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**Effects of brain lesions on moral agency: Ethical dilemmas in investigating  
moral behavior**

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Abstract	<p>Understanding how the “brain produces behavior” is a guiding idea in neuroscience. It is thus of no surprise that establishing an interrelation between brain pathology and antisocial behavior has a long history in brain research. However, interrelating the brain with moral agency—the ability to act in reference to right and wrong—is tricky with respect to therapy and rehabilitation of patients affected by brain lesions. In this contribution, we outline the complexity of the relationship between the brain and moral behavior, and we discuss ethical issues of the neuroscience of ethics and of its clinical consequences. First, we introduce a theory of moral agency and apply it to the issue of behavioral changes caused by brain lesions. Second, we present a typology of brain lesions both with respect to their cause, their temporal development, and the potential for neural plasticity allowing for rehabilitation. We exemplify this scheme with case studies and outline major knowledge gaps that are relevant for clinical practice. Third, we analyze ethical pitfalls when trying to understand the brain–morality relation. In this way, our contribution addresses both researchers in neuroscience of ethics and clinicians who treat patients affected by brain lesions to better understand the complex ethical questions, which are raised by research and therapy of brain lesion patients.</p>	
Keywords (separated by '-')	Brain injury - Brain lesion - Neurodegenerative diseases - Moral agency - Neuroscience of ethics - Neuroethics	

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# Effects of Brain Lesions on Moral Agency: Ethical Dilemmas in Investigating Moral Behavior

Markus Christen and Sabine Müller

**Abstract** Understanding how the “brain produces behavior” is a guiding idea in neuroscience. It is thus of no surprise that establishing an interrelation between brain pathology and antisocial behavior has a long history in brain research. However, interrelating the brain with moral agency—the ability to act in reference to right and wrong—is tricky with respect to therapy and rehabilitation of patients affected by brain lesions. In this contribution, we outline the complexity of the relationship between the brain and moral behavior, and we discuss ethical issues of the neuroscience of ethics and of its clinical consequences. First, we introduce a theory of moral agency and apply it to the issue of behavioral changes caused by brain lesions. Second, we present a typology of brain lesions both with respect to their cause, their temporal development, and the potential for neural plasticity allowing for rehabilitation. We exemplify this scheme with case studies and outline major knowledge gaps that are relevant for clinical practice. Third, we analyze ethical pitfalls when trying to understand the brain–morality relation. In this way, our contribution addresses both researchers in neuroscience of ethics and clinicians who treat patients affected by brain lesions to better understand the complex ethical questions, which are raised by research and therapy of brain lesion patients.

**Keywords** Brain injury · Brain lesion · Neurodegenerative diseases · Moral agency · Neuroscience of ethics · Neuroethics

## Abbreviations

DBS          Deep brain stimulation  
DLPFC       Dorsolateral prefrontal cortex

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27	FTD	Frontotemporal dementia
28	NMDA	N-Methyl-D-aspartate
29	ToM	Theory of mind
30	VMPFC	Ventromedial prefrontal cortex

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## 1 Introduction

**Case 1** The accident changed everything. One moment of inattention, and Madison fell down the scaffold, resulting in a severe head trauma. A complicated surgery and weeks of rehabilitation followed, until Madison could be discharged from the hospital. But Madison was not the same person any more. Soon, her marriage dissolved and she was unable to continue her work. Madison underwent several neuropsychological assessments to settle her health insurance claims. One time, she arrived in tears, because her grandfather just died. The neuropsychologist was very sorry and offered to cancel the meeting—but then Madison giggled, saying that this was just a joke. She sat down in her shorts, although it was winter. Her mood changed every minute—from exorbitant joy to deep sadness. She confabulated and was sometimes verbally aggressive. She insulted the neuropsychologists as one of the many incompetent physicians she had met so far, unable to help her; and the next minute, argued that everything was fine with her and that she needed no help. Somehow she managed her life—she initiated relationships, but the relationships never lasted long.



68 Sometime later, the neuropsychologist tried to contact her again, but the trail grew  
69 cold. None of the social workers **that** tried to help her after her accident knew where  
70 she was. No officials had any clue whether she was still living in town.

71 **Case 2** Doctor Tolliver was a popular pediatrician—until police caught him in the  
72 act of abusing a 7-year-old girl during a medical examination. The police knew about  
73 other reports on sexual abuse of girls aged 3–12 years by Tolliver, some of them were  
74 even filmed by Tolliver. The investigators also found child pornography on the  
75 desktop computer of Tolliver. During interrogation, Tolliver claimed that since a year  
76 ago, he sometimes had an unstoppable drive to touch girls during medical examin-  
77 ations. While in investigative custody, neurological problems emerged and a brain  
78 tumor was diagnosed. Tolliver was successfully operated on before his trial. During  
79 trial, the defense counsel argued that the tumor caused pedophilia and additionally  
80 deficits in impulse control and emotion recognition, which were responsible for  
81 Tolliver’s abusive actions toward children. He outlined a temporal correlation  
82 between tumor growth and the documented incidences of child abuse. However, the  
83 judge did not agree with this argument, since the scientific literature did not dem-  
84 onstrate a sufficiently deterministic relation between this type and location of brain  
85 tumor and delinquent behavior. Furthermore, Tolliver demonstrated an excellent  
86 ability to plan and organize the abuse and performed well as a pediatrician. Tolliver  
87 was found guilty and sentenced to 8 years in prison.

88 **Case 3** It was almost 10 years ago when Sten was diagnosed with Parkinson’s  
89 disease. In the early phase, the symptoms were well controlled by medication—but  
90 the disease progressed and it became increasingly difficult to avoid dyskinesia  
91 phases. In line with disease progression, Sten became depressed and apathetic; and  
92 his wife took care of him. She reduced her employment substantially and finally  
93 became his nurse. One day, Sten’s physician explained that he might be a candidate  
94 for deep brain stimulation (DBS) and that this therapy could help diminish the side  
95 effects of medication. An assessment—demonstrating that Sten did not have a  
96 history of psychiatric disorders besides his Parkinsonism-related depression—  
97 demonstrated that DBS indeed was a suitable therapy for him. Sten decided on this  
98 option, and the surgery went well. The result was amazing, in particular for Sten.  
99 He felt that he gained a new life—but his wife could barely recognize him. Now,  
100 Sten often wanted to go out without her and he came back late. When checking his  
101 credit card bill, Sten’s wife realized that her husband frequently visited strip clubs.  
102 Confronted with this fact, Sten admitted that he regularly visited prostitutes; he felt  
103 he had to catch up with all the life he had missed in the preceding years. He also  
104 admitted that somehow the DBS device might influence his new desires—but he  
105 rejects any change to his stimulation settings.

