of the inconsistent cognitions is activated. Three types of inconsistency are discussed. Firstly, inconsistency between two associatively activated cognitions (such as expectancies), either activated by one ambiguous event or by two conflicting events. Secondly, inconsistency between a cognition representing an actual external event (e.g., a novel object) and an associatively activated expected event. Thirdly, inconsistency between a cognition that is associatively activated by an internal perception (e.g., food in case of hunger) and cognitions that represent the actual external situation (e.g., the absence of food).

Festinger (1957) described two solutions to reduce dissonance between two cognitions. First, one or both of the inconsistent cognitions can be changed so as to increase consistency between them. If a subject performs behaviour of which the representation of its consequences is inconsistent with that of an existing attitude, the subject may for instance change the attitude or the behaviour. Second, a consonant cognition can be created or bolstered to alter the relation between the two inconsistent cognitions while keeping those as such unchanged. Subjects could blame context and circumstance, and could claim for instance that they were forced to behave the way they did, either by an authority figure or by social convention (Cialdini and Goldstein, 2004; Johnson-Laird et al., 2004). Attempts to explain dissonant behaviour by attributing a cause is the subject of attribution theory, and results in creating or bolstering consonant cognitions that reduce inconsistency (Heider, 1944, 1958; Malle, 2011; Rotter, 1966; Weiner, 1985).

Many ways of solving inconsistency have been described, although most of them are special cases or sub-categories of the two modes described by Festinger (e.g., Hardyck and Kardush, 1968; Jonas et al., 2014; Kaplan and Crockett, 1968; Kelman and Baron, 1968; Petty and Wegener, 1998). Some of these ways have also been described as ego defence mechanisms that function to maintain self-image and emotional homeostasis (Freud, 1936; Vaillant, 1977); for instance, rationalization, denial, distortion, and suppression. In rationalization, a subject tries to explain away an action or event by constructing a consonant element that associates it with a reinterpretation of its original intention, effect, or cause, such that it becomes consistent with existing attitudes, expectations, or desired events ("I did not want the job anyway"). In denial, a subject refuses to accept the truth of an unpleasant situation and changes the cognitive structure representing that situation in order to make it consistent with a more desirable one ("No, I'm not an excessive drinker"). In perceptual distortion, a subject reshapes sensory input to make it match expected events (see above), while in cognitive distortion, the inconsistent event is changed during encoding, consolidation, or retrieval, so it can be assimilated into the combined set of existing cognitive structures (Chaxel et al., 2016; Straube, 2012). In suppression, a subject consciously tries to push away thoughts that lead to cognitive inconsistency by shifting attention to other cognitions. This will reduce activation of the inconsistent event and consequently of the perceived inconsistency. When this process occurs subconsciously, it is referred to as “repression.” Although as a result of suppression the association between cognitive structures may change after a while, suppression as a mechanism differs from the two modes of resolution as described by Festinger. By changing cognitions and by creating or bolstering consonant cognitions, inconsistency is resolved structurally. In suppression and repression, however, cognitive structures remain structurally inconsistent and only perceived inconsistency is resolved by preventing those structures from becoming active simultaneously, or at least by reducing that probability (see Jonas et al., 2014). Based on the function of ego defence mechanisms, it should be possible to analyse each of the many mechanisms as at least temporarily decreasing perceived inconsistency.

Cognitive dissonance theory focuses mainly on cognitive solutions to inconsistencies between associatively activated cognitive structures. For instance, when subjects are asked a question about an action that was inconsistent with one of their attitudes, this question associatively activates the cognitive representations of both and induces dissonance. In situations in which only one of the cognitions is an associatively activated representation, such as an expectancy, and the other is the representation of an event perceived in the external environment, such as a novel stimulus, behavioural solutions impacting the perception become more obvious than cognitive solutions. Subjects may for instance withdraw from a situation in which inconsistent cognitions are, or are expected to be, activated, or, during a discussion, they may attempt to change another person’s opinion when that opinion conflicts with or even threatens their own. The first line of defence against the perception of an unexpected external event is exploration, which is employed to gather more detailed information about that event. Berlyne (1960) divided exploratory behaviour into three categories; namely, orientation (including saccadic eye movements), locomotor exploration, and exploratory manipulation, while the function of each was described as providing access to or increasing the amount of sensory information. Information gathered through exploration is used to facilitate recognition and categorization of the perceived event, and, if that event is still not recognized and inconsistency remains, to update the representation of the expected event through perceptual and

associative learning. In this way, learning solves inconsistency by making expectancy match perception.

