

OPINION ARTICLE

Beliefs Made It into Science: Believe It or Not

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A long-standing discourse in philosophy dating back to antiquity concerns the nature of beliefs and believing. Until today, the notion “belief” has been of importance in philosophy, as evident from the definition of knowledge as justified true belief. In fact, the notion “belief” was understood as a topic of research focused on people’s attitudes or opinions about what was or was not true in the world.¹ Research questions were summarized by the formula “S A that P,” where S denotes the mental state, A the attitude of a putatively rational agent, and P the verbally expressed proposition reflecting the belief.¹ By contrast, the study of beliefs was generally assumed to be incompatible with the natural sciences. Very recently, however, the term “belief” has been described as to be used widespread in the cognitive science literature to explain human reasoning and behavior.² Specifically, it has been described that beliefs act as fundamental hypotheses about the world that result from any amount of cognitive processing and are held with any degree of certainty.³ Thus, beliefs are apparently not propositions expressed by consciously aware, so-called rational agents, but, on the contrary, determinants of people’s spontaneous and intuitive behavior in a complex world, as highlighted in a recent interdisciplinary research topic.⁴ Here, we put the implications of the recent advancements in this rapidly evolving field in perspective for the sciences and beyond.

Beliefs as Brain Products

In cognitive neuroscience, beliefs are considered as brain products that result from neural processes. This hypothesis differs from the aforementioned formula whose implication is that the verbal statement P represents a belief that is accessible directly

and which, therefore, can be shared between people, whereas the mental state S and the attitude A must be inferred. By contrast, beliefs as brain products are not accessible directly, but can be inferred from a person’s behavior (Figure 1). The active inference of beliefs has been modeled according to the free energy principle integrating discrete events such as perceptions and continuous states such as mindsets.⁵ These processes imply that a person observes events in the external world, infers the causes of the events, and forms beliefs about them. In other words, belief formation results from the multisensory perception of external information within and across modalities in a probabilistic fashion, emotional valuation in terms of subjective effort/reward estimations, and encoding of this composite information in memory (Figure 1). Notably, humans trust their beliefs because our perceptions of the environment are processed effortlessly and rapidly and typically convey useful information. And our perceptual systems normally accept the matching of new information with prior information stored in memory as evidence of truth. Moreover, beliefs afford predictive coding of subsequent actions along with retrieval of prior information, and thereby provide a reliable link between a person’s past experience and his/her future behavior (Figure 1). As a consequence, beliefs denote a mindset or attitude that constrains an individual’s behavior in a stochastically predictable fashion before the person becomes aware of his/her intuitive action tendencies or could intentionally modify them. Thus, the inferred beliefs turn out to be attributions from a third-person perspective.⁴

There are, by now, already functional imaging studies that have revealed that the processes of believing involve widespread brain structures, including sensory cortical areas, value and confidence representations in the medial prefrontal cortex and

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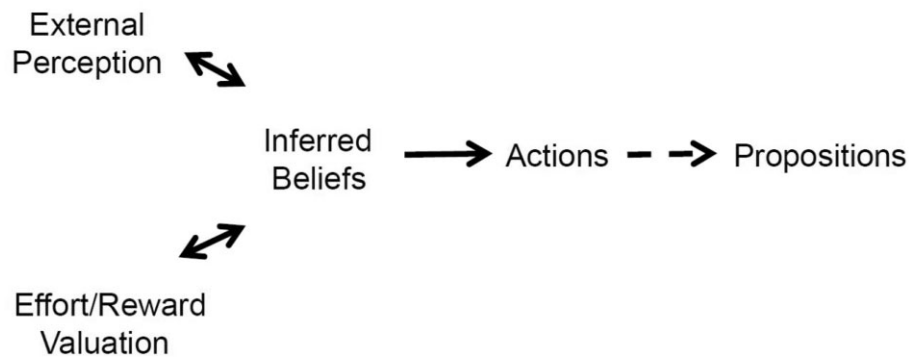


