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Affect and control: A conceptual clarification

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ABSTRACT

Converging evidence seems to suggest that affect and cognitive control are related in interesting ways, and some researchers have suggested that affect may play a causal, or at least otherwise interesting role in cognitive control. Here I discuss reasons to believe that these claims are either unfounded or based on a conceptual misunderstanding. They are unfounded with respect to the role of conscious affective experience, which is not supported by any unequivocal evidence. And they are based on a conceptual misunderstanding with respect to unconscious affect: Given the strong conceptual overlap between affect on the one hand and cognitive control on the other, finding mechanisms that are shared by affect and control is an almost necessary outcome that does not provide any mechanistic insight but merely reflects the semantic overlap between the concepts. However, this overlap may be taken to expand our research perspective and take affect-related and control-related outcomes as equivalent markers of one underlying function that encompasses, and thus goes beyond the traditional concept of affect and control.

1. Prologue

When the editors of this special issue on the connection between affect and cognitive control asked me for a contribution, I thought this would be an easy task. While my main interest leans towards the control side, research from our own and other colleagues' labs have generated many findings suggesting some kind of connection, such as the observation that mood manipulations have an impact on conflict monitoring (van Steenbergen et al., 2010) and on the style of response generation in creativity tasks (Akbari Chermahini and Hommel, 2012). And yet, my increasing doubt in the usefulness of the current style of theorizing and theory-testing in the cognitive sciences and related disciplines (Hommel and Colzato, 2015, 2017a; Hommel et al., in press) made me think twice. In particular, I began to wonder whether I really understood my task instruction. What do we mean when asking questions such as what the role of affective processes in cognitive control is and whether cognitive control depends on affective processes? In the following, I will consider two meanings that these kinds of questions might have and will argue that neither of them makes much sense or is likely to elicit interesting answers. The main reason being that affect and control are concepts that overlap both logically and mechanistically by definition, so that asking questions about the relationship must produce answers that are either trivial or unlikely. In other words, asking whether affect is related to control is similar to asking how women relate to the elderly or whether my best friend is male or a gardener.

I will discuss these questions with a strong focus on conflict monitoring, a hypothetical control function for which possible links with affect have been particularly often considered. The seminal work of Botvinick et al. (2001) has suggested that the human cognitive system might routinely monitor for response conflict, which can be assumed to regularly occur in the presence of response uncertainty. For instance, if in a Stroop task the green color of the stimulus signals a different response than its word meaning “red”, the participant is likely to be uncertain whether to respond “green” or “red”. The fact that the representations of multiple responses are simultaneously active—i.e., the presence of response conflict—is assumed to be registered by a dedicated conflict monitor, which then informs systems responsible for representing the goal and providing top-down support for goal-congruent responses (Botvinick et al., 2004). The increase of top-down support reduces and eventually eliminates the response conflict, which renders the conflict monitor an important ingredient of the human action control loop. A theoretically attractive aspect of this control loop is the absence of any (need for a) homunculus; hence, the loop might be considered to run automatically and yet generate smart, adaptive behavior.

In an attempt to reconcile the original conflict-monitoring approaches of Botvinick et al. (2001) with other approaches focusing more on decision-making, Botvinick (2007) suggested that conflict might be coded as an aversive, or negatively reinforcing event. This move to bring affect into play has triggered numerous investigations of how affective manipulations of various kinds impact cognitive control in tasks with a high degree of response uncertainty. For instance, trial-to-trial changes in stimulus-response congruency effects (aka Gratton effect, after Gratton et al., 1992) were found to be significantly reduced when participants are provided with unpredictive reward (van Steenbergen et al., 2009) or after positive-mood induction (van Steenbergen et al., 2010). Numerous authors have considered findings

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of that sort to indicate "a role of affect in cognitive control" (e.g., Dreisbach and Fischer, 2012), but my main question here is what exactly is meant by that.

