Beliefs: A challenge in neuropsychological disorders

Rüdiger J. Seitz*1,2
1Department of Neurology, Centre of Neurology and Neuropsychiatry, LVR-Klinikum Düsseldorf, Medical Faculty, Heinrich-Heine-University Düsseldorf, Germany
2Florey Neuroscience Institutes, Melbourne, Victoria, Australia

Introduction. Beliefs have recently been defined as the neural product of perception of objects and events in the external world and of an affirmative internal affective state reflecting personal meaning. It is, however, undetermined in which way diseases of the brain affect these integrative processes.

Methods. Here, the formation and updating of abnormal beliefs in cerebral disorders are described.

Results. It will be shown that well-defined neuropsychological syndromes resulting from brain lesions also interfere with the neural processes that enable the formation, updating and communication of beliefs. Similarly, in neuropsychiatric disorders abnormal and delusional beliefs appear to be caused by altered perception and/or misattribution of aversive meaning.

Conclusion. Given the importance of beliefs for ordinary social behaviour, abnormal beliefs are a challenge in neuropsychological disorders.

Beliefs, a heavily discussed topic in Western philosophy since centuries, have gained an increasing interest in cognitive psychology in recent years. The neuroscientific study of beliefs has enjoyed recently a multi-level approach including neural, psychic, experiential, behavioural and social levels. In functional terms, beliefs have been defined as relatively stable accounts of what a subject holds to be true and to predict future events (Connors & Halligan, 2015). In neural processing terms, it has been proposed that in most cases one of the functions of beliefs is to integrate perceived signals in the environment with attribution of personal emotional value (Fairley, Vyrastekova, Weitzel, & Sanfey, 2019; Sacks & Hirsch, 2008; Seitz, Paloutzian, & Angel, 2018; Todd, Miskovic, Chikazoe, & Anderson, 2019). Accordingly, individuals are not neutral concerning their beliefs but are affectively involved (Angel & Seitz, 2016). Since organisms have to act upon incomplete information and reward uncertainty in a fast-changing environment (Garcés & Finkel, 2019; Ma & Jazayeri, 2014), they have to utilize probability predictions for decision-making.
making and guidance of actions as, for example, has been shown in primates (Martin, 2019). These probability accounts of perceptual experience and emotional feelings provide subjective frames or beliefs that enable individuals to classify their environment intuitively according to friend or foe as well something nurturing or dangerous (Park & Tallon-Baudry, 2014).

Beliefs are omnipresent and indispensable in human life. They afford survival of the individual by constraining behaviour in spite of incomplete sensory information about the environment. Such personal probabilistic representations or beliefs are typically formed below awareness as somewhat stable, non-verbal precursors and possess high predictability for future actions (Connors & Halligan, 2020; Seitz et al., 2018). By their emotional value they bias a given perception according to which the subject can act (Peil, 2014). People tend to trust their beliefs. It was found that the illusory truth effect increases upon repeatedly perceiving the same events even if the evidence is false or corresponding statements in the propositions are implausible (Fazio, Rand, & Pennycook, 2019; Wright, Wade, & Watson, 2013). Thus, people may experience perceptions as true or real, although they are distorted or appear abnormal to other people (Ellis & Young, 1990; Fletcher & Frith, 2009). Such false beliefs are well-known components of psychosis. They may be polythematic involving a number of different semantic themes or monothematic affecting a specific distorted perception (Coltheart, 2015). Recently, it was argued from the view point of cognitive psychology that studying delusions will provide insight not only into the dysfunction of the cognitive processes associated with abnormal belief formation but, moreover, into understanding belief formation in general (Connors & Halligan, 2020).

Here, evidence is presented suggesting that belief formation is impaired in neuropsychological syndromes in a lesion-specific manner which is different from the attribution abnormalities in neuropsychiatric disorders. It will be shown that this approach offers novel insights into the pathophysiology of abnormal beliefs.