If the size of the inconsistency between perceived and expected or desired events is relatively large, and the perceived event cannot be assimilated into existing cognitive structures, exploratory approach and manipulation are inhibited and subjects may try to alter the perception using aggressive or fear behaviour in order to make it match expectancy (Archer, 1976; Hebb, 1946; van Kampen, 2015). Aggression can be employed to forcefully manipulate a perceived event into matching expected or desired events. When an unfamiliar conspecific enters the territory of a subject, this causes cognitive inconsistency, because of the novelty of the conspecific, because of the frustration of ongoing behaviour, and because of a difference between the perceived and the desired situation in which there is no intruder. Aggression may solve these inconsistencies by removing the intruder from the proximity and consequently altering perception (Archer, 1976, 1988; Rohlfs and Ramírez, 2006). Alternatively, subjects may employ fear behaviour to remove the stimulus responsible for the inconsistency from the perceptual field, not by removing the stimulus as such, but by moving away from it (Archer, 1976; Berlyne, 1960; Hebb, 1946; Salzen, 1962, 1970). Whether either aggression or fear is employed, depends upon the size of the inconsistency as well as the specific context. Subjects are more likely to attack when the inconsistency is large but not too large, when the strength of ongoing motivation is high, when resources are scarce, when there are no environmental stimuli affording escape (e.g., no nearby hiding place or escape route), and especially when a suitable target affording attack is present, where the size of that target is a decisive factor (Archer, 1976, 1988; Berkowitz, 1989; Cooper and Stankowich, 2010). In general, the largest inconsistencies are associated with a tendency to flee, although in case of thwarted escape, aggressive behaviour may be employed in an attempt to remove the thwarting stimulus. Thus, as Kagan (1972) noted, exploration, aggression, and fear are not only caused by cognitive inconsistency, but also function to solve it, "by assimilating, removing, or escaping from the discrepant event" (p. 55).

Dependent upon the size of the inconsistency between expectancy and perception, the cognitive structures involved, and the specific context, exploration, aggression, and fear may also be activated at the same time. When exploratory approach and fear behaviour are activated simultaneously and about equally strongly, this results in approach-avoidance conflict (Montgomery, 1955). This conflict may lead to an alternation between the tendencies to approach and withdraw, or to ambivalent behaviour patterns in which both tendencies are expressed simultaneously in an intermediate activity, such as stretched attention in rats (Hinde, 1970; Hogan, 1965; McFarland, 1999). The alternation between approach and withdrawal was already described by James (1890/1950), who wrote that "The spectacle of their alternation is often amusing enough, as in the timid approaches and scared wheelings which sheep or cattle will make in the presence of some new object they are investigating" (p. 429). In case of activation of both aggression and fear, for instance during an encounter with a conspecific intruder, the conflict between the respective tendencies may lead to ambivalent behaviour in the form of threat displays, in which aggressive and fear tendencies are expressed simultaneously (Andrew, 1956; Baerends, 1975; Tinbergen, 1952). If the inconsistency occurs in a sexual context, for instance when a male subject is frustrated because he is sexually aroused while the female is unwilling (constituting an inconsistency between perceived and desired events), conflict between aggressive and fear tendencies may result in courtship displays. These displays are ambivalent behaviour patterns in which elements of aggressive, fear, and sexual behaviour can all be discerned, and they have been shown to increase the probability that the female will meet the desired events from the male perspective (Kruijt, 1964; van Kampen, 2015; van Kampen and Hogan, 2000).