106 These three cases—all of them inspired by real patients—outline the complex  
107 relationship between changes in the brain and aberrations in morally relevant  
108 behaviors. This complexity is present on both sides of the brain–behavior rela-  
109 tionship. Behavioral changes may result from sudden injuries of the brain, slowly  
110 progressing brain diseases, or therapies intended to counteract brain disorders.

111 While some behavioral changes are reversible by neurosurgery, medication, reha-  
112 bilitation, natural healing processes, or adequate social surroundings, others are  
113 irreversible.

114 For some aberrant behaviors of brain lesion patients, it is difficult to evaluate the  
115 moral component of behavioral changes objectively, since no consensus exists  
116 about the morality of certain behaviors within a given society, and least of all  
117 between different cultures. Rather, moral evaluations of different behaviors depend  
118 on a given cultural context, differ between subcultures, and undergo transformation  
119 processes. By way of example, slavery is nearly undisputedly considered immoral  
120 today, whereas visiting prostitutes is discussed more controversially.

121 How to treat individuals living with damaged brains that influence their behavior  
122 poses ethical questions. Behavioral changes in individuals with a frontal lesion may  
123 be stressful for families and caregivers who live with them—and the social services  
124 and financial benefits in most modern societies may be inadequate for these  
125 patients.

126 This reminder of the complexity of the relationship between the brain and moral  
127 behavior is an important caveat against overly straightforward causal explanations  
128 of immoral behavior. Such a simplification is exemplified by the iconic figure of  
129 **Phineas Gage**—the railroad construction foreman who suffered in 1848 from one of  
130 the most prominent traumatic brain injuries in history. While using an iron-tamping  
131 rod to pack explosive powder into a hole, the powder detonated and the rod pen-  
132 etrated Gage's left cheek, tore through his brain, and exited his skull. Gage survived  
133 this accident, but became according to the popular narration, a different person. In  
134 the words of Dr. Edward H. Williams, the physician who treated Gage's injuries:  
135 "He is fitful, irreverent, indulging at times in the grossest profanity (which was not  
136 previously his custom), manifesting but little deference for his fellows, impatient of  
137 restraint or advice when it conflicts with his desires (...). His mind was radically  
138 changed, so decidedly that his friends and acquaintances said he was 'no longer  
139 Gage'" (Harlow 1868). Although most accounts of Gage's life after 1848 are  
140 strange mixtures of slight fact, considerable fancy and downright fabrication  
141 (Macmillan 2000), his case became a widely used example of how brain and moral  
142 behavior are related—that the dysfunction of some parts of the brain, namely the  
143 right orbitofrontal or ventromedial prefrontal cortex, inevitably leads to major  
144 aberrations in moral behavior. The case of Phineas Gage is frequently mentioned  
145 in the introduction of papers that discuss the relationship between brain and moral  
146 behavior.

147 Seen from a historical perspective, this relationship between brain lesions and  
148 (anti)social behavior is a recurrent topic in brain research. In 1888, Leonore Welt,  
149 the first woman in Switzerland who was allowed to study medicine at the University  
150 of Geneva, published what today would be called a review paper on character  
151 change after frontal lesions (Welt 1888). She discussed 11 cases—among them a  
152 case of her own clinical practice and the crowbar case referring to Phineas Gage—  
153 where frontal lesions were associated with negative changes in moral behavior. She  
154 also discussed 47 other cases, where such lesions did not have such effects. Cer-  
155 tainly, degree and localization of these injuries were much harder to describe when

156 neuroimaging was not yet available. Nevertheless, Welt urged for caution when  
157 deterministically associating brain lesions with character changes.

158 To what extent this diagnostic caution is present today can be questioned.  
159 Experimental and clinical studies demonstrating that focal lesions in the right  
160 frontal cortex lead to specific changes in moral and social behavior generate almost  
161 four times more citations when compared to studies that describe the complexity of  
162 behavioral changes and social adaptations after frontal lobe injuries (Christen and  
163 Regard 2012). This citation bias may indicate an ethical dilemma associated with  
164 the relationship between brain and morality, namely that research may promote a  
165 neurodeterministic view of moral agency that is not sufficiently supported by the  
166 current state of knowledge.

167 In outlining **these** ethical dilemmas, we have to resolve difficult measurement  
168 problems when analyzing the possible effects of brain injuries on **moral agency**,  
169 which denote the ability of individuals to act in reference to right and wrong. On the  
170 side of behavior, standardized questionnaires and tests (e.g., Iowa Gambling task,  
171 moral dilemmas) are available, but they may not reflect sufficiently the behavior  
172 changes and their effects in real life. And on the side of the brain, although  
173 sophisticated imaging techniques are used today, it is still difficult to directly assess  
174 residual functionalities in the affected brain tissue, particularly in cases involving  
175 neurodegenerative diseases, and the potential of neuroplasticity.

176 We structure the investigation as follows:

- 177 1. We need a detailed understanding of moral agency. This involves both an  
178 empirical part—namely outlining mental competencies and the related physio-  
179 logical conditions—and a normative part. The latter is needed to evaluate the  
180 legitimacy of moral claims toward the behavior of others.
- 181 2. We need a typology of brain injuries and their known behavioral sequelae. A  
182 major issue is the variability of behavioral sequelae of brain lesions. This vari-  
183 ability may be partly explained by difficulties of assessing the exact location of  
184 lesions and their effects on neural networks. Furthermore, the variability could  
185 be based on individual differences in neuronal plasticity and differences in  
186 rehabilitation measures as well as on differences in the pre-lesion personality  
187 and social relationships.
- 188 3. We have to keep in mind that the endeavor of relating brain and behavior itself  
189 has a history and may be driven by different agendas. Ethics research is not a  
190 purely objective or rational science. Ethical justifications appeal to intuitions  
191 that have both natural and cultural histories. Thus, the ethical framework used to  
192 investigate moral behavior itself needs to be reflected upon as well.

193 The structure of our contribution to this volume follows this basic outline: In  
194 Sect. 2, we introduce the notion of moral agency both with respect to its normative  
195 and empirical dimension. In Sect. 3, we provide a typology **on** effects of brain  
196 lesions on moral behavior. In Sect. 4, we discuss ethical pitfalls of relating brain  
197 lesions with moral behavior changes. Section 5 concludes our contribution with  
198 some preliminary thoughts on using knowledge on the relation between brain and  
199 morality to restore moral behavior that is compromised by a brain lesion.



