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Metacognition

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Summary

It has often been claimed that metacognition should be defined as 'cognition about one's own cognition', 'knowledge about one's own knowledge', or 'thinking about one's own thinking' (Carruthers, 2011, Nelson & Narens, 1992, Perner, 2012). These formulations, however, are now often seen as unduly restricting the scope of metacognition to a form of reflective judgment. There is evidence that agents with no concept of perception or knowledge, such as monkeys and young children, are nevertheless able to assess when they can confidently engage in a task (such as finding an object, discriminating visual patterns or recognizing whether an item was already presented) (Hampton, 2009). On an alternative definition, then, metacognition is the ability to evaluate whether one is likely to achieve a specific cognitive goal or to have successfully achieved it. These evaluations jointly contribute to the control of one's actions. They allow agents to select contextually efficient cognitive actions, such as trying or not trying to remember the location of an object, and to decide whether or not to rely on a specific cognitive output to act on the world. In both cases, on this broader definition, agents may rely either on the degree of confidence that they experience (a noetic feeling), or on what they judge to be the case, given their background beliefs and concept-based predictions (Arango-Muñoz 2011, Koriath & Levy-Sadot 1999, Proust 2007, 2013, 2015). Metacognition so conceived is distributed in domain-specific abilities, involved in the regulation of mental actions, the distribution of resources between rival processes, and the regulation of one's own emotions. Inter-agent metacognitive control is also exemplified in the pragmatic principles of conversation first explored by Paul Grice, and in collective forms of epistemic investigation and decision-making (such as in scientific research).

Defining Metacognition

Metacognition is best defined through its functional role within cognition (Shea et al. 2015). 'Cognition' extends to all the informational processes involved in representing the world and acting on it, with functions such as perceiving, desiring, learning, remembering, reasoning, intending and acting. 'Metacognition' refers to the specific processes whose function is a) to control the informational reliability of the cognitive activity in these various dimensions and b) to monitor the informational reliability of the processes engaged when performing specific cognitive tasks. What is meant by 'informational reliability' is the probability of information to be adequately channelled, retrieved and combined in generating decisions. Such decisions are involved in selecting or monitoring cognitive actions, i.e. actions performed in order to acquire or extend one's own knowledge, such as trying to discriminate, remember, or solve a problem (Arango-Muñoz, S. 2014, Proust, 2013). Control is related to the rational *selection of a given cognitive action* as a function of the agents' present goals and available resources (in particular, the amount of cognitive effort to be allocated for the action to succeed). Monitoring consists in *assessing the informational adequacy* of the current performance, by tracking deviations from the epistemic goal (perceptual or reasoning error, memory failure, inconsistency in beliefs or in preferences, improper concept use, etc.).

The defining property of metacognition does not consist in the specific control mechanisms that are being used: control and monitoring mechanisms are ubiquitous at all levels of behaviour (Carruthers, 2015, Shea et al. 2015). Furthermore, the mechanisms relevant to metacognition, while important for theorizing about metacognition, are only mentioned in its definition for their function: selecting appropriate informational goals and assessing the validity of particular decisions in the domain of perception, memory, or reasoning. What does it mean, however, to claim that a metacognitive subsystem "tracks the informational reliability of first-order cognitive actions"? To clarify this claim, a primary distinction between subjective and objective uncertainty needs to be made.

Two types of uncertainty

As observed by David Hume (*Treatise*, I, 4, 1), our ability to form true beliefs about the world is threatened by two forms of uncertainty. Objective uncertainty originates in the evidence on which our judgments are built – i.e. on the way the world appears to us. The more stable the world, the more likely it is that a prediction about it will turn out to be correct. A perpetually changing world would not be knowable, because information crucially depends on the existence of causal regularities (Dretske, 1988). Subjective uncertainty originates in the agent's own variable cognitive dispositions. Subjective probability of error can be assessed,

however, through "a reflex act of the mind, wherein the nature of our understanding and our reasoning from the first probability become our objects" (*Treatise*, p. 122). A 'reflex act of the mind' is one through which the mind assesses how likely it is that it correctly represents a given state of affairs. For example, recognizing an apparently familiar face in an unexpected location leads to doubting one's own perception.