The type of behaviour resulting from a conflict between two or more behavioural tendencies is not a random product of those tendencies. Conflict behaviour has been shaped by natural selection and ontogeny, which favour behaviour to be performed that somehow facilitates the resolution of the causing inconsistency (Bastock et al., 1953). The majority of agonistic interactions, for instance, end when one of the contestants withdraws or submits, either immediately after its opponent starts performing threat displays, or after some initial counter-displaying (Archer, 1988; Craig, 1921; Parker, 1974). In this way, threat displays aid in solving the inconsistency that was created by the perception of the competitor. Similarly, courtship displays help in solving the inconsistency between what the performer expects or desires and what is actually happening, and increases the chance of consummatory sexual behaviour to occur (Kruijt, 1964; van Kampen, 2015).

Besides ambivalent behaviour and alternation, classical ethological theory proposes a number of other behavioural phenomena that might occur as a result of the activation of two or more conflicting behavioural tendencies; most notably, intention movements, redirection, displacement activities, and regression (Hinde, 1970; McFarland, 1999). Both regression and redirection (confusingly referred to as "displacement" in psychology) have also been described as ego defence mechanisms (Freud, 1936; Vaillant, 1977), indicating that the latter are a mixture of cognitive and behavioural solutions. In regression, a subject reverts back to juvenile behaviour. An adult may start crying, which is a juvenile behaviour eliciting maternal behaviour, in an attempt to recruit help from others or to soften sentiments of other participants in the social interaction in order to change perceived events and reduce inconsistency with expected or desired events (Bretherton and Salter Ainsworth, 1974; Hinde, 1970). In redirection/displacement, a subject directs behaviour onto an object other than the one which initially elicited it. This can be explained partly as a form of misattribution of arousal (Schachter and Singer, 1962; Sinclair et al., 1994), but it helps in resolving inconsistency in a similar fashion as suppression and regression do; namely, by focusing attention on another cognition and making the inconsistent event less active in memory. When a redirected behaviour is part of a social display, its function is often to stress the point of that display. Beating your own chest during threat display functions to intimidate your opponent and may aid in resolving the agonistic interaction satisfactorily.

Although cognitive solutions are more obvious for inconsistencies between two associatively activated cognitions and behavioural solutions for inconsistencies involving a perception in the external environment, both may also be employed in similar situations. In extremely fearful situations in which escape is impossible and aggressive behaviour is ruled out, a person may alter their attitude to reduce inconsistency (e.g., Robinson et al., 2006). Dramatic examples were reported concerning prisoners of Chinese Communists (Lifton, 1961; Schein et al., 1961), while this principle may also explain the "Stockholm syndrome" (Bejerot, 1974; Namnyak et al., 2007). On the other hand, when subjects suffering from cognitive dissonance are asked about the inconsistent cognitions, they may alter the representation of either, but they may also try to avoid giving an answer by changing the subject of the conversation or they may become defensive ("Mind your own business!") to protect their self-esteem (Archer, 2009; Baumeister et al., 1996; Lazarus, 1993). An opponent expressing an opinion that poses a threat to self-esteem or discredits a fundamental belief may produce frustration and trigger aggression (Berkowitz, 1989, 1993; Dollard et al., 1939; Kagan, 1972; Sandstrom and Jordan, 2008). Avoidance, defensiveness, and aggression will not structurally solve these inconsistencies, but they will help in reducing perceived inconsistency. Just as in redirection/displacement, suppression, and repression, attention will not be focused on the inconsistent cognitions anymore and as a result these will become less active in the memory system. The opponent will also think twice before bringing up the issue again, and in that way the probability of the inconsistency becoming active again in the future is also reduced.

Behavioural solutions are not only obvious for inconsistencies involving a perception in the external environment, but also for those