One possibility that the wording in many of these articles may suggest is that participants need to *consciously experience* a particular kind of affect in order to get a particular control job done. On the one hand, the need to consciously experience affect is implied by a long psychological tradition of theorizing about affect (see Winkielman and Berridge, 2004), as apparent in the writings of James (1884), Freud (1950), Clore (1994), or Frijda (1999). On the other hand, however, researchers theorizing about the connection between affect and control often avoid the question whether affect does or does not need to be consciously experienced to interact with control functions. Whereas some authors explicitly stated that conscious experience of cognitive conflict is essential for action control to operate (e.g., Desender et al., 2014; Questienne et al., 2018), others were more skeptical regarding this assumption (Abrahamse and Braem, 2015; Foerster et al., 2017), and even others considered that both conscious and unconscious affect may contribute to action control (e.g., Dreisbach, 2006). Hence, it is fair to say that there is no widely shared consensus regarding the question whether affect needs to be conscious in order to interact with control processes. Accordingly, I will consider both possibilities in the following, beginning with a possible role of conscious affect in the next section and continuing with a possible role of unconscious affect in the section thereafter, without attributing one or the other view to particular authors—so to avoid building straw(wo)men.

2. Conscious affect and control

If affect would need to be conscious to interact with control, the simultaneous activation of two or more responses would induce the strengthening of goal representations and the increase of their top-down impact on response competition only if that makes me a bit more annoyed or otherwise feeling bad. Without me having this affective experience, I would be less efficient in dealing with my response conflict and show a lesser or no Gratton effect. Indirect evidence speaking to this issue comes from studies in which the conflict-inducing stimulus was masked, which provides the opportunity to study whether the presence or size of the Gratton effect depends on the conscious awareness of the stimulus that is assumed to trigger the processes producing this effect. The findings are very mixed, however (for an overview, see Kunde et al., 2012): Some studies obtained significant Gratton effects with clearly visible, but not with masked conflict-inducing stimuli (Greenwald et al., 1996; Kunde et al., 2003; Frings and Wentura, 2008; Ansorge et al., 2011), while others found equivalent effects for visible and masked stimuli (van Gaal et al., 2010; Desender et al., 2013). Moreover, even if we could be certain that masked stimuli do not produce a Gratton effect, this does not necessarily require the assumption that the conscious experience of affect was causally involved therein.

For one, there was no independent measure of the degree to which the stimuli actually created conflict, which leaves the possibility that masked stimuli tend to create no or less conflict than unmasked stimuli do. Whether this is the case or not may depend on specific parameters of the research design, which may account for the inconsistent outcomes. Consistent with this possibility, Ansorge et al. (2011) found that the presence of the Gratton effect depended on the visibility of the conflict-inducing stimulus but not on the participant's judgment whether the preceding trial contained an incongruent prime or not. In any case, the available findings are parsimoniously explained by assuming that the Gratton effect is smaller or absent if there is less or no conflict but do not provide any support for a role of conscious experience, including the conscious experience of affect.

For another, even if there would be unequivocal evidence demonstrating that the Gratton effect only occurs under circumstances that generate conscious experience, there is no reason to believe that having the latter represents an important causal element in creating the former. As I will discuss in the next section, it is not unlikely that processes that eventually generate the Gratton effect make use of the same neural signals that are reflected in conscious experience. It is widely accepted that, say, form codes in the primary visual cortex can trigger activation through the ventral stream to reach inferotemporal cortex and provide the basis for conscious shape judgments and at the same time trigger activation through the dorsal stream to control grasping movements (Goodale and Milner, 1992). Even though there is an ongoing debate with respect to the degree to which these two streams interact (e.g., McIntosh and Schenk, 2009), there is no evidence suggesting that the conscious representation would be a precondition for, and a process preceding successful grasping. Quite to the contrary, successful grasping has been demonstrated under conditions where the conscious representation of the grasping goal was incorrect (e.g., Goodale et al., 1986). Hence, the fact that a given neural or functional process feeds into different processing chains, which depending on the characteristics of these chains may or may not result in correlations between the eventual outcomes, does not provide any support for the assumption that the outcome of one chain is a causal precondition for the outcome of another. This would be true even if the correlation would be perfect—which outside of the laboratory is for instance likely to be the case for judging and grasping for shapes.

Even if we would assume that a causal relationship between affect and control could have been demonstrated already, this would still leave serious interpretational problems. Conscious affective states are known to be subject to substantial cognitive penetration, as evident from findings showing strong situational, personal, and cultural impact on how people affectively experience and evaluate stimulus events (e.g., Barrett, 2017; Mesquita et al., 2015). That is, the exact same signals can be interpreted in different ways by different people. This in turn raises the question exactly what kind of affective state (e.g., which particular emotion) needs to be created to get conflict monitoring systems going and, in view of the substantial cultural impact on affect, how people have learned to translate conflict signals into exactly this kind of state.

