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Cognition and Emotion

What is the role of emotion in (human) cognition? Or is this actually the wrong question to raise and we should better reverse it as to ask what role cognition plays in emotion? Either way, how do emotional and cognitive processes—assuming it is at all possible to draw this distinction—interact? Is one merely regulatory for the other or is there a dynamical, bidirectional interaction?

In due course I will consider different views on the matter. First I will give some examples demonstrating emotions can have an impact on cognitive processes; second, I will present cases suggesting there is a role to play for cognition in emotion. Third, I will introduce a model of emotion activation according to which emotions can, but need not, have a cognitive precursor. This model, I will argue, might turn out promising if combined with a dynamical systems approach. I will conclude reciprocal connections between emotion and cognition are plausible to assume but ultimately their identification depends on, first, conceptual work to be done and, second, empirical investigations to be made.

Note that before one can come to elaborate on the above questions, at least a preliminary account of how to distinguish cognition and emotions must be given. Traditionally, cognition and emotion have been conceived as complementary processes; where cognition—or, to use Kant's term *reason*—was associated with human *knowledge* while emotions are associated with *motivation*. Candidate definitions offered in recent debates, however, are far from being crisp and clear for either cognition or emotion. Intuitively, it may seem

like "cognition" just refers to the *process of thought* (including remembering, associating, concentrating, reasoning, learning, dreaming, reading etc.) while "emotions" refer the sort of thing giving rise to *subjective feelings* we (as cognitive agents) *experience*. In its broadest outline this means that the cognitive and the emotional are still to be seen as separate realms. Nevertheless, there are scientists considering emotions rather as part of the cognitive while others talk about emotions themselves having a "cognitive component" [12]. In what follows, however, I shall assume the intuitive distinction just drawn.

1 The Impact of Emotions

Sometimes when we are sad the entire world is drained of color. We find it hard to concentrate, struggle to focus on a task and become selective in what experiences we recall. These aspects of emotional experience point to a global, all-embracing impact of emotions on cognitive processes such as learning, attention and memory.

In his 2002 review, Ray Dolan [3] cites various studies from psychology and neuroscience that support the following set of hypotheses:

(a) *Pre-attentive processing* of emotional stimuli. Neurophyisological data point toward the amygdala—an almond-shaped structure located deep within the medial temporal lobes—as an important mediator of emotional effects on perception. Notably, even patients with attentional deficits (such as neglect) happen to perceive emotional stimuli in locations they do not normally recognize neutral ones.

(b) *Enhanced memory for/ recognition of* emotional stimuli or events.

Emotionally laden events are remembered significantly better than others. Here again, the amygdala occurs to play a crucial role beyond its mediating functions; it is found to be active during encoding and recall of highly emotional memories.

(c) *Subjective feeling states and emotions mediated via different pathways*. According to Dolan, evidence accumulates to indicate that the automatic response elicited by an emotional event—the emotion—is accompanied by subjective feeling states. These are mediated via hypothalamus, somatosensory cortex, insular and orbitofrontal cortices rather than the amygdala.

(d) *Decisions biased by emotions*. Processes related to emotions can bias our judgment and reasoning. For illustration consider someone in love doing things she might otherwise have taken to be 'unreasonable'.

Taken together (a) to (d) suggest emotions do have a strong impact on cognition. Additional, and more recent, evidence for this conception comes from a 2009 study by De Martino *et al.* [2] who investigated the neural underpinnings of threat processing in an attentional blink paradigm[1] where faces of differing emotionality served as target stimuli. Behavioral data support hypothesis (a) from above as fearful second targets were recognized significantly better than neutral ones. fMRI recordings revealed correct identification of emotional second targets goes along with increased activity in fusiform

[1] In a typical attentional blink experiment subjects are presented with a rapid succession of visual stimuli. At the end of each trial, they are asked to indicate whether or not they have seen any of two target stimuli where these are known to them in advance. As it turns out, the second target is not recognized if presented during a period of about 250 to 500 ms after the first. The standard explanation is that once the first target is selected for higher-level processing, attentional resources do not suffice to recognize the second target (they are still occupied with processing the first one).

face area—a brain area specialized for recognizing and processing faces—which is unsurprising given the stimuli employed in the current study. Further, activity in rostral anterior cingulate cortex was found to correlate with enhanced processing of emotional stimuli while attentional resources were limited. The authors thus suggest their data "support a model in which a prefrontal 'gate' mechanism controls conscious access of emotional information under conditions of limited attentional resources" ([2], p. 128).

In a different study (from 2003), Susanne Erk and her colleagues investigated the neural substrates of encoding episodic memory in different emotional contexts [4]. Their results generally support hypothesis (b) from above but go beyond postulating a role for the amygdala in such modulatory effects. Using event-related fMRI recordings and a subsequent memory paradigm[2] they investigated how emotional context affects encoding activity associated with subsequent recall. From the obtained data they conclude that (i) activation of inferior frontal regions predicts recall in general while (ii) emotional context differentailly modulates successful episodic encoding as follows: amygdala activation predicts recall in negative encoding context while activation in extrastriate visual and right anterior parahippocampal areas predicts recall in positive encoding contexts.