**Omnipresence of beliefs**

In appreciation of the notion that beliefs are closely related to brain function, it was proposed recently that the function of beliefs is to stabilize a given perception in the light of its adaptive value to a given subject (Connors & Halligan, 2015). Beliefs would do this by increasing the effectiveness and efficiency of brain mechanisms involved in problem solving, decision making, goal setting as well as in manoeuvring in the environment (Connors & Halligan, 2020; Garcés & Finkel, 2019). Beliefs are affirmative such that people trust their beliefs. In a simplified model, beliefs are composed of probabilities of perception and valuation ($P \times V$) and a probabilistic change term consisting of a prediction error ($\delta$) and its value ($V_\delta$) to account for adaptive flexibility as detailed elsewhere (Seitz et al., 2018). On the neural level of analysis, beliefs representations in the healthy human brain have been described to be related to extensive neural circuits involving lateral and medial frontal and parietal cortical areas (Han, Zhang, Wang, & Han, 2017; Harris, Sheth, & Cohen, 2007; Howlett & Paulus, 2015). Formation and maintenance of beliefs of healthy persons were hypothesized to involve neural computations in parallel and subsequently arranged striato-thalamo-cortical loops that are under dopamine influence and characterized by Bayesian model averaging of processed information and prediction-outcome comparisons (Friston, Parr, & de Vries, 2017; Seitz et al., 2019). These complex computations allow for making inferences about perceptions and are known to develop during infancy (Wellman, Cross, & Watson, 2001).
With respect to the neural processes affording belief formation, three belief categories have been identified on the psychic level (Figure 1). As detailed elsewhere (Seitz & Angel, 2020), the first category concerns concrete objects in the external environment. For example, a perceived object is valued in terms of what its meaning is to the exploring subject, such that an emotional loading becomes assigned to the object including aesthetic value, desirability or averseness and threat (Ishizu & Zeki, 2013; Rolls, 2006; Thiruchselvam, Harper, & Homer, 2016). Although empirical beliefs become established fast and outside of conscious awareness, people can become aware of them and express verbally their personal relevance and confidence in them.

The second category of beliefs concerns the relation of a subject to objects or to other subjects in the constantly changing environment. For example, in personal interactions the counterparts may develop a belief of interpersonal deception or trust (de Visser & Krueger, 2013). Interestingly, in the first 2 months after birth babies engage in reassuring social interactions with their mothers or caregivers, which is followed upon to the sixth month by first attempts of the baby to explore the immediate physical environment (Ulwelling, 2020). The confidence of the baby into these social perceptions has been shown to be of vital relevance.

Beliefs of the third category refer to higher order conceptual processing that requires the use of a symbolic language. During the long human evolution, humans have communicated their thoughts, emotions and intentions as well as beliefs about their own and other people’s past, their origins, and their goals, and their future after physical death (Belzen, 2010; Zaidel, 2019). Such conceptual beliefs evolve gradually over years from infancy onwards into adult life upon countless repetitions. Conceptual beliefs ultimately may include transcendent meanings about a deity, people’s fate or the world (Paloutzian & Park, 2015).

Abnormal beliefs in brain diseases

As beliefs are supraordinate probability models of subjective relevance about the external world brought about by more basic neural processes in the healthy brain, one has to expect that diseases of the brain are likely to induce the formation of distorted beliefs or a breakdown in the neural processes underlying belief evaluation leading to false beliefs or delusions (Langdon & Coltheart, 2000; McKay & Dennett, 2009; Pechey & Halliga, 2012). For example, brain infarcts may cause neuropsychic deficits affecting perception, value attribution, action prediction and language processing that typically are long-lasting and relatively stable in their presentation. It is hypothesized that such brain lesions also impair

![Figure 1. Categories of beliefs. The processes of believing result in beliefs that humans express according to their content, empirical beliefs by 'I believe that', relational beliefs by 'I believe someone', conceptual beliefs by 'I believe in'. For further details see Seitz and Angel (2020).](image)
belief formation and updating which becomes apparent upon neurological examination as neuropsychological syndromes depicted in Figure 2. In such conditions, belief formation ($P \times V$) can be impaired due to deficits either in perception or in affective labelling. Also, belief updating can be impaired due to abnormal predictions ($\delta$) or abnormal affective weighting of predictions ($V_\delta$). In neuropsychiatric disorders, the disease defining cognitive abnormalities including hallucinations and delusions become apparent upon verbal report by the patients (Fletcher & Frith, 2009). Thus, abnormal perceptions and/or abnormal affective weighing of these perceptions with an aversive loading would lead to abnormal beliefs.