These problems might be avoided by considering affect not as an umbrella term for all kinds of processes but as the raw material for higher-order emotions. For instance, Zajonc (1980) has suggested that affective signals are so simple (by only coding how positive or negative a particular stimulus event is) and so fast that the cognitive penetration of affective judgments is low or absent. Along these lines, one might consider affective signals as the raw material from which emotional experiences are constructed, suggesting that evidence for the strong cognitive penetration of the latter need not imply any cognitive penetration of the former. Such a view would fit with constructivist approaches to emotion as suggested by Schachter (1971) and Barrett (2017), and with Botvinick's (2007) suggestion that positively or negatively reinforcing signals might suffice to inform conflict monitoring systems. It would also fit with the observation that the impact of mood induction on cognitive control is restricted to changes in valence but not sensitive to changes in arousal (van Steenbergen et al., 2010). Hence, a more specific interpretation of affect would not only avoid conceptual problems but also be consistent with the available data. The problem is, however, that such a more specific interpretation does not seem to imply any role of conscious experience. If it is true that the human brain generates signals that indicate whether a particular stimulus event is positive or negative with respect to a particular reference frame, it is difficult to see why the signals would need to become conscious in order to inform cognitive control processes. To the contrary, the fact that a functioning control loop is likely to benefit more from simple, pure, not yet cognitively penetrated information would suggest that contributions from conscious representations are counterproductive. Moreover, bringing the consciously perceiving subject into play, who then actively tries to reduce conflict in order to get rid of the negative feelings, undermines the intellectual beauty of the original

control-loop idea, which derived its power from the absence of any necessary homunculus in the processing chain.

I conclude that there is no compelling evidence for any systematic role of conscious experience—affective or not—to cognitive control. While I have restricted this discussion to trial-to-trial processes in conflict tasks, because here the evidence for a connection between affect and control is particularly strong, the consideration of other control processes elsewhere (Hommel, 2007, 2013) has led to the same conclusion: that consciousness and control have little to do with each other.

3. Unconscious affect and control

A second possibility how affect and cognitive control might be connected relates not to the conscious experience of affect but, rather, to the processes underlying this experience and/or other processes that are considered to be affective in nature but do not require conscious experience, such as unconscious affect. Various researchers interested in human emotion have rejected the what they consider outdated view of affect necessarily being consciously experienced and claimed the existence of "unconscious affect" (e.g., Winkielman and Berridge, 2004; Smith and Lane, 2016). If it would be such unconscious affect that interacts with control processes, the above-discussed evidence against a causal role of conscious affect would be irrelevant for the claim of affect-control interactions and leave it fully intact. The question is whether the notion of unconscious affect makes sense.

Arguments that unconscious affect exists are commonly based on two kinds of demonstrations. For one, there is strong evidence that the subliminal presentation of what are considered to be affective stimuli, like pictures of happy or sad faces, are able to systematically bias self-reported mood of participants (e.g., Öhman et al., 2000). Along the same lines, mood reports were also found to be biased by the familiarity of unrelated stimuli (e.g., Monahan et al., 2000). The problem with these kinds of findings is that they speak more to the question of how conscious the inducing stimuli or their characteristics were perceived rather than to whether the affect they induced was conscious or not (Berridge and Winkielman, 2003; Kihlstrom, 1999). As I will explain below in more detail, if the conscious experience of affect and mood represents a cognitive construction from internal cues, as Barrett (2017) and others have suggested, there is no reason to assume that the cues from which the experience is constructed need to have a dedicatedly affective nature.

For another, the claim that affect can be unconscious is often based on demonstrations that subliminal presentations of what are considered affective stimuli can induce what is called "unconscious emotional reactions" (Winkielman and Berridge, 2004). For instance, participants liked unfamiliar symbols more (Chen and Bargh, 1999) and thirsty participants consumed more beverages (Berridge and Winkielman, 2003) after exposure to subliminal pictures showing happy faces. The standard interpretation of such findings is that the subliminal stimuli caused some sort of "affective reactions", which in turn altered behavior accordingly (Winkielman and Berridge, 2004). Is that a tenable assumption? On the one hand, it seems uncontroversial that the findings demonstrate that subliminal stimuli can systematically alter behavior. On the other hand, however, proponents of unconscious affect tend to over-interpret the available findings in at least three different ways.