## 2 Moral Agency and the Brain

Human beings possess the ability to act with reference to right and wrong, which is framed as **moral agency**. The structure of moral agency as we construe it here is threefold (Christen and Alfano 2013). First, moral agency requires a specified set of competencies that the agent must have. Second, it involves a normative reference frame to which the agent has at least partial access. Third, moral agency is always situated in a context that consists of other agents and physical boundary conditions that constrain behavior. Competencies, normative frame, and context thus form the structural components of moral agency. A particular empirical investigation of moral agency may refer to just one or two of these structural components or to the interaction of two or all three components.

### 2.1 Conceptual Issues of **Moral Agency**

A relevant problem refers to the prescription of agency. In theory, most would agree that behaviors caused by defined brain lesions or abnormalities are not under the control of the individual and thus cannot be called acts or considered as an expression of moral agency. But in practice, brain lesions or other abnormalities often do not prove a lack of understanding the wrongness of a certain act at the time of commission (Batts 2009). Neither does it prove an absent ability to act according to one's insight, which would justify a diminished or missing criminal responsibility in most European **states**. Therefore, in most cases, it is not possible to draw a clear causal line from a brain lesion or other abnormality to a missing moral agency and thus to a missing moral and legal responsibility. Another controversial issue is to what extent patients with ventromedial frontal damage possess moral concepts or relevant moral beliefs (Cholbi 2006; Roskies 2006), a discussion that relates to the philosophical debate on internalism and externalism (for an overview see Björklund et al. 2012). These important issues refer to the broad discussion on free will and the determination of behavior by the brain. This problem can have practical consequences, as our second case with Tolliver outlines, **where counsel** was unable to convince the judge that the defendant's brain tumor caused him to abuse children sexually. We will come back to this point in Sect. 4.

For the following explanations, we propose to relate moral agency to the fact that patterns of moral behavior are displayed by persons whose behavior is somehow regulated by a normative framework that includes an idea of good and bad. We use the term "patterns of moral behavior" rather than "moral actions" in this context because we do not want to restrict it to punctate actions. This is consistent with the clinical practice of therapy and rehabilitation that does not address specific acts but behavioral patterns and dispositions.

The first thing to specify is what the term **moral** should denote. A simple fact about **morality** is that people are disposed to react to issues according to what they

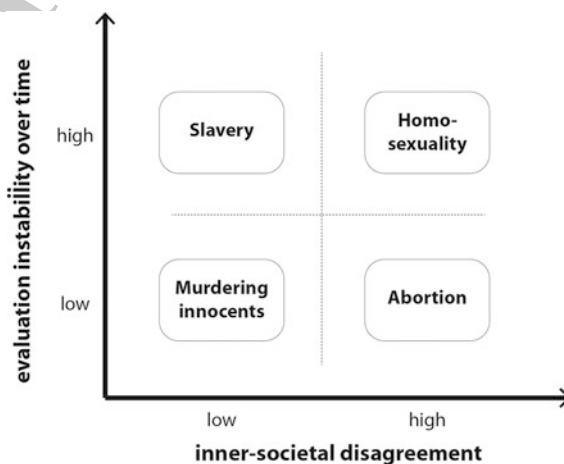


239 consider right or wrong, good or bad. This implies the existence of some normative  
 240 frame and its connection with the real world in the sense that it guides thought,  
 241 feeling, deliberation, and behavior of people. Another basic fact is that morality is  
 242 situated in a social world of actions, judgments, negotiations, and other kinds of  
 243 expressions made by social beings. This social world is embedded in a history, and  
 244 its evolution is driven by many different factors. This means that acts, norms, and  
 245 virtues that we may call moral are subject to fuzziness in two respects: First, within  
 246 a society, there are actions that are undisputedly either moral or immoral, whereas  
 247 other actions are less clear in that respect. Second, across societies and during  
 248 history, the moral condemnation of some behaviors seems to be stable, whereas  
 249 others undergo remarkable changes. Thus, moral evaluations of given actions differ  
 250 both with respect to inner-societal agreement and evaluation stability over time.

251 Figure 1 illustrates these two dimensions with exemplary cases, although the  
 252 precise location of these acts in this scheme can be debated. Morally, condemning  
 253 the murder of innocent people is relatively stable both within a society as well as  
 254 during the course of time. Slavery was for a long time morally accepted within  
 255 societies but lost acceptance in a relatively short time span and is now regarded as  
 256 absolutely unacceptable (Appiah 2010). Abortion has a long history of moral dis-  
 257 agreement, whereas each position is relatively stable in time. Finally, the degree of  
 258 moral acceptance of homosexuality shifted several times in history and to date the  
 259 inner-societal disagreement is still high in many countries.

260 When evaluating the changes in moral behavior of patients, both the evaluation  
 261 instability of moral behaviors and the inner-societal disagreement about them have  
 262 to be taken into account. For the following general discussion, we define **morality**  
 263 very broadly as a set of norms, principles, values, and virtues that are governed by  
 264 an orientation toward the good. As such, morality reflects respect and concern  
 265 for oneself and for other entities (persons, animals, or environment) and is  
 266 embedded in a justification structure. We are aware that understanding one's moral

**Fig. 1** Exemplary cases of moral valuation structured along the dimensions inner-societal disagreement and evaluation instability over time. The figure only identifies ideal cases in the four quadrants of the scheme, separated by a dotted line



267 decision-making and behavior requires an analysis of the agent's understanding of  
268 morality and on what he or she considers right or wrong. In addition, one would  
269 have to assess the actual justifications and their adequateness for an analysis of  
270 arguments.

## 271 2.2 **Moral Intelligence** as a Psychological Working Model

272 In our topic, a natural focus would be on the competencies and their foundation in  
273 the brain. This requires a theoretical framework that summarizes our knowledge on  
274 how agents reason, decide, and act morally. The major source of this knowledge is  
275 still **moral psychology**, which underwent a remarkable development in the last few  
276 years. In the following, we propose to use the concept of moral intelligence (Tanner  
277 and Christen 2013) as a theoretical framework.

