Frame-based analysis of mental disorders: towards a novel systematic approach to represent mental disorders

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Abstract

**Introduction:** Current advances concerning the classification of mental disorders require the development of new approaches to bridge the gap between the neurosciences and psychopathological findings. One innovative approach to define and classify mental disorders is a frame-based representation of mental disorders based on Barsalou’s Frame Theory. Frame Theory is a general format of the representation of concepts in human cognition using frame structures, consisting of attributes of mental representations and the values they may take.

**Methods:** In our study, we applied Barsalou’s Frame Theory for the representation of mental disorders using specific phobias as an example.

**Results:** We show that pathophysiological and classificatory aspects of specific phobias can be integrated into a comprehensive frame structure, so that a complete picture of the complex interrelationships between different pathogenic processes and classification issues emerges.

**Conclusion:** A frame-based analysis of mental disorders according to Barsalou’s Frame Theory provides a novel systematic approach to represent mental disorders. Furthermore, frame-based representation of mental disorders offers a stringent basis for analyzing complex interrelationships of pathophysiological and classificatory aspects of mental disorders, which may be helpful to develop novel approaches towards a classification of mental disorders based on pathophysiological principles.

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1. Introduction

There is increasing evidence that cognitive dysfunctions play an important role in the pathophysiology of mental disorders like, e.g., schizophrenia (Green et al., 2004) or specific phobias (Armfield, 2006). New proposals for including cognitive impairment and other neuropsychological findings in the classification of mental disorders are being put forward (Cuthbert, 2013). Acknowledging the importance of cognitive dysfunctions for the classification of mental disorders, the newly revised Diagnostic and Statistical Manual contains cognitive specificers (APA, 2013). As another example, in schizophrenia, where cognitive dysfunctions play a major role in determining functional impairments, there are recommendations in the current revision process of ICD 11 to replace the existing clinical subtypes by symptom qualifiers, one of which represents cognitive symptoms (Gaebel, 2012). New concepts to incorporate the neuroscientific advances on the pathophysiology of mental disorders in future classifications of mental disorders are underway (Cuthbert, 2013). We investigated whether using a frame-based representation of mental disorders according to Barsalou’s Frame Theory (Barsalou, 1992) would be applicable for such concepts. Frame Theory is a general format for the representation of cognitive and other aspects of human brain function using frame-structures. According to Barsalou (Barsalou, 1992), frames are recursive structures, by which mental representations of abstract ideas or concrete experiences and observations can be described in terms of attributes and the values they take. Following the conventions developed by Petersen (Petersen, 2007), Barsalou frames can be represented by directed graphs. In such a graphic representation, arrows represent the attributes and oval fields indicate the values that these attributes may have. The main concept is represented by a central node with a double line. Figure 1 illustrates a general attribute-value structure proposed by Barsalou (Barsalou, 1992).

![Figure 1. The general attribute-value structure of frames.](image)

Representation of the general attribute–value structure of frames proposed by Barsalou [6]. The main concept is represented by a central node with a double line. Arrows represent attributes and oval fields indicate values.

Attributes are general properties or functions by which a mental representation is described. For instance, the frame for a person may have attributes like eye color, gender etc. The values are concrete specifications of such attributes. Thus, the attributes mentioned above may have values such as blue for eye color, and male for gender.

We apply Barsalou’s Frame Theory for the representation of the pathophysiology psychopathology and clinical classification of mental disorders. The central idea is that cognitive processes are crucial targets of pathophysiological processes in mental disorders. For example, cognitive processes represent core pathophysiological features of anxiety disorders (Armfield, 2006 and Mathews et al., 1985). Using frame theory, such cognitive processes may be described using appropriate attributes and values.
We chose specific phobia as an example of mental disorders because of its fixed stimulus-reaction relation and comparably well-known pathomechanisms. Specific phobias are defined as a marked fear of a specific object or situation during the actual contact with or during imagining the threat-related stimulus. As a result, emotional distress is experienced, which causes significant impairment in daily life (WHO, 1992). Specific phobias are among the most common anxiety disorders with a lifetime prevalence of approximately 12.5% (Kessler, 2005).

To our knowledge, this is the first attempt to represent mental disorders systematically using attribute-value structures according to Barsalou’s Frame Theory. We aim to investigate the feasibility of a putative new approach towards a comprehensive, systematic and stringent representation of the psychopathology and the pathomechanisms of a mental disorder in a descriptive way by means of Frame Theory. Furthermore, we aim to show that by providing a clearer picture of the partial overlap of mental dysfunctions in different attribute-value pairs, complex interrelationships may become discernible and complex systemic effects of single localizable disturbances can be identified.