First, it is theoretically questionable, and in fact misleading to call a stimulus "affective". Let us consider, for instance, why researchers assume that the picture of a happy face is an affective stimulus, and what they mean by making that assumption. A happy face shows the facial expression of an emotion, so that the stimulus can be said to have affective content. But so has the neutral face, as it informs about the absence of a specific affect. The intuition rather seems to be that the stimulus has the potential to evoke affective reactions. Given that unconscious affective reactions cannot be directly measured, researchers thus seem to rely on the potential to evoke conscious, reportable affective reactions, and thus borrow from our knowledge about conscious affect. If so, it is actually worrying that studies have shown that indications of unconscious affect can be dissociated from indications of conscious affect (Berridge and Winkielman, 2003; Winkielman et al., 2005), as these dissociations seem to undermine the idea that our knowledge about conscious affect can motivate the labeling of a stimulus as affective. Rather, this label seems to take the hypothetical unconscious affective reaction for granted, which renders the theoretical reasoning circular: Any effect of unconscious face stimuli on behavior is attributed to unconscious affect, and that attribution is taken to suffice to have demonstrated the existence of unconscious affect, in the absence of any direct assessment of the hypothesized state. All this is the more worrying as there is no stimulus that carries exclusively affective information: the picture of a happy face may or may not induce happiness in the perceiver, but it can just as well inform her about some physical state of affairs (e.g., which muscles are activated if the depicted person smiles), motivate her (e.g., to make the happy person cry), or remind her about the presence of other people in general. In other words, each stimulus can be considered affective, cognitive, motivational, and social (to name just a few possibilities) at the same time, which renders the label affective meaningless and incorrectly suggests that the stimulus does not carry any other information.

Second, it is by no means self-evident that effects of so-called affective stimuli on behavior are mediated by what is commonly called "affective reactions". The intuition often seems to be that being exposed to a happy face makes the perceiver more happy and that this (hypothetically unconscious) happiness was responsible for the change in behavior, such as the increase of drinking in the study of Berridge and Winkielman (2003) or the preference for particular symbols in the experiments of Chen and Bargh (1999). I will get back to the conceptual problems with this assumption in the next section, but another problem of these kinds of interpretations is that they ignore possible alternatives. For instance, most participants will have grown up under circumstances in which a smiling face (e.g., of a parent or peer group member) signaled social approval, thus supporting less inhibited behavior, and recommendation of particular choices. Seeing a smiling face is thus likely to reactivate behavioral parameters that may just as well have led to the observed behavior. Along the same lines, smiling faces are commonly taken as motivational signals to support the continuation of the present behavior. Hence, the cognitive, motivational, social, and otherwise non-affective characteristics of stimuli like happy or otherwise affective faces are likely to trigger internal processes that may explain the observed behavior in an entirely non-affective fashion.

Third, and this is a related point, the dependent measures used to demonstrate the impact of "affective stimuli" are anything but process-pure measures of the hypothesized affective reactions or processes. Preferences for particular choices are notorious for being impacted by all sorts of influences, rational or not, and the same holds for drinking behavior or any other dependent measure used in demonstrations of nonconscious affect. Again, characterizing the respective behaviors as "affective" neglects the many other characteristics they have, the many non-affective stimulus characteristics they are sensitive to, and the many non-affective processes involved in producing them.

But there are even more serious, conceptual problems with assigning terms used to refer to psychological phenomena, like affect, which is an important explanandum of psychological research, to the elements considered to explain these phenomena, the explananda that is. As I have just pointed out, characterizing a stimulus as "affective" does not exclude the possibility that the exact same stimulus may just as well be characterized as "motivational", "cognitive", and "social", as most stimuli that have the potential to evoke affective reactions can evoke motivational, cognitive, and social reactions as well, and the same holds for the processes involved in generating these reactions. Hence, these different terms can be applied to the exact same set of phenomena and mechanisms just in order to emphasize different aspects and implications of them. For instance, colleagues and I have