In the following, these abnormalities of belief formation and updating are described with respect to defined neuropsychic syndromes.

**Agnosia**

_Astereognosia_ is the inability to identify an object by tactile exploration due to circumscribed lesions of the superior parietal cortex (Hömke et al., 2009; Roland, 1987). Thus, a subject cannot identify, for example, a key or a coin in his pocket when he puts his hand into a pocket and may not be able to use these items to open a door or to pay for something. Therefore, the items have no meaning for the person and, thus, will not achieve any value for him. Consequently, the perceptive deficit precludes the formation of the belief that there is a valuable item in his pocket. As the patient can identify the object using a different modality, for example vision, the perceptive nature of this deficit becomes obvious to her/him.

Similarly, _prosopagnosia_ is the inability to recognize a face (Albonico & Barton, 2019). In a recent systematic review, the most frequent brain lesion resulting in prosopagnosia was the fusiform gyrus (Cohen et al., 2019). In the most severe form, a patient may not be able to discriminate a face from other objects, for example a house. In less severe disturbances, the patient may realize that he sees a face but fails to state whether it is the face of a famous person or of a person he knows. Thus, all faces are strange and, therefore, of no relevance to the person. In addition, also the impairment of recognition of emotion in a face has been reported (Potthoff & Seitz, 2015). Thus, the patient becomes aware that he sees a face but it is emotionally neutral to him/her. The patient will not be able to develop a belief such as ‘I know and like this person’ or ‘I recognize this famous person who is beautiful’. From patients with multiple sclerosis, it is known that impaired face recognition affects behaviour interfering with social functioning (Prochnow et al., 2011).

Recently, it was described that _anosognosia_ is a characteristic abnormality with high prediction in Alzheimer’s disease (Hanseeuw et al., 2020). In this condition, the patients

![Figure 2. Abnormalities of belief formation in neuropsychological and neuropsychiatric disorders.](image-url)
typically deny to be impaired and affected by disease continuing to believe that they are healthy. This can result in overestimation of own body strength, refusal of assistance by other people, and incompliance with prescribed medication.

In mirror agnosia, the patients lose the ability to identify a mirror. For example, when an object is shown to them via the mirror, they would believe that it is located in the mirror and insist of reaching out wrongly to the mirror as described first in patients with dementia (Conners & Coltheart, 2011). In patients with brain infarcts, it was shown that mirror agnosia can be localized to lesions of the temporo-parietal cortex (Binkofski, Buccino, Dohle, Seitz, & Freund, 1999). Notably, these patients can recognize themselves and their body parts in the mirror but are unable to reach out correctly to objects seen in mirrored space.

**Apraxia**

*Apraxia* is the inability to perform and to imitate movements on command and to use objects and tools appropriately (Halsband et al., 2001; Leiguarda & Marsden, 2000) appearing as an interference in relational beliefs. While apraxia was initially described to be related to lesions of the parietal cortex (Leiguarda & Marsden, 2000), recently more extensive lesions patterns have provided a more refined view on the relation of the clinical deficits and associated lesions (Lesourd et al., 2018). Typically, limb movements cannot be perceived by the patient and/or the spatio-temporal evolution of limb movements is disrupted. Also, patients with apraxia are impaired to use tools appropriately. These tools have lost their meaning and value for the given patient upon unimodal and multimodal testing. Furthermore, the affected patients cannot believe that they are no longer able to use the tools as they used them before the deficit had occurred. Note, however, they still may know what the movements and tools are called.