278 Moral intelligence is defined as the capability to process moral information and  
279 to manage self-regulation in any way that desirable moral ends can be attained. It  
280 refers to the set of skills the moral agent needs in order to align her behavior with  
281 the moral ends she has set for herself, using the broad understanding of morality  
282 defined above. It is thus a skill-based conception of moral behavior, analogous to  
283 the concept of emotional intelligence that describes the ability to deal with emo-  
284 tions. The framework describes the sequential logic of moral behavior along with  
285 the associated underlying psychological processes, and the way in which implicit  
286 and explicit knowledge of morality and its justifications are included. These ele-  
287 ments underlie the five competencies of moral intelligence (see also Fig. 2):

- 288 • **Moral compass:** This metaphor encompasses the set of moral schemata whose  
289 content is responsible for orienting the subject's behavior (Narvaez 2005). As  
290 such, it is concerned with mental representations of both declarative and pro-  
291 cedural knowledge, each of which is accessible to the subject in varying degrees.
- 292 • **Moral commitment:** The ability to activate or sustain a motivation for the  
293 inclusion of moral considerations in the process of perception, decision-making,  
294 and action. In contrast to the typical process logic of moral behavior

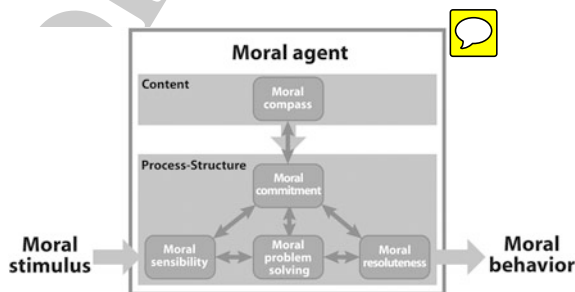


Fig. 2 The five building blocks representing competencies of moral intelligence in relation to the multistage model of moral functioning (adaptation from Tanner and Christen 2013)

295 (perception → decision → motivation → action; Rest 1986), moral commit-  
296 ment is a capacity that influences all stages of the process, and in particular  
297 provides a motivational force to the semantic content of the moral compass.

- 298 • **Moral sensibility**: The ability to recognize morally salient aspects of a particular  
299 situation. The relevance of moral sensibility is obvious: If morally relevant  
300 aspects of a situation are not recognized, there is no cause to be concerned with  
301 the question of right action.
- 302 • **Moral problem solving**: The ability to bring the morally salient features of a  
303 situation to the decision-making process, and depending on the degree of  
304 conflict involved (e.g., if the problem has the structure of a dilemma), to arrive at  
305 a decision consistent with the subject's particular moral compass.
- 306 • **Moral resoluteness**: The ability to carry out one's own decisions despite, inter  
307 alia, external or internal resistance and barriers.

308 The concept of moral intelligence integrates the findings of (moral) psycho-  
309 logical research into a unified model. As such, it enters an area with a rather long  
310 tradition. What distinguishes our model from other approaches is the central role of  
311 moral commitment, i.e., the capacity to uphold the demands of morality throughout  
312 this entire process and to align one's cognitions, decisions, and actions with one's  
313 moral ends. Moral commitment is to some extent the bridge between the moral  
314 compass and the other competencies of moral intelligence, and expresses the will to  
315 apply the contents of the moral compass.

316 It is unlikely that the building blocks of moral intelligence are related to distinct  
317 and clearly separable neuronal modules, because it is generally questionable  
318 whether mental processes can be defined and separated in a way that permits them  
319 to be associated with particular brain regions (Uttal 2001). The competencies also  
320 differ in their degree of exactness: Whereas moral sensibility is conceptually the  
321 simplest component, moral problem solving and moral resoluteness are more rich  
322 theoretical constructs. In addition, the psychological literature on the five compe-  
323 tencies is not equally well developed. Moral problem solving or decision-making  
324 and, to a lesser degree, moral commitment within motivation psychology have been  
325 the subject of research for decades, in particular within developmental **moral psy-**  
326 **chology** advanced, among others, by Jean Piaget (1932) and Kohlberg (1981).  
327 Moral sensibility and moral resoluteness, however, are less well studied. Despite  
328 these difficulties, the framework of moral intelligence provides more precise con-  
329 siderations of which competencies may be affected by brain lesions, although one  
330 cannot expect that a specified lesion affects only one of those competencies, leaving  
331 the others intact.

### 332 **2.3 Problems in Interrelating the Brain with Moral Agency**

333 Our current knowledge on the neuroscience of ethics supports the expectation that  
334 there is no one-to-one correspondence between clearly discernible brain structures

and functions on the one hand and the competencies that outline moral intelligence, or even moral agency in general, on the other hand. The so-called **moral brain** obviously consists of a large functional network including both cortical and subcortical anatomical structures (recent overviews: Mendez 2009; Fumagalli and Priori 2012; Pascual et al. 2013). Because moral agency is based on a complex process, these brain structures share their neural circuits with those controlling other mental processes, such as emotions, motivations, decision-making in general, impulse control, and **theory of mind** (ToM). A moral brain does not exist per se; rather, many subsystems of the emotional and the cognitive brain systems are engaged in moral processes. These complex processes are influenced by many genetic, endocrine, and environmental factors (Fumagalli and Priori 2012; Pascual et al. 2013).

Among the anatomical structures implicated in moral agency are the frontal, temporal, and cingulate cortices; i.e., considerable parts of the cortical hemispheres: The **prefrontal cortex** (PFC) regulates activity in subcortical emotional centers and is involved in planning and supervising moral decisions. When its functionality is disturbed, impulsive aggression becomes more probable (Fumagalli and Priori 2012). Patients with prefrontal lesions—especially in the orbito-prefrontal and medial regions—are often significantly impaired in both cognitive and affective empathy (Shamay-Tsoory et al. 2004; Eslinger et al. 2004). Patients with bilateral lesions of the **orbitofrontal cortex** show impairments in social behavior (Hornak et al. 2003). Furthermore, changes in moral decision-making have been found in prefrontal lesion patients (Koenigs et al. 2007; Ciaramelli et al. 2007). Based on such studies, it has been claimed that the **ventromedial prefrontal cortex** (VMPFC) attaches moral and emotional value to social events and anticipates their future outcomes. It is involved in ToM and empathy, mediates automatic moral and prosocial reactions, and participates in social emotions, including guilt, embarrassment, and compassion. The temporal lobes are also involved in ToM, and their dysfunction is often implicated in violent psychopathy. The **dorsolateral prefrontal cortex** (DLPFC) is involved in cognitive empathy and in the application of reasoned analysis to moral situations (Mendez 2009). The **cingulate cortex** mediates conflicts, particularly conflicts between emotional and rational components of moral reasoning (Fumagalli and Priori 2012). Current research suggests that the cortical structures most directly involved in abnormal moral behavior are the right medial orbitofrontal cortex and the right ventromedial prefrontal cortex (Fumagalli and Priori 2012). Subcortical structures are also involved in moral behavior, particularly the amygdalae, the hippocampus and the basal ganglia (Mendez 2009; Fumagalli and Priori 2012; Pascual et al. 2013).