argued that the concepts "perception" and "action" indeed refer to the exact same kinds of sensory-motor activity but are intended to emphasize the knowledge-acquisition aspect of such activity by using the former and the event-generating aspect by using the latter term (Hommel et al., 2001). Along the same lines, one may well refer to the exact same process or activity, such as the conflict signal responsible for the Gratton effect, as "cognitive", to emphasize its information-generating aspect (it informs, or at least can be taken to indicate, the presence of multiple response activation), as "affective", to emphasize that either this signal or any of the processes it triggers eventually leads to a "bad feeling", as "motivational", to emphasize all the things that it gets going, such as the refreshing and strengthening of goal representations, and as "social", as it indicates that more needs to be done to satisfy the contract between participant and experimenter. In other words, characterizing a particular internal process by means of any of those terms is meaningful if, and only if the characterization is intended to express the contribution to a particular phenomenon, but not to imply that this is the only function that this process has. If so, characterizing a particular process as "affective" does not exclude that it is "cognitive" and involved in realizing cognitive at the same time. If we thus characterize a process X as affective and a process Y as control-related, we cannot exclude that we are referring to the exact same process.

There are indeed various hints suggesting that the processes underlying affect and the processes underlying cognitive control are at least partially identical (cf., Inzlicht et al., 2015, who discuss many of these shared processes and yet suggest a causal interpretation). As already mentioned, Botvinick (2007) assumed that the presence of response conflict generates a signal that provides negative feedback to associative learning, so to support avoidance learning. The same signal might be used to construct negative emotions along the lines of Barrett (2017), which would fit observations that conflicts are perceived to be aversive (Dreisbach and Fischer, 2015) and echo the main theme of cognitive-dissonance theory (Festinger, 1957). Hence, the same signal may underlie both cognitive control and affect—be it consciously perceived or implicit/unconscious.

Likewise, there is evidence suggesting that both changes in cognitive-control style and in emotional experience covary with changes in (presumably striatal) dopamine levels (Hommel and Colzato, 2017b). For instance, Akbari Chermahini and Hommel (2012) observed that positive mood induction increased both spontaneous eyeblink rates, a possible marker of dopamine levels (Jongkees and Colzato, 2016), and flexibility in a creativity task. Moreover, incidental, unexpected monetary reward impacts cognitive control the same way as classical mood induction does (van Steenbergen et al., 2009, 2010), and even longer-term affective states like depression show the same kind of impact (van Steenbergen et al., 2012). Again, this suggests that the same neuromodular dynamic may be part of both cognitive control and affect.

While these and many other observations support the idea that affect and cognitive control are related, there are reasons to believe that they teach us more about the semantics of our language (i.e., about the fact that we use different words to refer to the same thing) than about the interplay between independent processes. Psychology has notorious difficulties to translate the affect-related everyday terms "affect", "emotion", and "mood" into scientifically meaningful concepts. The term "affective" is often used to distinguish the thereby characterized process or system from "cognitive" or "motivational" processes or systems, a tripartition of the human psyche that continues a tradition since Plato (Republic IV, see Calian, 2012), who divided the human psyche into reason, spirit, and appetite, and suggested that people differ with respect to the degree to which one of these components dominates their action control. While the translation of this tripartition into functional and neural theorizing is not without problems, the term affective is still used to indicate that the characterized processes or systems are less rational and less well informed by the current context, the current task goals, and general background knowledge than cognitive processes or systems are. Following this logic, "affect" would be an umbrella term for all sorts of affective processes and systems, including emotions, moods, and feelings (https://en.wikipedia.org/wiki/Affect_(psychology)). In practice, however, these seemingly fine-grained distinctions are difficult to maintain. For instance, according to a poll of 35 distinguished emotion researchers (Izard, 2010), emotion can be defined as consisting of "neural circuits (that are at least partially dedicated), response systems, and a feeling state/process that motivates and organizes cognition and action" (p. 367; see Inzlicht et al., 2015). It is difficult to see in which sense such a definition provides a clear-cut distinction between emotion, cognition, motivation, and action control, which in turn suggests that what is considered to be an interesting interaction between different, separable systems (between affect and control, that is) might turn out to be a trivial implication of the semantically overlapping way in which these systems were conceptualized.