Despite supporting the hypothesis that emotions have an impact on cognitive functions, these results by Erk *et al.* suggest the classical view of the limbic system—anatomically often described as a ring-

[2]Typically, subjects are presented with words while lying in the scanner and asked to classify them (e.g., whether they refer to living or non-living things). Subsequently, and without having been told in advance, their memory is tested by showing them a partially identical set of words and asking the subjects to indicate which of the words are new to them. The "subsequent memory effect" refers to the differential activation pattern associated with those words that are, in the later task, correctly recognized as previously encountered items as opposed to those that are incorrectly judged as new.

like complex located in the medial hemispheres including amygdala, hippocampus, parahippocampical gyrus, cingulate gyrus, fronix, hypothalamus and thalamus—as the "circuit of emotions" [11] or "emotional brain" [9] might only be part of the story, viz. emotional processing in the brain cannot be limited to these areas.

2 A Role for Cognition

In the previous section I have outlined how emotion might play a (possibly crucial) role in cognition. I will now come to shortly introduce two example cases and a recent study that suggest a role for cognition to play in emotion.

From everyday experiences we know that emotions can be influenced by our interpretation and source attribution of the very feeling we recognize. As an example might serve the following scenario noted by Julius Kuhl in [8]. Imagine you are out for a walk and suddenly recognize something pointed at your back. What's up? Who is the guy walking right behind you sticking this thing to your back? The emotions you are experiencing strongly depend on your interpretation of the current situation. If, for example, you just saw an old friend crossing the way behind you, you might expect her to wind you up. You thus might feel happy to see her again despite the slight annoyance about the childish game. If, on the other hand, last night you have heard about a robbery in the street you are currently walking, you might suspect a robber has approached you with a knife, be fearful and frightened. Thus, our cognitive interpretation of a situation can modulate our emotional response.

Early scientific evidence for a cognitive influence on emotions comes from a study conducted by Stuart Valins in 1966 [14]. While viewing playboy photographs male participants' heart rate was mon-

itored. Those falsely being told their heart rate was accelerated later judged the pictures more emotional than controls. Thus, the emotional valence of the pictures was said to not merely have arisen from the photographs themselves but also be influenced by the feedback. False feedback, i.e. telling a subject his heart is beating faster than it actually was, is taken to indicate a role for cognition in emotional processing.

Note, however, that Valins' results can be explained away by claiming emotional processing itself was not affected at all. For increased emotional valence of the pictures, as reported by the subjects, might be due to cognitive refection about their experiences in conjunction with the false feedback rather than an alternation of the emotional experience itself.

More recent research focuses, e.g., on a possible role of memories in emotions and emotion regulation. Among the best-known claims about emotion regulation is that "thinking of something nice" might help people "get over it" and improve their moods. In a 2007 study Jutta Joormann and her colleagues conducted an experiment investigating mood regulation abilities in three groups of patients: currently depressed, formerly depressed, and never-depressed [6]. More specifically, the patients' ability to regulate sad mood either via distraction or via recall of happy memories was examined. As it turned out, all subjects improved their mood in the distraction condition while differential effects were observed for the three groups during incongruent (i.e. happy) memory recall. Whereas the mood of healthy subjects improved, formerly depressed subjects' mood did not change in response to the recall. Currently depressed subjects, however, did react to recalling positive memories with a significantly worsened mood. Despite their implications for depression as being associated with an impaired ability to regulate sad mood by recalling

positive memories, these findings suggest that recalling memories, viz. cognition, does have an effect on emotional processing (at least in healthy subjects).

3 Emotion Activation

Thus far I have introduced evidence for emotional influences on cognition (in section 1) as well as cognitive influences on emotion (in section 2). Taken together, this suggests a reciprocal connection between the cognitive, viz. the realm of human mind associated with knowledge rather than feelings, and the emotional, viz. that which is associated with motivation. However, things are not this easy; for (i) it is not clear how the cognitive exhibits its impact on the emotional and vice versa; and (ii) nothing has been said about whether the reciprocal influence (or even a unidirectional one) might be necessary, i.e. whether there can be cognition without emotion and/ or emotion without cognition.

In this section, I will sketch a model of emotion activation due to Carroll Izard [5] according to which cognition is one among four ways to elicit emotions. In the following section I will briefly sketch how this model can be further developed using a dynamical systems approach.

According to Izard's "multisystem model of emotion activation", all emotions necessarily involve neural processing. However, there are four different ways to (i.e. four kinds of processes that) elicit emotions.

1. *Neural Processes.* Mere neurobiological, non-cognitive, processes—typically subconscious and associated with the release of certain neurotransmitters in the limbic system—can be used to explain the generation of certain emotional experiences.

2. *Sensorimotor Processes*. Emotions are activated by efferent (or motor) commands where processing might include afferent feedback from muscles and muscle spindles. This includes, e.g., reflexes.