Although the relationship between frontal lobe damage and morally relevant behavior aberrations like aggression has been part of clinical experience for more than 60 years, most of the evidence is case-based. There are only a few larger studies with appropriate design (Hawkins and Trobst 2000). The most known retrospective study examined the relationship between frontal lobe lesions and aggression in 279 veterans who had sustained penetrating head injuries, which were compared to 57 veterans without brain injury matched by age, education, and time



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380 served in Vietnam (Grafman et al. 1996). They found that the veterans with brain  
381 injury were more aggressive than control veterans, as reported by family and  
382 friends. In particular, veterans with ventromedial frontal lobe lesions were reported  
383 to be most aggressive, when compared to veterans with lesions elsewhere in the  
384 brain. But the authors also reported that “not all patients with these lesions had such  
385 behavior, and some patients with lesions elsewhere in the brain, and even normal  
386 controls, can show an increased tendency toward aggressive and violent behavior”  
387 (Grafman et al. 1996, p. 1237). There are also other case studies of patients with  
388 massive frontal lesions that are not compatible with a clear causal link between  
389 lesion and lasting behavior changes. For example, some patients do not show  
390 aberrant social behavior despite the lesions (Feinstein et al. 2010), in some patients  
391 the behavior changes after the lesions are reversible (Frías Ibáñez et al. 2008), and  
392 in some patients the behavioral and personality changes are compatible with stable  
393 functioning in family, professional, and social settings (Mataró et al. 2001).  
394 Therefore, the available evidence does not provide conclusive evidence that frontal  
395 lesions inevitably lead to such behavior changes. A too schematic, one-to-one  
396 connection between lesions in specific brain areas and specific moral behavior  
397 aberrations is misleading.

398 One reason for this variety found in the literature on the interrelation between the  
399 brain and moral behavior refers to the experiments that are used in these studies.  
400 Currently, a gross variety of tasks is used for assessing morality in the context of  
401 moral psychology or the neuroscience of ethics, which makes it difficult to compare  
402 the results of these studies. Furthermore, most moral tasks have intrinsic limitations.  
403 For example, they are not ecologically valid in that they reflect environmental and  
404 daily experience only poorly, or they request abstract judgments that exclude the  
405 complex decisional context. Additionally, task instructions usually forbid the  
406 subjects to make additional assumptions not included in the text, even though  
407 problem solving automatically intervenes in these situations. Finally, moral items  
408 distinctly differ from one another and involve different moral rules, violations, and  
409 values such as honesty, money, life, health, probity, or solidarity.

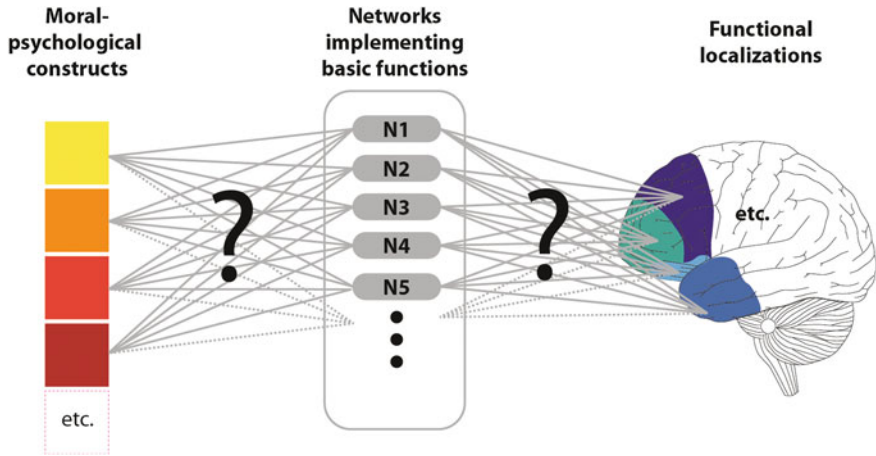
410 An important methodological limitation of most experimental studies is that they  
411 focus on **moral judgments**, i.e., the researchers account for, predict, or find neural  
412 correlates to moral judgments that they use in their experiments. These moral  
413 judgments are of a specific kind and have several defining features (Abend 2013).  
414 They are made in response to specific stimuli in imaginary situations, and they use  
415 only thin ethical concepts such as: okay, appropriate, permissible, acceptable,  
416 wrong, etc. In addition, they are fixed, verdict-like, and clear—not conceptually or  
417 semantically muddled, incoherent, etc. But moral judgments do not only occur as  
418 responses to specific stimuli or eliciting situations. Rather, some moral judgments  
419 develop over longer periods and are based on the reflection of many experiences  
420 and theoretical deliberation. In addition, morality cannot be reduced to moral  
421 judgments. This problem concerns in particular virtue ethics—an ethical approach  
422 that evaluates the character of persons in contrast to approaches that evaluate their  
423 actions, either in terms of duties or rules (deontology) or their consequences  
424 (consequentialism). Moral evaluations of actions are more easily expressed by

425 moral judgments. Abend (2013) argues correctly that the object of study of much  
426 recent work on the connection between the brain and morality is not morality per se,  
427 but a particular kind of individual moral judgment.

428 And even within this special sample, complexity remains. Parkinson et al. (2011)  
429 investigated moral scenarios that involved disgusting, harmful, and dishonest  
430 behavior along with a neutral scenario, and asked subjects to judge the general  
431 moral wrongness of the actions within each scenario as well as the degree of  
432 disgust, harm or dishonesty while in an fMRI scanner. They found that the latter  
433 three statements were subserved by distinct neural systems and these differences  
434 were much more robust than differences in wrongness judgments within a moral  
435 area. The dorsomedial prefrontal cortex was the only region activated by all sce-  
436 narios judged to be morally wrong in comparison with neutral scenarios. However,  
437 this region was also activated by dishonest and harmful scenarios judged not to be  
438 morally wrong. Furthermore, these scenarios were not suggestive of a domain-  
439 general role that is neither specific for nor predictive of moral decisions. The results  
440 suggest that moral judgment is not a wholly unified faculty in the human brain, but  
441 rather, instantiated in dissociable neural systems that are engaged differentially  
442 depending on the type of transgression being judged.

443 In summary, this brief overview suggests that the attempt to find clear-cut  
444 connections between a fine-grained understanding of moral agency and defined  
445 neuronal structures may lead to a picture that is too complex to be useful in a  
446 clinical context. For example, there may be different neuronal systems that are  
447 responsible for moral sensibility related to harm versus moral sensibility related to  
448 honesty. A focal lesion may thus impair one aspect of moral sensibility more than  
449 others—but the relevance of this imbalance will depend on the situation in which  
450 this competence is needed. In addition to impairing one aspect of moral sensibility,  
451 a focal lesion may also influence other competencies (maybe also nonmoral ones),  
452 as the affected brain region serves many basic functions. This complexity, however,  
453 is usually not assessed in experimental studies involving lesion patients because it is  
454 not feasible to perform a full evaluation of all possible impairments a brain lesion  
455 may cause.