It is important to emphasize that these kinds of conceptual problems are not restricted to the field of affect and control but can be found everywhere in the cognitive (neuro-) sciences (Hommel, in press; Hommel et al., in press). Western researchers treat the concepts of cognition (including cognitive control) and affect/emotion as referring to natural kinds, that is, to two different, non-overlapping sets of phenomena and mechanisms. Accordingly, the idea that a member of one of these sets might be associated with a member of the other set is interesting and tends to imply some kind of interaction, perhaps even some kind of causal impact. Historical and intercultural analyses reveal a different picture, however. The semantics of what is meant by cognition and affect/emotion differ rather dramatically between cultures and have changed dramatically over time (Danziger, 1997), which implies that concepts of that sort are better conceived of as "human kinds" (Hacking, 1991). As Danziger (1997, p. 5–6) writes, "Psychologists did not invent the concept of 'emotion' … to account for certain empirical findings; they obtained certain empirical findings because of their desire to investigate a set of events which their culture had taught them to distinguish as 'emotional'", which implies that "… psychological theory operates on the basis of some pre-understanding of that which it is a theory of". Indeed, psychologists rather uncritically take over common sense or (often ancient) philosophical preoccupations with particular concepts and take it for granted that the referents of these concepts are completely distinct. But there is no reason to believe so.

Taken altogether, this means that it makes little sense to speak of cognitive and affective (and motivational and social, …) processes, as the fact that a given process contributes to, or is involved in one phenomenon (the explanandum) that is labeled accordingly does not exclude contributions of the same process to many other phenomena carrying different labels. In other words, there is no reason to reserve a particular explanans for just one explanandum. But once we apply more conceptual discipline and restrict the use of labels to the explanandum under investigation, such as affect and cognitive control in our case, and do not extend them to the processes that serve as explanans, the question whether affect and cognitive control are related becomes meaningless. More technically speaking, if the concept AFFECT is associated with the (functionally or neurally defined) set of processes X that comprises of the processes $x_{1, ..., } x_n$, and the concept CONTROL is associated with the set of processes Y that comprises of the processes $y_{1, ..., } y_n$, any overlap between the sets X and Y renders the two concepts partly identical. Given the numerous indications of existing overlap, such as dopaminergic activity or sensitivity to the same experimental manipulations, at least partial overlap can be taken as a given. Accordingly, the two concepts cannot be considered independent in a logical or statistical sense, so that the question whether they interact causally is about as meaningful as asking whether my bodily fitness interacts with my state of health. With respect to experimental manipulations, this implies that we need to assume that inducing a

particular mood also implies inducing a particular control state, and vice versa. This ironically renders the above-criticized non-specificity of the definition of emotion as "neural circuits (that are at least partially dedicated), response systems, and a feeling state/process that motivates and organizes cognition and action" (Izard 2010; p. 367) rather realistic.

4. Affect as process marker

As I have argued, the best we can do is to ask is whether the same process impacts both cognitive control and affective experience or unconscious affect, but that does not imply that the latter would impact the former. In other words, if control and affect overlap, they do so because we are using semantically overlapping concepts but not because there would be any interesting interaction between the underlying processes. Nevertheless, the semantic overlap and the resulting overlap in the underlying processes might be of considerable practical importance for research on cognitive control and emotion. Consider, for the sake of the argument, that the conflict signal that is generated in the presence of multiple response activations has two effects: it leads to the strengthening of goal representations to make the agent focus more on the task, as conflict-monitoring theorists have claimed (Botvinick et al., 2004), and it makes the agent feel a bit worse than before. As I tried to explain, it makes little sense to assume that the latter is causally responsible for the former, as the two effects are merely correlated by virtue of originating from the same signal. And yet, if that correlation is strong enough, as various findings suggest (e.g., Dreisbach and Fischer, 2015), the latter can be taken as a marker of the former.

For one, such a marker would be useful as a manipulation check of experimental interventions that target the conflict signal in order to bias cognitive-control operations. If these operations change as predicted, showing that mood also changed accordingly might be taken to provide converging evidence. Conversely, changes in cognitive-control style might be considered converging evidence for interventions targeting mood. For another, such a marker may also serve as an equivalent, depending on the degree of correlation, that would allow testing predictions from novel theories. It may sound odd at first to argue that empirically demonstrating changes in mood should be taken as an argument relating to cognitive control, but once we acknowledge that cognitive control and affect are merely exchangeable labels for aspects of what might be the same function or ability, these kinds of generalization may look less far-fetched.