**Aphasia**

*Aphasia* is the first described neuropsychological deficit which is characterized by the inability to produce or to understand language due to damage involving the language network (Kertesz, 1993). Apart from global aphasia, well-defined subtypes such as motor, sensory, conduction, transcortical and amnesic aphasia have been differentiated on clinico-pathological means (Catani, Jones, & Ffytche, 2005). However, language processing is far more complex and distributed in the brain as found by functional neuroimaging and electrophysiology (Friederici & Gierhan, 2013; Grabowski & Damasio, 2000). The core language area in left inferior frontal gyrus was found by a multimodal imaging study of adult macaque monkeys as well as children and adolescents to be similar in phylogeny and human development (Wang, Yang, Zhao, Zuo, & Tan, 2020). Note that closely related disturbances are *agraphia*, the inability to produce language in written format, and *alexia*, the ability to understand text by reading (Henderson, 2019).

With respect to the disturbance of belief formation two aspects need to be highlighted. *Motor aphasia* interferes with the phrasing of an empirical or relational belief. Thus, a patient may develop such a belief, but may not be able to phrase it internally or to communicate it to other people, although the patient can develop a firm belief about an object or event. *Sensory aphasia* interferes with the processing of narratives. When perceiving language is compromised, the patient will not be able to understand what is said to him or what he reads. In fact, the patient is incapable to form a new conceptual belief, although previously acquired beliefs continue to exist for him. Conversely, when
language production is impaired, the patient cannot express his beliefs as propositions or his stance concerning concepts including autoreferential, religious and political identities and norms, although the patient typically is well aware of what his position and preferences are and what he would like to do. Thus, sensory aphasia impairs the language-bound aspects of a conceptual belief, but the emotional flavour of a message or the essence of a ritual act may be conveyed via other sensory channels. Thus, the patient may behave appropriately due to his previous beliefs. Importantly, however, internal phrasing and communication to other people is impaired which prevents the spread of the patient’s beliefs as statements to other people.

Alexithymia

Alexithymia has been advanced as a personal trait and a symptom of a number of brain diseases characterized by the inability to appreciate one’s own emotions as well as emotions occurring in other persons (Bird & Viding, 2014; Goerlich, 2018). While emotion detection is a rapid process in the range of below 100 ms which was found to be impaired in alexithymia (Franz, Schaefer, Schneider, Sittre, & Bacho, 2004), emotion expression in a subject is an event that takes a couple of seconds. Alexithymia is a severe condition impairing the social interaction of the affected person, but has been put in focus for further epistemological elaboration (López-Muñoz & Pérez-Fernández, 2020). Due to the impairment in attribution of emotion, alexithymia affects the ability to develop a close relation or trust to another person. Accordingly, alexithymia interferes with the emotional valuation of other people impairing the formation of any belief concerning the mood, receptiveness or intention of the counterpart. Lesions of the cortex along the superior and inferior frontal cortex have been shown to impair or abolish the capacity of the afflicted individuals to attribute personal value to the perceived objects and events typical for alexithymia (Shamay-Tsoory, Aharon-Peretz, & Perry, 2009; Sifneos, 2000). Due to the associated deficit of introspection, the patients typically do not become aware of their abnormal beliefs concerning other persons in their environment.

Alien limb

In alien limb phenomenon, patients have the feeling that an arm or leg does not belong to their body, rather the extremity feels strange and disturbing as if it would not belong to the body (Feinberg, Schindler, Flanagan, & Haber, 1992; Graff-Radford et al., 2013). The causal lesions were found initially in the dorsal frontomesial cortex as well of the parietal cortex, particularly on the right. Moreover, there is a disturbance of allocating the perception to the own body, a function involving the anterior cingulate gyrus (Northoff et al., 2006). Recently, a network type of analysis of brain atrophy in patients with corticobasal degeneration which is characterized by the alien limb phenomenon revealed a far more widespread lesion pattern involving the lateral and medial parietal cortex (Tetreault et al., 2020). On the behavioural level, the patients typically cannot use the affected limb which makes it useless for them exaggerating their discomfort and rejection. In fact, the patients typically develop the abnormal relational belief that the affected arm or leg does not belong to them but rather behaves as driven by an alien. Notably, this false belief is supramodal and cannot be overcome by explaining the abnormal condition to the patient.
**Disorientation**