456 The basic problem (see Fig. 3) is that on the side of the phenomenology of moral  
457 behavior, one needs a sufficiently elaborated but not too complex set of constructs  
458 that describe competencies relevant for moral behavior, such as the moral intelli-  
459 gence model. A rehabilitation specialist can neither work with a too general concept  
460 such as moral behavior, nor with a too fine-grained understanding of moral  
461 behavior such as impairment of honesty-related moral resoluteness. On the side of  
462 the investigation of the lesions, a similar problem emerges: One needs a partitioning  
463 that is compatible with the size of regions that can be affected through focal lesions  
464 —and with the methods available to actually identify regions and their degree of  
465 impairment. It is no coincidence that the current neuroscience of ethics denotes still  
466 rather large regions as being relevant for moral behavior, for example, the orbito-  
467 frontal cortex, which extends over several square centimeters. Taking all method-  
468 ological issues of properly identifying such regions aside, it is clear that they are  
469 involved in many basic functional networks that may be clearly identified sometime



**Fig. 3** Illustrating the problem of connecting moral–psychological constructs that describe relevant and usable moral competencies (*left side*) and functional localizations (*right side*) that actually involve many networks (N1, N2, N3, etc.) that may be affected by a lesion

470 in the future. This will be a challenging endeavor, as it is still rather unclear what  
 471 constitutes a basic function and what should be the demarcation criterion within the  
 472 huge cortical networks. Several of those networks that implement basic functions  
 473 will then be recruited in order to form a defined moral–psychological construct that  
 474 is useful, for example, in rehabilitation.

475 A way out of this problem is to resign from an elaborated phenomenology of  
 476 moral agency and to focus on very few behavior types that seem to have clear moral  
 477 impact, like violence. Fumagalli and Priori (2012) write: “From a behavioral point  
 478 of view, the major consequence of moral abnormality is violence,” which stands  
 479 exemplarily for this position. However, as we will outline in Sect. 3.3, this position  
 480 also raises ethical questions. We now proceed by providing a typology of brain  
 481 lesions that may affect moral behavior.

### 482 3 Effects of Brain Injuries on Moral Behavior

483 Various types of pathological processes can affect the brain in a way that produces  
 484 changes in behavior. Some of them occur instantly such as in trauma or stroke;  
 485 others develop over a longer time scale, for example tumor growth or neurode-  
 486 generation. In the following, we use the notion of lesion or damage in a rather  
 487 general way to indicate any kind of structural damage to brain tissue that have  
 488 functional consequences. Examples of brain lesions include the following:

- 489 • Direct injury of brain tissue (e.g., gunshot)
- 490 • Ischemic damage to brain tissue (e.g., stroke, aneurysm rupture)

- 491 • Tumor-related damage to brain tissue (e.g., damage due to infiltrating tumor
- 492 growth or expansion lesion due to increased pressure)
- 493 • Neurodegenerative processes (e.g., death of specific cell types as in
- 494 Parkinsonism)
- 495 • Brain inflammation (e.g., encephalitis)

496 For analyzing differences between types of brain injuries, we classify them along  
497 two dimensions: the temporal scale of the brain injury and the **plasticity** potential of  
498 the brain injury.

499 The first dimension describes the typical temporal course of different types of  
500 brain injuries, namely the temporal course of their onset, of the subsequent  
501 development of changes in personality and behavior, and of the necessary therapies  
502 and rehabilitation processes. For example, the type of brain tumors determines the  
503 occurrence of symptoms (suddenly or gradually), the duration of necessary thera-  
504 pies (several hours for tumor resection or life-long for pharmacotherapy) and of  
505 necessary rehabilitation (short training course or life-long training). This dimension  
506 also influences how other people, particularly from the direct social surrounding of  
507 the patient, will react to lesion-related changes. For example, personality changes  
508 that develop slowly allow the family a better customization to changed behavior of  
509 the patient.

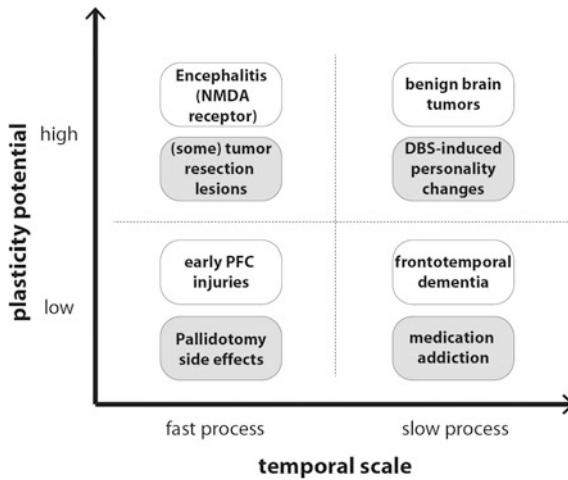
510 The second dimension is the **plasticity** of the brain that may allow for a partial or  
511 full reversibility or compensation of functional losses. This dimension comprises  
512 both healing processes of the affected brain tissue and functional shifts. An example  
513 for the latter is the transfer of the language centers from the left to the right  
514 hemisphere after resection of the left hemisphere due to Rasmussen encephalitis  
515 causing therapy-refractory epilepsy, which has been reported only from children  
516 younger than 5–6 years (Varadkar et al. 2014). Several factors influence the plas-  
517 ticity of the brain:

- 518 • The patient's age at the time of a brain lesion
- 519 • The exact location of the lesioned area and its physiological functions
- 520 • Healing processes
- 521 • Compensation processes (e.g., shift from certain functions to another than the
- 522 affected area)
- 523 • The therapy and rehabilitation measures used (including medication) and their
- 524 efficiency

525 Figure 4 provides an overview on these two dimensions. On the x-axis, brain  
526 injuries are sorted according to their temporal scale, that is, whether they develop  
527 fast or slowly. On the y-axis, brain injuries are sorted according to their plasticity  
528 potential. These two dimensions are relevant for brain damage resulting from  
529 pathological processes (white boxes) and from interventions as unintended side  
530 effects (gray boxes). Again, ideal types are shown, and the location of each example  
531 within each of the four quadrants is not intended to be precise.

532 Using this classification, we will now provide a case-based overview to outline  
533 the diversity of moral behavior changes due to brain lesions.





**Fig. 4** Examples of pathological processes or interventions side effects influencing the brain. The examples are structured along the dimensions temporal scale of the process and the plasticity potential (potential of functional reversibility of the lesion sequelae). The *white boxes* denote changes due to pathological processes, the *gray boxes* non-intended changes due to interventions. The figure only identifies ideal types in the four quadrants of the scheme (*dotted line*)

### 3.1 Fast Processes with High Plasticity Potential

If changes in personality and behavior are caused by fast developing brain lesions which are reversible by adequate therapies or by natural healing processes, then for the patient and people in his/her social surrounding it becomes obvious that the changes were caused by a brain lesion, and not by the patient's "evil will." Such cases may be caused either by disease, injury, or therapy. They are particularly interesting since they allow us to study causal relationships between brain lesions and changes in personality and behavior in a bidirectional way.