A sceptical argument about metacognition

David Hume considers the sceptical move through which our primary *subjective* uncertainty (did I actually recognize N?) is seen as applicable to our critical estimation itself (am I right to think that I did ?). This recursive process, iterated in infinity, should progressively diminish the probability for a belief to be correct toward a "total extinction of belief and evidence" (Hume, 2007, p. 122). Hume recognizes the cogency of the argument, but describes our beliefs as being *de facto* insensitive to this recursive threat. Such insensitivity indicates, on his view, that reasoning and belief are not governed by ideas and reflections, but rather by "some sensation or peculiar manner of conception". An argument that requires an effort of thought, even when perfectly comprehended, may look far less persuasive than a "lively conception", i.e. a consideration that is easy to represent (Hume, 2007, p. 123). In agreement with Hume, psychological studies indeed suggest that laypersons take 'ease of reasoning' – i.e. 'fluency' – as an indicator of truth (Reber & Unkelbach, 2010). This finding, however, should not suggest that metacognition is merely based on a least effort principle, nor that it tends to motivate irrational decisions. To summarize: Hume's sceptical argument about metacognition was that, when assessments of subjective uncertainty are recursively applied to one's own prior assessments, the subjective likelihood for being correct should tend to zero. As Hume observes, the fact that this argument does not describe humans' way of assessing their uncertainty suggests that metacognition is based on feelings rather than reasons.

Objective and subjective informational reliability

Just as there are two forms of uncertainty, subjective and objective, there are two forms of informational reliability. Objective informational reliability refers to the causal properties of events that makes them objectively predictable (for example the time of the day objectively predicts light intensity). Subjective informational reliability refers to the causal properties of cognitive and metacognitive processing that make errors predictable or detectable (for example slow cognitive processing tends to predict error). In both cases, reliability is measured by the frequency of predictive success. Metacognition assesses subjective

informational reliability, that is: the degree of subjective certainty attached to a given task or outcome.

For an agent to generate correct results in a given cognitive task, informational reliability in the first order task (such as remembering) should be consistent with the subjective probabilities that are collected. Calibration mechanisms are important informational channels allowing felt confidence to track over time the objective probability of subjective predictions being correct in a type of cognitive performance. For example, having repeatedly failed to retrieve a proper name from memory leads one to experience a lower confidence in being able to retrieve another proper name. Calibration of confidence is optimal when confidence in a set of performances coincides with objective accuracy in that set. For example, someone with a moderately high confidence in her memory for names is well calibrated if her retrieval rate is about 75% of the names searched, not if her retrieval rate is about 30%. Successful calibration of subjective assessments of confidence is subjected to two conditions. First, cognitive actions of the same type have to be repeatedly performed for collecting sufficient calibrating feedback. Second, the feedback so collected must be informative about action success. In other words, it must not be positively or negatively biased (Fleming et al., 2012). In a positive bias, such as the equality bias, the subjects' decisions are made to appear systematically better than they actually are; in a negative bias, such as the gender bias, they are systematically presented as worse. Overconfidence or underconfidence in performing this type of task results from such biasing effects, often motivated by social prejudices.

A computational approach to metacognition can be represented as addressing the sceptical argument in a more principled way than Hume's proposal. Hume's sceptical argument was that, when assessments of subjective uncertainty are recursively applied to one's own prior assessments, the subjective likelihood for being correct should tend to zero. If subjective uncertainty, i.e., confidence in one's own perceptual discriminations, is modelled as the ratio of the mean of the sensory estimate to its standard deviation, there is no additional deviation to be expected at a higher level. Further calibration allows convergence to occur toward an internal reliability standard. The reason for this convergence is that calibration mechanisms permanently adjust the threshold of confidence to the updated standard deviation (Bahrami et al., 2012).

A sceptic could argue, however, that a calibration mechanism may occasionally fail to be reliable. Social biases, such as an equality bias, a gender bias, or a misguided deference to pseudo-experts, have been demonstrated to promote biased metacognitive feedback (i.e. inadequate feelings of confidence), which jeopardizes calibration (Mahmoodi et al., 2015).

Theories of metacognition: attributivism vs evaluativism

What are the abilities that allow metacognition to develop? A major controversy concerns the scope and informational basis of metacognitive assessments. A number of the early theorists of metacognition, including psychologists John Flavell (Flavell, 1979), Thomas Nelson and Louis Narens, (Nelson & Narens 1992) have claimed that metacognition requires modelling first-order cognitive states, and that, consequently, a form of mindreading is involved in assessing the informational reliability of one's own mental states. Because metacognition is seen as engaging mindreading, i.e., mental state attribution, this view has been referred to as attributivism (Proust, 2013). More recently, attributivism has been further defended by Peter Carruthers (2009, 2011). On this view, non-mindreaders, such as rodents and monkeys, are unable to perform metacognitive control and monitoring of their own mental states.

In contrast, evaluativism is the view that two informational sources are available to human agents in order to predict cognitive accuracy, consisting respectively in emotional experience and in concept possession. The first, which is shared with some non-human species, relies on dedicated emotions, called 'noetic feelings'. For example, one can feel that one knows or does not know a given proper name, while failing to retrieve it; feeling uncertain does not depend on a conceptual competence or a judgment that one can remember a specific name any more than feeling angry depends on having a concept of anger. The other relies on innate or acquired knowledge about mental functions. For example, one may judge that one can respond to a question because it belongs to one's own area of expertise. In such cases, one uses concepts and theories (about learning and remembering) to assess one's own competence.