Disorientation concerns the basic categories place, time, person and situation. The descriptors of these categories are conveyed by narratives held in groups and societies representing fundamental conceptual beliefs. The causes of disorientation are quite different including brain trauma, encephalitis, stroke, epilepsy, dementia and metabolic changes. For example, in Korsakoff’s syndrome, transient global amnesia and chronic amnesia the patients are unable to rehearse the previously heard or read narratives from memory. A prominent example is the patient H.M. who suffered complete anterograde amnesia after bilateral hippocampal lesions (Milner & Klein, 2016). Likewise, inability to understand language, for example, due to sensory aphasia typically leads to disorientation. Therefore, the afflicted patient fails to develop a belief about where she/he is in location and time and what the relation of these conditions is. Rather, the patient sticks to his previously held beliefs that no longer are valid. This may provide a clue to the treating physician when the brain disease of the patient began. Moreover, disorientation can temporarily go along with depression or anxiety as can be observed frequently in developing dementia (Wiels, Baeken, & Engellorhgs, 2020). Importantly, confabulation as a hallmark of Korsakoff’s syndrome may reflect – at least temporarily – the false conceptual belief of the patient that he or she is oriented.

**Hallucinations**

Hallucinations are sensory appearances that occur in a patient but have no objective counterpart in the environment and are heterogeneous in presentation and association to brain diseases (de Leede-Smith & Barkus, 2013). As described in a systematic meta-analysis of functional imaging studies, auditory and visual hallucinations were related to activations in cortical circuits concerned with the processing modality as well as the motor and sensory speech areas (Billock & Tso, 2012; Blom, 2015; Zmigrod, Garrison, Carr, & Simons, 2016). While hallucinations may be triggered by items in the patient’s environment, where they are then called mis-interpretive illusions as in severe alcohol abuse, they often occur spontaneously. Hallucinations can involve all sensory modalities and may concern objects, events and narratives. From the patient’s perspective, these sensory appearances are misattributed to be real events and typically may be accompanied by positive emotions but frequently frighten the patient. Thus, the patients tend to believe that they are real similarly to ordinary sensory sensations. Such hallucinations may also involve beliefs about hearing voices generated by the patients or putative external agents (Connors, Robidoux, Langdon, & Coltheart, 2016). Patients typically trust their hallucinations and may even be convinced that they are caused by an alien agent (Figure 2). However, upon successful treatment the patient may identify and describe them as abnormal perceptions. Thus, belief evaluation by the patient is a critical step for the identification of sensory perceptions as hallucinations and the communication of their content to other people (Connors & Halligan, 2020; Oakley & Halligan, 2017).

**Delusions**

Delusions are distorted monothematic beliefs and polythematic conceptual belief systems associated with abnormal perceptions and unrealistic thoughts about the own person and the environment (Coltheart, 2015; Ellis & Young, 1990). Characteristically, patients may experience that fictional persons or a hidden voice speak to them and they can repeat these phrases that often are experienced as aversive by the patients. This
appears as a severe impairment in attribution of agency and authorship of actions (Frith, 2005) and may result in endangering patients to do harm against themselves as well as to other people when experiencing an urge to do harm to other people. It was proposed by Anticevic and Corlett (2012) that due to a disturbed interaction of cognition and emotion, patients are impaired in maintaining affective information over time, in detecting it and attributing it to future events. Specifically, people with delusions exhibit a tendency to accept an abnormal belief early in the inferential valuation process and to stick to it thereafter (Fletcher & Frith, 2009; Schmack & Sterzer, 2019). Formal thought disorders and delusions have been found in a large meta-analysis of imaging data to be related to left-hemispheric abnormalities with particular emphasis on language areas (Wensing et al., 2017). It is noteworthy, that the activity of these cortico-subcortical circuits are modulated by neurotransmitters, as for example abnormalities in dopamine function were found to be related to paranoid ideation (Nour et al., 2018) and ketamine to affect prediction error processing (Corlett, Honey, & Fletcher, 2016). In addition, the stimulant drugs such as cocaine and methamphetamine, which can cause paranoid delusional beliefs, do so by facilitating the transmission of dopamine (Ermakova, Ramachandra, Corlett, Fletcher, & Murray, 2014; Sora et al., 2009).