involving a perception in the internal environment. The perception of stomach contractions or a low blood sugar level, that is, the perception of hunger, is generally removed by the behavioural act of consuming food. The involvement of inconsistency in hunger is twofold. First of all, hunger has often been described in terms of a homeostatic process intended to maintain a steady state regarding for instance blood sugar level. Second, and more relevant for the present section, the perception of hunger associatively activates representations of stimuli supporting the consummatory act that reduces the appetitive state, i.e., representations of food, which leads to cognitive inconsistency when such stimuli are not actually perceived in the external environment (Hebb, 1949; Inglis, 1983; Wolpert et al., 2003). The activated representation of a stimulus required to alleviate an appetitive state has been referred to as a "search image" (Bravo and Farid, 2012; Desimone and Duncan, 1995; Langley et al., 1996; Tinbergen, 1960), a term originally coined by von Uexkull (1934/1957;"Suchbild"). A search image increases the salience of matching stimuli and primes perceptual mechanisms to process relevant stimuli more fluently than others, just as other expectancies do. Arousal resulting from the inconsistency between this "expectancy" and perception triggers behaviour expected to solve the inconsistency, in particular searching behaviour intended to locate the required stimuli. This may also involve the activation of representations of locations where food was previously experienced, and the activation of a motor plan to travel to that location (O'Keefe and Nadel, 1978). This motor plan may include going from one landmark to another using a sequence of consecutive search images of locations along the way to the target (Collett et al., 1993).

Closely related to search images are templates, internal models that are used to shape behaviour into the right form. The best known ethological example of the use of templates is that of song learning in birds. During a memorization phase, young male songbirds form a template combining existing predispositions and the songs they hear, and during a sensorimotor phase, juvenile birds will gradually adjust their own vocalizations to match that template (Hinde, 1970; Konishi, 1965; Marler, 1970, 1997; Thorpe, 1961). The matching and correcting of vocal output during song learning has been suggested to be comparable to human speech development (Doupe and Kuhl, 1999; Bolhuis and Everaert, 2013). Another example of the use of templates comes from research into nest-building in birds. Nest-building is triggered in the breeding season, and has been proposed to consist of a step-by-step elimination of inconsistencies between an internal model of a completed nest and the perceived incomplete nest (Lashley, 1938; Thorpe, 1963). This proposal is often taken as just one example of a general principle (Hinde, 1970; Hogan, 2017), to which Hebb (1949, p. 169) added the example of a rat retrieving its pups in order to reduce the inconsistency with an internal model of the pups in the nest. Templates have also been suggested to be involved in action imitation. Subjects are suggested to form an internal model of an action and its consequences during observational learning, and subsequently they match and shape their own behaviour against that template (Iacoboni, 2009; Jeannerod, 1995; Meltzoff and Moore, 1977).

In summary, besides the cognitive solutions of changing cognitions and adding or bolstering consonant cognitions, behavioural solutions to cognitive inconsistency are just as pertinent. Resolution of inconsistency has been explicitly agued to be the function of exploration, aggression, fear, and feeding, while many other forms of behaviour can and have been analysed using the principle of consistency; for instance, social displays such as threat and courtship, and the use of templates in foraging, nest-building, and song learning and other types of imitation.

5. Discussion

Each of the three main sections of the present paper investigated one of the three components that make up the principle of consistency; namely, the simultaneous activation of inconsistent cognitive structures, the resulting increase in arousal, and the subsequent activation of processes expected to increase consistency. Relevant ideas and models from many different fields of research concerned with the behaviour of animal and man were presented, including social psychology, perception, neurocognition, learning, motor control, system control, ethology, and stress. The application of the principle of consistency was shown to have a long and continuing history within this broad range of scientific areas, and the selected ideas and models can be combined easily to outline an overall consistent picture concerning cause and function of behaviour; namely, all behaviour involving cognitive processing is caused by a logical inconsistency between two or more simultaneously active cognitive structures and functions to increase perceived consistency. This proposal is consistent with the fact that the consequence of normal behaviour is a change in the current perception of the internal or external environment (Powers, 1978).

The brief overview also reveals that at all levels of information processing in the brain, from perceptual mechanisms to central mechanisms and to motor mechanisms (see Hogan, 2017), neural and cognitive structures tend towards a state of consistency. Moreover, the production of behaviour following a certain perception will often involve inconsistency at more than one level. In social psychological literature it has been suggested that cognitive consistency can only play a role in case of propositional processing, involving verbally reportable higher-level, relatively complex cognitive structures such as beliefs, attitudes, and judgments, which are processed consciously, intentionally, and with effort (e.g., Gawronski and Bodenhausen, 2006). This is then taken to indicate that the principle of consistency may not apply to nonhuman subjects. However, the fact that other fields of research do apply the principle of consistency to all levels of information processing and to both human and nonhuman subjects, clearly indicates that consistency is a fundamental principle of all cognitive processing and is not limited to propositional processes only (see also Brock, 1968; Harmon-Jones et al., 2017; Topolinski, 2012). It has even been proposed that inconsistency detection and reduction play a significant role at levels at which cognition cannot be assumed to play a role.