Empirical arguments have been offered by evaluativists, documenting the contrast between two metacognitive systems. Nonhumans, such as monkeys and rodents, in particular, seem to be unable to judge that they can perceive or remember an item because they do not have the associated mental concepts available. However, they are able to control and monitor their own cognitive activity just as humans do, in tasks involving memory of former presentations, or perceptual discriminations of displays (Call 2010, Couchman et al. 2012, Kornell et al. (2007). Three year-old children, similarly, are notoriously unable to reliably attribute knowledge to themselves and to others, when tested verbally (Gopnik & Astington, 1988). They are able, however, to reliably decide when to inform, or not to inform, another person about objects and properties as a function of what they know to be the case, well before they are able to reliably apply the concept of knowledge to the informational states

they have (Kim et al., 2016). Twenty-month old infants have even been demonstrated to ask for help – and hence, communicate their uncertainty to others – only when objectively needed (Goupil et al., 2016): hence, monitoring their own uncertainty does not seem to require from the children that they *judge that they know*, (when 'know' is taken to refer to a mental concept possessed by the child). Finally, this dissociation is also present in human adults; subjects tend to make different predictions about future recall when having engaged themselves in a learning task— a cognitive action— and when having merely observed others perform the task (Koriat & Ackerman, 2010).

Because they define metacognition as requiring a metarepresentation of one's own mental states as mental, the mindreading theorists of metacognition have been unconvinced by these arguments. For example, developmental psychologist Josef Perner (2012, p.113-115), thinks that "apes' desire for getting good looks" (to locate where the food is hidden) does not qualify as metacognitive, "because the animal does not need to know that it lacks sufficient knowledge". This objection amounts to claiming that a conceptual understanding of one's own ignorance is a presupposition of metacognition. Theory-theorists have also emphasized that metacognition in children flourishes well after they are able to pass false-belief tasks. This argument however, has been contradicted by evidence for non-verbal metacognitive decisions in infants and young children (Goupil et al., 2016, Balcomb and Gerken, 2008).

Others, such as Peter Carruthers and J. Brendan Ritchie (2012), recognize that feelings can guide uncertainty-based decision-making, and that evidence for this ability in animals is impressive. They deny, however, that this function is metacognitive (for reasons that, again, are terminological). Animals' decisions to opt out from a cognitive task are seen to belong to the regulation of action, rather than to the regulation of informational reliability. An additional objection to the infant studies stems from modularism (nativism about mindreading) (Carruthers & Ritchie, 2012): children's failure in verbal tests might reflect executive rather than conceptual difficulties. Seen from this viewpoint, dissociation between practical decisions to inform and self-knowledge report does not speak in favor of a two-system view of metacognition.

Noetic feelings

Granting that emotional mental events called 'noetic feelings' play a central role in metacognition, how do we characterize them? Feelings of confidence, of knowing, of being right, and the tip of the tongue phenomenon (experienced when failing to recall a word while sensing that retrieval is imminent) are seen as appraisals of likely success or failure of one's

own current cognitive actions (De Sousa, 2009). Variations in valence (pleasurable or aversive) and in intensity guide epistemic decision in an immediate way (Hookway, 2003). These variations have been shown to be based on the discrepancies between observed and expected feedback predicting likely success in a current cognitive task (Proust, 2015a). A noetic feeling of uncertainty of a given degree, for example, motivates agents to try harder to perceive, remember or solve a problem, or to give up their current task. Attributing a crucial evaluative role to feelings in epistemic decision substantially modifies the traditional view that emotions are generally obstacles rather than instruments of rationality (de Sousa, 2009).

There are also controversies about whether noetic feelings have intrinsic or derived intentional content. While some theorists, following Tye (2009), take them to be introspective experiences of first-order states, others hold that they are rather bodily experiences with a merely derived intentional content. On this view, noetic feelings carry information about what might easily happen. Hence, they provide agents with modal knowledge about their own competence in a current task (Dokic, 2012). In contrast, some philosophers take noetic feelings to be representations of intrinsic intentional states. What they transparently indicate, however, is neither a fact about the environment, nor a fact about mental properties, but rather a subjective relation between agents and environments. The intentionality of emotional states, then, is seen as 'Janus-faced' (de Sousa, 2009), or claimed to exemplify 'Pushmi-Pullyu' representations of epistemic affordances (Millikan, 1995) endowed with a non-propositional, associative format (Proust, 2015b).

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