2. Methods

We applied Barsalou’s Frame Theory for representing specific phobias. The frame for specific phobia is a representation of the stimulus-reaction-relation, its possible etiological causes, and its pathological consequences. For the development of this frame representation, we used the general format of attribute-value sets as proposed by Barsalou (Barsalou, 1992). Our frame analysis is based on a systematic review of cognitive pathomechanisms in specific phobia conducted in 2013 (not yet published). We also considered classification information for representing it in frames, since mental disorders are currently conceptualized as normative representations of sets of clinical criteria, which reflect common denominators of the clinical pictures of a multitude of individual cases.

Studies which have investigated cognitive dysfunctions (attentional, memory and other biases) as well as characteristic brain activity in adults fulfilling criteria for phobic disorder answered the first inclusion criteria set in our review. The second inclusion criterion for studies was the appliance of quasi-experimental between-group design comparing phobic and non-phobic persons. After this steps of selection articles which have encased phobic patients having another mental disorder as fact of co-morbidity were excluded. Another reason for exclusion was any participation on therapeutic or psychotropic treatment. The core features of study samples (size, diagnosis, treatments, etc.) and relevant results were extracted in a standardized matter. Finally, 34 papers have been reviewed using method of narrative synthesis of reported results.

We have chosen the following way to build sortal frames representing all found results summed up in this systematic review:

a) Evidently shown altered cognitive and brain functions were understood as attributes or arrows. Considering the frame notion of classificatory definition - behavioral, emotional and enviromental conditions relevant for the phobic disorder were applied to the arrows.

b) Values in the nodes were assigned to the empirically observed distinctions between phobic and non-phobic populations as well as classificatory defined symptoms and states of conditions.
c) We also included other factors which may lead to the development and/or the maintenance of specific phobia, including genetic and environmental factors, and alterations of brain functions or brain structure.

3. Results

The result of the frame-based analysis of specific phobia is shown in Figure 2, which illustrates the complete frame-based analysis of specific phobia. Different colors mark the different levels of analysis. The analysis of the classificatory definition of specific phobia according to ICD-10 (WHO, 1992) is distinguished by yellow color. Cognitive processes are marked in blue. The analysis of the pathogenesis of specific phobia is marked in green.

![Frame-based representation of specific phobia](image)

This figure shows a Barsalou-type frame-based analysis of the classificatory definition and pathomechanisms of specific phobia. The definition of the disorder is highlighted by yellow color, pathomechanisms by green color. The involved cognitive processes are shown in the blue field. Arrows indicate attributes. Oval fields represent values.

3.1. Frame-based analysis of the classificatory definition of specific phobia

Figure 3 depicts the frame-based analysis of the classificatory definition of specific phobia according to ICD-10 criteria (WHO, 1992). Figure 3 demonstrates that specific phobia is part of the group of anxiety disorders. The concept specific phobia, represented by a double line, implies a fear of a specific object or situations, which is represented by the attributes specificity and fear of. This specific fear-related stimulus is represented by the value object/situation. This node has several further attributes such as danger, presence, and reactions. The attribute danger and its value intensity imply that the intensity of danger is considered to be higher by persons with specific phobias compared to non-phobic persons.
This frame-based representation of the definition of specific phobia contents among others the representation of an exclusion/inclusion criterion for the diagnosis of specific phobia represented by an attribute comparison. The corresponding value subjective > objective means that for the diagnosis of specific phobia, the subjective danger intensity for a specific object or situation of a person should be higher than the objective danger intensity of the most of people. The attribute presence with a same-named value presence shows that encounter with a feared stimulus, independent of the actual presence, or imagining of such a stimulus, evokes behavioral, emotional and physiological reactions depicted by the corresponding attributes.

Figure 3. Frame-based analysis of the classificatory definition of specific phobia.

This figure shows the frame-based analysis of a classificatory definition of specific phobia. The concept of specific phobia is represented by a central node with a double line. Arrows indicate attributes. Oval fields represent values.

3.2. Frame-based analysis of the pathophysiology of specific phobia

Figure 4 shows the frame-based analysis of the pathophysiology of specific phobia. The etiological causes of specific phobia are complex and yet unknown, but various factors, represented by values of the attributes causes, contribute to the development of specific phobia. We found evidence for alterations in the domains such as cognitive processes, somatic physiological functions, and brain functions in persons with specific phobia. Due to inconsistent research results in the environmental risks and genetic risks factors, the frame analysis of these two factors was considered as not efficient.