Eventually, the study and further discovery of markers of the same or strongly overlapping underlying processes might have an educational effect on theorizing. Elsewhere (Hommel and Colzato, 2015), we have argued that the common analytical approach to psychological phenomena, which takes everyday concepts, translates them into pseudoscientific labels, tries to increase distinctiveness by further (commonly futile and heatedly debated attempts of) definition (see Danziger, 1997), and continuously increasing fragmentation, as exemplified by the areas of human attention (Hommel et al., in press) and action control (Hommel and Colzato, 2015), may no longer be productive. A promising alternative would be a synthetic approach following Lewin (1931, see Hommel and Colzato, 2017a) and Braitenberg (1984), which turns around the scientific discovery process: it starts with a toolbox of well-understood basic mechanisms and tries to reconstruct as many empirical phenomena from them as possible. Integrative theorizing would thus no longer consist of fleshing out the mechanisms underlying one specific empirical observation or class of observations, such as the Stroop effect, or working memory capacity, or task switching, but rather of accounting for an increasing number of empirical observations from various domains by means of the same set of basic processing mechanisms.

Such toolboxes of basic processing mechanisms may vary in format, depending on the level of analysis and the interests of the researcher. It may for instance be couched in informational terms. If, to take up the response-conflict scenario, two or more response representations are measurably activated by external state of affairs, such as an incongruent Stroop stimulus, one may assess various kinds of impact that this co-activation might have. In other words, one may ask which kinds of phenomena or behavior the availability of information about co-occurrence or conflict (which by the way need not be the same thing) might have. It would be important to restrain from labeling this information as cognitive, affective, motivational, social, or otherwise, simply because it is both logically and empirically very likely that multiple-response activation has effects on all these domains: it might activate control operations reducing the conflict, make the person feel uncertain or bad, make the person curious and motivated to find out more about the stimulus situation, and/or seek social contact and communication. The causal direction would be clear: the availability of information about multiple-response activation could be expected to cause all these behaviors, whereas the behaviors would be considered as dependent measures, but not as causes—at least in the absence of additional reasons and observations. Hence, the research strategy would not consist in accounting for one selected effect but rather to take a possible signal and track down all its effects.

A toolbox may also consist of basic mechanisms that are couched in terms of mechanistic principles. For instance, colleagues and I have tried to understand how cultural context might generate individual differences in conflict and other tasks. We reasoned that most tasks require some kind of decision-making, which in humans is commonly assumed to be competitive and guided by goal-related top-down biases (Bogacz, 2007), which points to two (possibly related) parameters that may be sensitive to individual differences: the degree of competition between alternatives and the degree of top-down bias. After having found surprisingly substantial evidence for a rather systematic impact of culture on these parameters in tasks as diverse as global-local tasks, Simon tasks, attentional-blink tasks, and temporal-discounting tasks, and in tasks sensitive to social representation, we studied the same principle as a function of genetics, mood induction, bilingualism, and meditation (Hommel and Colzato, 2017b). It would thus make little sense to label the studied mechanism cognitive, affective, motivational, or social, but rather leave it as is: a mechanism that explains how various factors can generate interindividual differences in many kinds of behavior. Obviously, other formats or levels of descriptions of mechanisms are possible: one may think of the workings of a particular neural circuit or a particular computational principle that may just as well affect various kinds of behaviors in the same, systematic way. It is thus not the way researchers define basic mechanisms that matters but the fact that they are truly mechanisms (i.e., elements that interact in an orchestrated fashion: see Hommel, in press) and that they are not pre-labeled according to (and thus in a sense "occupied by") a particular phenomenon one is interested in, thus leaving open contributions of the same mechanism to other phenomena.

Overcoming the apparent distinction between cognitive control and affect by defining a toolbox of basic mechanisms that can account for various control- and affect-related phenomena that hitherto were discussed and theorized about separately, would be an important step towards a better, truly mechanistic understanding of the human mind and brain. This might even change our interpretation of conscious experiences. If it is true that affect and control (in addition to other functions not discussed here) are not two separable modules of the human mind/brain but two functions that are derived from the same interconnected cognitive/brain dynamics, we may start to understand that the conscious experience of what we now call an emotion may at the same time be the conscious experience of a particular control mode, and vice versa. In other words, a better understanding of the actual mechanisms may work back on our conceptual terminology, as one would expect from a mature scientific discipline.

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