Figure 1. The position of beliefs in the sequence of neural processes that mediate the guidance of human behavior. \longleftrightarrow : re-iterative bottom-up and top-down flow of information; \longrightarrow : predictive coding; $- - - \rightarrow$: transition to conscious awareness.

distinct reward representations in the anterior insula, amygdala, and ventral striatum.⁶ Recently, believing judgments about positive and negative personality traits as presented in trait adjectives were investigated in Chinese and Danish subjects.⁶ The medial prefrontal cortex was found to be involved in both cultural groups and accompanied by stronger left anterior insular and ventral frontal activations in Chinese subjects. Moreover, in the Chinese subjects activity occurred in the dorsal medial prefrontal cortex and was associated with predicted slower memory retrieval of self-related information. In Danes, activity was localized more anteriorly in the medial prefrontal cortex and predicted faster retrieval of self-related information. These findings highlight that the neurocognitive processes engaged in believing have subtle differences between individuals from Western and East Asian cultures.

Communication of Beliefs

People can become aware of what they believe and may want to communicate it to other people.⁷ In verbal statements or propositions, beliefs reflect a first-person perspective typically grounded in fundamental biases such as being good, well-reasoned, and belonging to a favored and active group.³ However, people may also be mistaken and report a delusion-like belief. For example, with an exposure time of a visual stimulus shorter than 400 ms and the instruction to predict its eventual form, people have been prone to incorrectly think they predicted the real outcome.⁸ Thus, although beliefs manifest rapidly and with ease, there seems to be a critical temporal limit for a valid recognition of stimuli. Also, people may intentionally deceive others, or may state something or behave in a way that is inconsistent with their real beliefs due to brain diseases.⁴ Therefore, it is important to appreciate that beliefs can be inferred from observable actions with a high degree of accuracy, but not necessarily from their verbal statements (Figure 1).

People may have numerous perceptions that result in diverse beliefs about the world. Two general categories of beliefs can be identified. These are (1) language-independent primal beliefs about objects and events in the physical environment, and (2) language-based conceptual beliefs that are communicated as narratives.⁴ Narratives can be classified into different domains with respect to autobiographic, religious or spiritual, and political content. However, because beliefs serve as starting points for how people perceive the world and process its information, it has been proposed that prior beliefs bias the processing of novel

information as well as other stages of processing novel information.³ Because conceptual beliefs have broad implications for social life and human culture, we can assume that their formation involves distinct cognitive capabilities.² Conversely, how beliefs may be updated involves a challenging discussion, particularly when communicating about complex conceptual beliefs is involved. It remains to be seen which neural systems subserve belief updating. It seems that when the assertions provided by beliefs no longer match the predictions, beliefs are likely to become updated or eventually fade.

Developmental Influence of Beliefs

Beliefs are of particular importance to the psychological developmental of children and adolescents because as they relate to biological, social, environmental, and economic issues, they shape the personalities of young people.⁹ There is good evidence that maturation through adolescence is likely to take place via neuroplasticity. However, abnormal or traumatic experiences may adversely affect development and lead to abnormal beliefs and personality disorders.¹⁰ Similarly, neurological and psychiatric brain diseases acquired during adulthood have been found to induce false beliefs such as hallucinations and delusions in addition to the disease-specific abnormalities. Also, the perception of an effort–reward imbalance has been reported to be widely prevalent in many different work settings and to predict health hazards such as stroke or myocardial infarction.¹⁰ Because effort–reward valuation is fundamental for belief formation and a person’s preferences (Figure 1), an imbalance toward high efforts relative to reward is likely to induce disturbed self-beliefs that are perceived as irritating and hard to cope with. Thus, the relation of beliefs and brain and behavioral maturation is challenging to explore.

Conclusion

The processes of believing appear to subserve a genuinely universal human brain function as detailed in a recent interdisciplinary research topic.⁴ It is expected that this discourse will pave the way for novel research agendas both in the basic and applied sciences.

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Conflict of Interest

None declared.

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