Our frame analysis demonstrates that different etiological factors may lead to the development of specific phobia. Furthermore, Figure 4 shows that these factors may interplay and therefore evoke some alterations in other factors and by this way contribute to the development of specific phobia.
We found evidence for altered brain functions, represented in Figure 4 by attributes such as insula, amygdala, anterior cingulate cortex, medial prefrontal cortex, dorsomedial prefrontal cortex activities, and hormone stress level with their corresponding values. Some of these factors may be a cause for alterations of cognitive processes like attention, cognitive control and emotion. The increased hormone stress level results in activation of the sympathetic nervous system and evokes alterations in physiological processes represented by the following attributes: heart rate, skin conductance, blood pressure, respiratory rate, and sweat production. The corresponding values imply alterations in these functions in persons with specific phobia.

![Figure 4. Frame-based analysis of the pathomechanisms of specific phobia.](image)

This figure shows the frame-based analysis of various pathophysiological and psychopathological domains of specific phobia. Arrows indicate attributes. Oval fields represent values.

### 3.3. Frame-based analysis of the cognitive pathomechanisms of specific phobia

This last section of our frame analysis illustrates the cognitive processes which are involved in the pathophysiology of specific phobia as a result of a systematic review of the relevant literature (manuscript in preparation). Figure 5 shows these cognitive processes, which are represented by the attributes emotions, learning, memory, attention, perception, attribution, and cognitive control. The frame in Figure 5 demonstrates that fear of a specific object can be learned in different ways, for instance through linkage of stimuli with each other (conditional learning), through observation of another person (observational learning), or through a traumatic event (situational learning). This learned information will be saved in memory storage. The biased attentional process hypervigilance for threat stimuli is associated with increased...
memory performance for threat-related stimuli in persons with specific phobia. Furthermore, there is an association of hypervigilance with biased processing of encoded sensory information. This biased perception process is further enhanced by biased attribution processes and by insufficient cognitive control. This decreased cognitive control leads to insufficient control of negative emotions, which are associated with avoidant behavior, biased attentional and biased attributional processes in persons with specific phobia.

![Figure 5. Frame-based analysis of the cognitive pathomechanisms of specific phobia.](image)

This figure represents the frame-based analysis of the cognitive pathomechanisms of specific phobia. Arrows indicate attributes. Oval fields represent values.

### 4. Discussion

We show by the example of specific phobia how information from multiple domains such as classificatory definition criteria and pathomechanisms can be integrated into a comprehensive Barsalou-type frame structure, so that a complete picture of the complex interrelations between different pathogenic processes and their ensuing classificatory importance emerges. The frame shows the interplay of different factors including alterations in cognitive processes, which appears to be crucial for anxiety disorders (Grupe et al., 2013). Therefore, Barsalou’s Frame Theory appears appropriate to systematically represent the complex structure of the pathomechanisms in mental disorders, their possible neural correlates and ensuing classificatory elements.

Some limitations of representing mental disorders in Barsalou’s type frames need to be taken into consideration. First, Frame Theory has not yet defined a way to represent the time-course-variable clinical picture of mental disorders. Another aspect which needs to be addressed is the question of a continuum between symptoms of mental disorders and less intense
similar symptoms in persons without mental disorders. Finally, the etiological causes of specific phobia are unknown, but several pathophysiologic mechanisms can be demonstrated. The strength of frame-based analysis is that it bridges such important borders as those between “causes” and ensuing pathophysiologic processes by representing them in a single frame.

The frame-based representation of mental disorders provides a useful basis for the systematic representation of the complex pathomechanisms of mental disorders. Furthermore, this novel kind of representation has benefits compared to traditional flow charts and diagrams. Due to systematic rules for the representation of the concepts according to Barsalou’s Frame Theory, it becomes possible to compare different mental disorders and to identify possible overlaps in their pathomechanisms. “Bridge symptoms” common to “comorbid” mental disorders may provide a starting point for comorbidity analyses (Cramer et al., 2010). Also, frame-theory may be used as a tool to depict and unify different levels of analysis in a single representation, like shown here for informations from the neurosciences, cognitive psychology or clinical observations as reflected by clinical classification criteria.

In conclusion, frame-based analysis of mental disorders according to Barsalou’s Frame Theory provides a novel tool for a systematic and comprehensive representation of the complex structure of the pathomechanisms and classification of mental disorders, with a view to analyze comorbidity patterns in mental disorders, which may be helpful for the future development of classification systems of mental disorders based on pathomechanistic information (Borsboom et al., 2011).

Conflict of interest

All authors state no conflict of interest

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