The tendency towards consistency is not so much a goal as it is a consequence of the way the cognitive system is organized, and, at a lower level, of the way complex neural structures are formed. From an information processing perspective, a system can only function adequately when all information within that system is consistent according to the rules of formal logic (Abelson and Rosenberg, 1958; Gawronski and Strack, 2012b; Read and Simon, 2012). From a neurophysiological perspective, a state of consistency is the logical consequence of the processes forming excitatory and inhibitory connections between pre- and post-synaptic neurons and between different "cell assemblies" (Hebb, 1949; McClelland and Rumelhart, 1981). If assembly P has excitatory links to assembly X while O has inhibitory links to X, the simultaneous activation of P and O would result in the disruption of existing "phase sequences" and consequently in aversive arousal (Hebb, 1946, 1949). From a functional perspective, a state of consistency is necessary to avoid conflict in the production of behaviour and to increase behavioural effectiveness (Gawronski, 2012; Harmon-Jones, 2012; Ramachandran, 1996).

A relatively recent take on the principle of consistency proposes that the tendency towards consistency can ultimately be deduced from a definition of life itself. From a thermodynamical perspective, a living organism can be defined as an open system that maintains its internal order by increasing disorder in its environment (Lehninger, 1982; Schrödinger, 1944). Disorder can also be referred to as "entropy," or, more accurately in the case of the definition of life, as "Gibbs free energy." Although this may all sound rather technical, it is important as it has been argued that from this definition it follows that the brain of a living organism should function to minimize "free energy," which can be equated to "uncertainty" and "surprise" in information processing theory and to "the sum of prediction error" in neurocognition (Hirsh et al., 2012; Hohwy, 2016). According to this free-energy principle, the brain acts to maintain itself and the organism within an adaptively

limited set of expected sensory and physiological states (Friston, 2010; Ramstead et al., 2018), a proposal closely related to the concepts of homeostasis and allostasis. Within this framework, "[…] all behavior of the system can be understood in terms of the prediction error minimizing interplay between sensory input and the hypotheses of internal models" (Hohwy, 2016;). This means that behaviour is performed because its expected consequence is a reduction of prediction error, or, free energy, even though the activation of a motor command itself temporarily creates a different inconsistency, namely, between the expected sensory feedback (the "efference copy") and the actually perceived feedback.

Explaining a behavioural act by stating that it is caused by inconsistency and functions to increase consistency does not, of course, explain everything about the cause and function of that act. It is still necessary to know more about the cognitive structures that are inconsistent – which structures are involved; how were they formed; how were they activated – and about the mode of resolution that is employed – which modes could be used; how do they solve inconsistency; why was this particular mode selected. In answering these questions, individual differences in experience and predisposition need to be considered (Glass, 1968). Individuals may differ in inconsistency (or arousal) tolerance (Miller and Rokeach, 1968; see also Roberti, 2004), in expected ability to resolve inconsistency (Silvia and Duval, 2001), and in coping strategy; that is, the set of behavioural and cognitive responses they prefer to employ to resolve inconsistency (Koolhaas and de Boer, 2008). Besides individual differences, the context in which the inconsistency is detected also needs to be taken into account: How relevant is the inconsistency to the individual at the time of detection, for instance in relation to concurrent motivational tendencies or regarding self-esteem (Singer, 1968). Notwithstanding these footnotes, the present paper still reveals that we need to extend the conclusion of Mower White (1982) that "inconsistency, in all its facets, is a cognitive mechanism that […] could well form the foundation of social psychology and of society" (p. 170) to include all the different scientific areas concerned with behaviour and all different aspects of life, and that cognitive consistency should be considered a fundamental principle in the cause and function of all behaviour.

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