3. *Affective Processes* (Motivational System). Physiological drives (i.e. a subject's intrinsic motivation to satisfy her most basic needs) and basic emotions (such as pain) including the sensory processing coming along with them give rise to the experience of emotions. Further, emotions might themselves activate other emotions that they are innately linked to or have been associated with through learning.

4. *Cognitive Processes*. The 'highest' mechanism of emotion generation occurs only beyond a certain level of evolutionary as well as individual development. It includes appraisal processes and attributions to lead to an emotion.

These four kinds of processes, or "activating systems" as Izard calls them, operate in princtiple independently of one another but might be found to interact under certain conditions. Importantly, the systems are hiereachically organized (with neural processes being at the lowest and cognitive processes being at the top level) where the resulting hierarchy is associated with development. In very young infants (or fully developed simple organisms) emotions arise from neural processes only but as they develop (or evolve) the other systems become available. Thus, emotion activation might take one of the alternative routes. Though each of these possible routes strongly builds upon a neural basis, the level of description of the underlying mechanisms is different. If giving an explanation for an emotion elicited by cognitive processes, for instance, it is not feasible to name each and every ion exchange in whole population of cells. Rather, we

should aim for a functional explanation referring to certain larger-scale processes (such as "memory" as opposed to "change in the strength of synaptic connections due to mossy fiber activation"[3]). As Izard puts it, "causal explanations of emotions in terms of the different activating systems (e.g., the neural and cognitive) involve not only different levels of analysis but also different mechanisms and processes" (p. 74, [5]).

Despite the favorable account of explanation[4] Izard presents, his model has appeal. It clearly shows that cognition can be causally relevant to emotion. And, even further, it clearly states that involvement of the cognitive is not necessary for emotional experience. An apparent difficulty with the model is, however, that it takes the cognitive to be a mere precursor of the emotional, i.e. the model happens to present only a single side of the coin we would—in the light of empirical results like the ones sketched earlier—expect of it to display. This is not to deny that cognitive processes can give rise to emotions, neither is it to deny there can be emotional experiences without cognition. Rather, it is a call for extending the model as to tell us how emotions might figure in cognition; which was, admittedly, not Izard's objective in the paper under discussion. But I take his account to be promising enough to give such an extension a try.

The link would would need then is one leading from emotional experience to cognitive processes. Although the sketch presented in the 1993 paper indeed displays a link from emotional experience

[3]Appropriately timed mossy and climbing fiber activation is the basis for long-term-potentiation (LTP) as well as long-term-depression (LTD), viz. learning and memory.

[4]Izard's model can be seen as an early step toward mechanistic explanation, an account more recently developed by Carl Craver [1]. The basic idea is that mechanisms consist in component parts performing different operations. These parts are organized and their operations orchestrated as to make the mechanism as a whole, in appropriate context, perform the phenomenon in question. Paul Thagard [13] explicitly applied a similar account to emotions.

back to neural processes (but not cognitive processes *per se*) this link remains largely unexplained. All that is said about this connection is that there might be some influence of emotions on neural processes simply because they have a neural substrate. And this is clearly not what I have in mind when talking about emotions having a role to play in cognition (see section 1).

In 1995, Marc Lewis [10] sketched a model according to which cognition and emotion are constantly receiving and providing reciprocal feedback. Such a dynamical approach seems promising for it admits both cognition-emotion and emotion-cognition interaction—even at the same time, to various degrees and dynamically changing. This relation seems to square relatively well with empirical evidence suggesting a causal link both from cognition to emotion and from emotion to cognition—assuming, of course, we really can draw such a clearcut distinction. Moreover, Lewis' account postulates a crucial role for these feedback connections in personal development—which happens to have empirical appeal, too (for brevity's sake, however, I shall not go into into detail with this point).

Another theoretical framework proposing sort of a dynamical interaction between the cognitive and the emotional is Kuhl's PSI-theory [7]. Here too, cognition is assumed to be a modulator of the emotional while at the same time emotions affect cognition.

Taken together, in light of evidence such as discussed in sections 1 and 2, dynamical approaches happen to be promising candidates in search for a model of the observed interaction between emotion and cognition.

4 Upshot

Empirical evidence suggests that cognition and emotion—understood roughly as "thought" and "motivation", respectively—are mutually dependent. Emotions can frequently be observed to modulate, viz. facilitate or inhibit, cognitive processes while cognitive processes might serve as (i) a source of emotional experiences and (ii) a regulator of emotions (e.g. if recalling happy memories to get over a sad mood).

Theories postulating a dynamical interaction between the two realms seem promising. But, after all, they are no more than theoretical frameworks resulting from inferences to the best explanation. There are two things we need in order to determine how cognition and emotion really relate: first, a less squishy distinction of what to call "emotional" and what to call "cognitive" has to be found—an endeavor that probably requires conceptual rather than empirical investigations; second, empirical sciences will have to find out what the substrates of cognitive and emotional phenomena, respectively, are. The proof of how they are interconnected then is ultimately, as so often, in the empirical pudding. At least for now, with our merely intuitive distinction of cognition and emotion at hand, it seems as if there are genuine reciprocal connections to be discovered.

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