An impressive example is **NMDA receptor antibody encephalitis** (NMDA: N-Methyl-D-aspartate), which was first described in 2007 as an autoimmune disease characterized by rapid development of psychosis, paranoia, aggressiveness, and other symptoms which may lead to a misdiagnosis of schizophrenia. Fortunately, the inflammation-caused mental sequelae are mostly reversible with timely administration of an effective therapy consisting of cortisol administration, hemodialysis, and immunotherapy (Dalmau et al. 2007, 2008). But since this disease has not been discovered before 2007, and since new scientific findings need some time for clinical translation, it is likely that many patients suffering from psychosis have been misdiagnosed with schizophrenia and thus have not received an effective therapy.

Sometimes interventions in the brain cause relatively fast changes in personality and behavior that may be reversible. After right **pallidotomy** for medically treatment-refractory Parkinsonism, a 59-year-old patient developed hypersexuality

including pedophilic behavior. Immediately after the pallidotomy, he became markedly hypersexual. He forced his wife to have sex with him, masturbated frequently, propositioned his wife's female friends, hired strippers and prostitutes, and spent hours viewing Internet pornography. The patient was accused of touching his 5-year-old granddaughter inappropriately and asking her to touch his penis. He was ashamed of his behavior, complained of intrusive sexual thoughts and urges that overwhelmed him, and desired to just have his libidinal urges normalized again. The patient had no history of psychiatric illness, unusual sexual behavior, or drug-induced behavioral changes prior to his surgery. A reduction of his dopaminergic drugs resulted in a gradual decrease in sexual behaviors but worsened the symptoms of Parkinsonism (Mendez and Shapira 2011).

### 3.2 Fast Processes with Low Plasticity Potential

Particularly dramatic are fast processes with a low plasticity potential. In these cases, the personality and the behavior of an individual change rapidly, that is, within minutes, hours, or days. In addition, the changes are not reversible. Such cases can occur both by brain disease and by interventions in the brain. Again, the fast development of the lesion increases the likelihood that the behavioral changes are perceived as externally caused; however, the low reversibility potential also increases the likelihood of stigmatization.

**Strokes** can suddenly affect personality and behavior, often irreversibly. In one case, a 70-year-old man developed hemiballism, persistent hypersexuality, memory and executive dysfunction, and poor judgment after a small stroke involving the nucleus subthalamicus (Absher et al. 2000). Another example is the resection of **brain tumors**, which can change personality or behavior directly and often irreversibly. Although there is no evidence-based knowledge on the incidence, direction and extent of personality changes after brain tumor resection, several studies reveal a relationship between brain tumor surgery and changes in personality and (moral) behavior: Patients who had brain surgery for tumors have higher degrees of emotional and social dysfunction compared to extra-cerebral neurosurgery patients and terminally ill cancer patients (Andrewes et al. 2003,  $n = 69$ ). Particularly, tumor resections from the frontal lobes can cause a lack of emotion and problems with decision-making, even in case of intact cognitive functions. In severe cases, psychopathy can develop which is characterized by impulsivity, antisocial behavior, and uncontrollable aggressions (Phineas Gage syndrome; Damasio 1994; Eslinger and Damasio 1985; Eslinger et al. 2004; Meyers et al. 1992; Tranel et al. 2002, patient SB-2046). Different behavioral disorders have also been reported after surgery for frontolimbic tumors. By way of example, a patient developed kleptomania and compulsive gambling after removal of a craniopharyngioma. Besides this, he became circumstantial and logorrheic, and displayed hypergraphia and a preoccupation with religious and moral ideas (Nyffeler and Regard 2001). In children, aggressive microsurgery for craniopharyngiomas has a significant impact

597 on social–emotional and behavioral functioning (Sands et al. 2005). A prospective  
598 study reports that the majority of children who had total resections of craniophar-  
599 yngiomas were more or less severely affected by a hypothalamic syndrome that  
600 altered their social integration and caused academic failure (Pierre-Kahn et al. 2005,  
601  $n = 14$ ). High rates of intellectual impairment, poor social adaptation, and emotional  
602 lability in craniopharyngioma survivors (30–60 %) might be caused by an impaired  
603 frontal lobe function following surgery (Stelling et al. 1986).

604 In some cases, the resection of **brain tumors** can cause the onset of new psy-  
605 chiatric symptoms. For example, a patient with no previous mental illness devel-  
606 oped major depression with psychosis after resection of a giant middle fossa  
607 hemangiopericytoma (Sade et al. 2006). Another patient developed a schizo-  
608 phreniform psychosis after excision and postoperative radiotherapy of an oligo-  
609 dendroglioma (Mace and Trimble 1991, case C).

610 Tumor resections from brain areas, which have recently been considered irrel-  
611 evant for cognitive capacities, personality, and behavior, can cause a wide spectrum  
612 of neuropsychological and behavioral abnormalities. Behavioral deficits or attention  
613 deficit problems were detected in 33 % or 12.5 % of patients, respectively, who  
614 were operated for benign cerebellar tumors during childhood (Steinlin et al. 2003,  
615  $n = 24$ ). Some demonstrated psychiatric symptoms such as mutism, addiction  
616 problems, anorexia, uncontrolled temper tantrums and phobia. Patients had diffi-  
617 culties in selective and, more notably, sustained attention, which resemble dys-  
618 functions seen in patients with frontal lesions (Steinlin et al. 2003). There is  
619 evidence that cerebellar dysfunction includes a mild frontal dysfunction due to  
620 destroyed cerebello-frontal connections (Steinlin et al. 2003). The resection of  
621 benign cerebellar tumors causes the posterior fossa syndrome in 28 % of children,  
622 which is characterized by mutism, oropharyngeal dyspraxia, emotional lability,  
623 different neuropsychiatric symptoms, and autistic behavior (Catsman-Berrevoets  
624 and Aarsen 2010,  $n = 148$ ).