As with other sensations and thoughts, the affected patient considers his delusions as real resulting in a mismatch of expectations and experience (Corlett, Taylor, Wang, Fletcher, & Krystal, 2010). For example, patients with ‘somatoparaphrenia’ who are paralysed on the left side express the belief that their paralysed limbs are not their own but rather belong to someone else (Coltheart, Langdon, & McKay, 2011). In contrast, in hemiparesis the patients continue to believe that the paralysed limb is part of their own body and realize that they cannot move it voluntarily. In motor neglect, the patients are not aware of their paralysed limbs related to a network of abnormal brain function involving the lateral prefrontal, parietal and cingulate cortex (von Giesen et al., 1994). Typically, neglect occurs in right hemisphere stroke affecting several sensory modalities, but can in the acute phase transiently also occur in severe left-hemispheric stroke (Marshall, 2009). On the behavioural level, the patients believe that space around them is limited to that what they are aware of. Thus, they orient themselves to the normal side and stop acting in their midline leaving work unfinished on the affected side. The critical structure affected in spatial neglect was found to be the basal ganglia and the inferior occipitofrontal fasciculus (Karnath & Rorden, 2012).

Monothematic and polythematic delusions can be expressed as abnormal personal narratives which owing to their unrealistic content are recognized by other people as abnormal beliefs (Coltheart, 2015). For example, when a patient with Capgras delusion sees his wife, he will say that the woman looks like his wife but does not ascribe affective value to her (Coltheart et al., 2011). Likewise, the mirrored-self misidentification has been reported to be a delusion in which patients looking into a mirror have the belief that the person they see in the mirror is a stranger (Coltheart et al., 2011). This is different from mirror agnosia where the patients can identify themselves in the mirror but fail to perceive the spatial inversion by the mirror when acting on objects they see in the mirror (Binkofski et al., 1999) as described above. Nevertheless, mirror agnosia und mirrored-self misidentification are closely related as was shown by hypnosis (Connors, Cox, Barnier, Langdon, & Coltheart, 2012). Most strikingly, there are patients who report the atrocious belief to be dead which has been called Cotard delusion (Coltheart et al., 2011).

In contrast to these abnormal relational or conceptual beliefs that are characterized by their aversive, repellent or threatening delusions, in bipolar disorder the patient has delusional, most commonly grandiose beliefs during the manic episodes that appear to
reflect distorted perception. But at another time, the beliefs may be very negative and about 180° different from their semantic content when the patient was manic, perhaps on a week or two earlier. Moreover, when a normal mood returns (i.e., ‘euthymia’), he or she will go back to their premorbid belief. Interestingly, in bipolar manic patients, who have grandiose delusions (false beliefs), lowering their elated mood with something as simple as lithium carbonate can cause the grandiose delusions (false beliefs) to go away within a week. By contrast, in many patients with schizophrenia, a chronic disorder, neuroleptic anti-psychotic medication can in many cases take away their delusions (false beliefs), such as paranoid beliefs that someone is trying to kill them, or other bizarre beliefs of though insertion. All the older neuroleptic medications block the brain’s D2 dopamine receptor, which causes uncomfortable motoric side effects. The newer neuroleptic medications have less of an effect on the D2 receptor and also block the D3 and D4 receptors. How all this pharmacology is related to taking away delusional beliefs is not known (Beaulieu, Espinoza, & Gainetdinov, 2015; Meltzer, 2017).

**Discussion**

The idea presented here advocates that the physiological processes of believing are affected concerning belief formation, up-dating and communication in a differentiated manner related to neuropsychic disturbances of human brain functions. The essentially bottom-up establishment of beliefs by integration of sensory perceptions and their affective meanings in a given subject can be disrupted at different instances during processing of either type of information. These interferences in belief formation and updating may occur when the beliefs are still out of conscious awareness and prior to phrasing as personal narratives (Figure 3). Thus, an important step in the processes of believing is when an individual becomes aware of the content of a belief. Conscious access to beliefs is known to rely on intact long-distance cerebral connectivity which when affected by a brain disorder was shown to be linked to the occurrence of psychotic symptoms (Berkovitch et al., 2021). Following the conscious awareness, the content of a belief can be coded semantically and rehearsed internally. But the belief may also be communicated to other people which was labelled as internal and external broadcasting, respectively (Oakley & Halligan, 2017). While such broadcasting may be severely disturbed in aphasia, the plausibility and reality of beliefs are usually evaluated against the environment during entire life. In childhood, feedback is given by parents and educators, later by friends, neighbours and partners. Thereby, humans learn what a probably valid sensory or emotional perception, a dream, an imagination, and what an abnormal perception or an abnormal or false belief are. Notably, also self-deception may result in false beliefs.

As proposed in the so-called credition concept, believing is similarly to speaking or remembering a complex brain function brought about by more basic neural processes such as perception and valuation (Angel & Seitz, 2016). This involves the meaning making of perception of objects and events in the external world (Seitz & Angel, 2015). In addition, emotional or affective value is attributed to such information which affords a personal stance and allows for prediction of future events (Seitz et al., 2018). As was proposed recently, beliefs can be categorized with respect to the external information into empirical, relational and conceptual beliefs (Figure 1). Since usually individuals have no doubt to believe their own perceptions, valuations and thoughts, the resulting beliefs are held to be true by the individual. In this neurophysiological perspective, beliefs can be
understood without referring to the notions of truth, knowledge and rationality. This deviates from the long-standing Western philosophical tradition according to which beliefs are considered to be mental states that occur upon the appraisal (justification) of a belief-based proposition as true or probably true (Churchland & Churchland, 2013; Leicester, 2008). While in some philosophical approaches, beliefs have been described as dispositions, interpretations or delineated according to their functions (Schwitzgebel, 2015), neuropsychology suggests that beliefs are formed prior to linguistic coding. In line with this notion beliefs about objects and events can be considered as pre-linguistic primal beliefs. Furthermore, from birth onwards humans are exposed to narratives as presented in fairy tales and nursery rhymes. Thereby, they intuitively develop concepts about themselves and their environment (Belzen, 2010). In addition, children are told norms how to behave properly and what is appreciated in contrast to what must be avoided (Carpendale & Hammond, 2016). Beliefs are shared by groups of subjects providing benefits such as group identity and group cohesion (Gelpi, Cunningham, & Buchsbaum, 2019; Han & Ma, 2015). Such conceptual beliefs may be labelled according to their content such as factual, autobiographical, semantic, ethical, political and religious (Harris et al., 2007; Howlett & Paulus, 2015). It is noteworthy that social groups and societies differ in which autoreflexive, political, religious and cultural beliefs they have, although aspects of such different conceptual beliefs were found to be exchangeable (Oviedo & Szocik, 2020).

It was presented here that well-defined neuropsychological syndromes of which only few were named here interfere with belief formation and up-dating, leaving the affected patients with unrealistic beliefs concerning their residual executive and functional capabilities (Figure 2). For example, patients with focal brain damage impairing the perception of objects including faces, limbs and their bodily appearance as found in the agnosias believe that new information is strange and disturbing and most of all not relevant for them. Consequently, patients with agnosia execute inappropriate actions and typically may not be capable of correcting them upon repetition, although they may realize that the actions are dysfunctional. Likewise, deficient recognition of events as in apraxia may render patients incapable of mimicking actions or using tools. Thus, the patient’s beliefs about the spatiotemporal relation of his body parts or to external objects formed prior to the disease are distorted such that the patient is no longer able to execute such actions. Similarly, a disturbance of the belief about one’s interpersonal relations to other people as

Figure 3. Evolution of beliefs. Owing to the high neural processing speed beliefs evolve below conscious awareness. When an individual becomes aware of a belief, it will be expressed verbally as a personal narrative. Communication of such a narrative to other individuals will cause verbal or behavioural feedback. Note, that this scheme of personal interactions can be extrapolated also to groups of individuals.
in alexithymia can affect interpersonal interactions. Finally, the inability to perceive or to produce language as in aphasia severely interferes with personal orientation with respect to autobiography, place, time and situation. All this information is coded semantically underlying personal narratives of what individuals believe.

This view accords with the claim that abnormal perceptions are one key factor leading to abnormal or unrealistic beliefs on which the patients base their unrealistic actions and predictions (Conners & Coltheart, 2011). The abnormal beliefs can be inferred by the observer from the abnormal actions the patients execute. For example, a patient with apraxia, anosognosia or neglect may believe to be able to drive a car but, in fact acts inappropriately causing an accident. Furthermore, brain diseases may result in abnormal perceptions or false beliefs with the ensuing possibility that the afflicted individuals may engage in aversive and possibly even destructive behaviour. This may be seen in alexithymia, sensory aphasia and disorientation. It should be noted, however, that brain lesions occur upon their disease-specific pathophysiology causing neurological deficits that vary to some degree among different patients in spite of the similar clinical syndrome. It was shown in the so-called Gerstmann syndrome that the integration of mapping of specific brain functions, nerve fibre tractography between the cerebral activations and lesion mapping of corresponding deficits provides means to reveal the critical brain lesions that cause such a composite neuropsychological deficit (Rusconi et al., 2009).

In contrast to brain lesions that typically cause stable deficits, neuropsychiatric disorders, such as schizophrenia, whose pathophysiology is considered to affect the brain more globally being far less well understood cause false perceptions and beliefs which may fluctuate in content and severity over time (Frith, 2005). Typically, such distorted or purely imagined perceptions are combined with negative emotional loadings. Also, misattribution of aversive, repelling or threatening emotions to perceptions has been described in rare forms of monothematic delusions including somatoparaphrenia, Capgras delusion or Cotard delusion (Coltheart, 2015). Importantly, the afflicted patient believes what he experiences and sticks to this belief even in presence of contradicting evidence (Schmack & Sterzer, 2019). Accordingly, deficient belief evaluation by the patient is a critical second factor for becoming deceived by hallucinations and delusions (Conners & Coltheart, 2011; Connors & Halligan, 2020; Langdon & Coltheart, 2000). In consequence, abnormal beliefs in neuropsychiatric patients impair between-subject interactions possibly resulting in a loss of social functioning. In terms of cognitive neuroscience, this resembles punishment anticipation which was shown by functional neuroimaging to involve a brain network different from reward anticipation except for a shared representation in the middorsal anterior cingulate gyrus (Lake et al., 2019).

Some medicated patients with schizophrenia, bipolar disorder or drug-induced delusions may become aware of their false beliefs allowing them to speak about them (Figure 3). Moreover, they would be in the position to evaluate their contents and predictions, and potentially distance themselves from them (Fletcher & Frith, 2009). For example, in bipolar disorder the patient will realize that his/her prediction, such something wonderful would be happening, was false. In such beneficial situations, the content of hallucinations and delusions may be communicated by the patient to other people or to the treating psychiatrist (Oakley & Halligan, 2017). Unfortunately however, in many patients with schizophrenia, even on psychotropic medication, their delusional beliefs persist. Nevertheless, the perspective of psychotherapy is to enhance the patients’ ability to consider evidence against delusional beliefs and modify them accordingly.

In conclusion, the neural processes involved in formation, updating and communication of beliefs can be affected in a differentiated manner by a number of specific
neuropsychological disorders. In addition to their impact on processing of sensory and affective information, they can lead to a failure of belief formation or to abnormal beliefs as described here. In contrast, hallucinations and delusions are the hallmark of psychotic disorders. However, they are not specific to psychoses but can occur in other brain diseases including autoimmune encephalitis, epilepsy and dementia (Conners & Coltheart, 2011; Elliott, Joyce, & Shorvon, 2009; Kasper, Kasper, Pauli, & Stefan, 2010; Pollak, Nicholson, Mellers, Vincent, & David, 2014). They seem to occur preferentially in damage of the limbic mesiotemporal region which is known to be of key relevance for memory functions (Squire, 1986). This opens a broad avenue for future research. When abnormal beliefs manifest, by some yet to be understood neurophysiological and/or neurochemical mechanism, the resulting behaviour is likely to be inadequate or to offend social norms. Thus, the challenging question for social neuroscience remains by which means social groups agree upon which narratives may qualify as normal or abnormal beliefs.

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The author declares no conflict of interest.

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