625 **Hypersexuality** following brain surgery has also been reported. Two patients  
626 developed hypersexuality with inappropriate sexual behavior following the place-  
627 ment of ventriculoperitoneal shunts for the treatment of hydrocephalus (Gorman  
628 and Cummings 1992). The sexual disorder was likely caused by septal damage due  
629 to the shunt placement. Both lesions and stimulation of the septum have caused  
630 hypersexuality in animals and humans. The septum is presumably one locus of a  
631 circuit of structures mediating sexual behavior (Gorman and Cummings 1992).  
632 Further loci of this circuit include the inferior frontal cortex, the hypothalamus, and  
633 the amygdaloid nuclei. Lesions in any of these regions have a major, site-specific  
634 impact on sexual behavior. Bilateral lesions of the amygdaloid nuclei produce  
635 hypersexuality (Klüver Bucy syndrome); whereas lesions in the hypothalamus  
636 reduce sexual activity (Gorman and Cummings 1992). A few long-lasting cases of  
637 disinhibition and inappropriate sexual behavior following pallidotomy (lesion of  
638 parts of the globus pallidus) for treating medically treatment-resistant Parkinsonism  
639 have been published (Shannon et al. 1998,  $n = 3$ , persistent for at least 6 months).

640 Fast negative changes in personality and behavior can also occur after  
641 psychiatric neurosurgery, which is used very rarely for the treatment of severe

642 therapy-resistant cases. By way of example, possible sequelae of capsulotomy  
643 include aggressiveness, dysexecutive function deterioration, and sexual disinhibi-  
644 tion (Cosgrove and Rauch 1995; D’Astous et al. 2013; Dougherty et al. 2002;  
645 Feldman et al. 2001; Rück et al. 2008). Following subcaudatetractotomy, the  
646 development of undesirable personality traits has been reported in some patients  
647 (Feldman et al. 2001). After ventromedial frontal leukotomy, most patients with  
648 lesions in the ventral striatum (8 out of 11) developed substance dependence (Irle  
649 et al. 1998). The reports indicated no potential of reversibility of these sequelae.

### 650 *3.3 Slow Processes with High Plasticity Potential*

651 When changes in personality and behavior occur gradually due to slowly devel-  
652 oping brain lesions, they allow for better adaptation to the changes, both for the  
653 patient and for people in the social surrounding. Slow processes could be consid-  
654 ered as less dramatic than fast processes. On the other hand, slow development can  
655 conceal the fact that problematic changes in personality and behavior are caused by  
656 a disease and not by the patients’ “evil will.” Particularly, if the disease is not yet  
657 diagnosed, or if the patient’s significant others do not understand its effects on the  
658 patient’s personality and behavior, the patient may be blamed for aberrant behavior.  
659 However, this risk is diminished if these slowly developing changes in personality  
660 and behavior are reversible by adequate medical or neurosurgical therapies. Notable  
661 examples can be found particularly in studies about the neurosurgical treatment of  
662 epilepsy, Parkinson’s disease, and brain tumors.

663 In patients suffering from **epilepsy**, changes in personality and behavior mostly  
664 develop over several years. However, in many cases, they are reversible after  
665 neurosurgical resection of the epileptic focus. Patients with epilepsy have a higher  
666 prevalence of lifetime psychiatric disorders (35 %) than the general population  
667 (20.7 %; Téllez-Zenteno et al. 2007), and particularly high are the rates in patients  
668 with temporal lobe epilepsy (Foong and Flugel 2007). Following surgery for epi-  
669 lepsy, depression, anxiety, behavioral disorders, and severe obsessive–compulsive  
670 disorders—which are often, but not always comorbidities of the disease—are often  
671 improved (Devinsky et al. 2005; Guangming et al. 2009; Guarnieri et al. 2005;  
672 Hannan et al. 2009; Lendt et al. 2000; Witt et al. 2008; review: Foong and Flugel  
673 2007). In many patients, increased warmth in social relationships and reduced  
674 egotism have been described (Hill et al. 1957). Improvements in aggressive  
675 behavior in children following surgery for temporal lobe epilepsy have been  
676 reported in several papers (review: Foong and Flugel 2007). In children, the most  
677 notable improvements after surgery for epilepsy include decreased hyperactivity,  
678 greater emotional well being, and improved socialization (review: Spencer and Huh  
679 2008).

680 In patients suffering from **Parkinson’s disease**, some disease-related changes in  
681 personality are sometimes reversed after deep brain stimulation (DBS) of the  
682 nucleus subthalamicus (Schneider et al. 2003). Changes in behavior caused by



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683 Parkinsonism drug therapy, such as impulse control disorders, pathological gam-  
684 bling, addiction to levodopa, and hypersexuality, can disappear after DBS since it  
685 allows for the reduction of the dopaminergic drugs (Demetriades et al. 2011).

686 Whether patients suffering from brain tumors develop changes in personality and  
687 behavior depends on tumor location, tumor size, and tumor type. In many cases,  
688 these changes are reversible after resection of the tumor, irradiation, or chemo-  
689 therapy. The reversibility of tumor-related personality changes depends both on the  
690 healing processes in the damaged brain tissue and on the amount of brain tissue that  
691 is further damaged by treatment. A notable case in the discussion to follow illus-  
692 trates how detrimental personality changes can result from a brain tumor and how  
693 brain surgery can restore the personality. A 40-year-old married schoolteacher  
694 became obsessed with child pornography and started to solicit prostitutes and to  
695 molest his stepdaughter. His wife evicted him from the family home after dis-  
696 covering his sexual advances to her daughter. He was accused and found guilty of  
697 molesting children. He had to enter a treatment program for convicted sexual  
698 offenders where he continued asking women for sex and was expelled from the  
699 program. One day before the start of his prison sentence, he was admitted to the  
700 hospital for headaches and an indomitable sex drive. An MRI scan revealed that he  
701 had an egg-sized brain tumor in the frontal lobe, a brain area essential for judgment,  
702 social behavior, and self-control. The tumor had already infiltrated the hypothala-  
703 mus, which also controls sex drive. After tumor resection, the pedophilic drive  
704 vanished completely, and the patient went home to his family. But several months  
705 later, he secretly started to collect pornography again. An MRI scan showed that the  
706 tumor had regrown. It was removed once more, and his abnormal sexual drive  
707 vanished again (Burns and Swerdlow 2003).

### 708 3.4 Slow Processes with Low Plasticity Potential

709 When changes in personality and behavior occur gradually due to slowly devel-  
710 oping brain lesions that in addition have low plasticity potential, the risk that these  
711 changes are attributed to the “evil will” of the patient resurfaces, and thus, the  
712 problem of misunderstanding, blame, and stigmatization will be aggravated.

713 Many neurodegenerative brain diseases affect an individual’s personality and  
714 behavior deeply and enduringly, particularly frontotemporal or vascular dementia,  
715 Parkinson’s disease and Huntington’s disease. Frontotemporal dementia (FTD) is a  
716 notable example of sociopathic behavior caused by an acquired frontal brain dis-  
717 order. FTD is a progressive neurodegenerative disorder that affects mainly the  
718 ventromedial prefrontal cortex, anterior temporal regions, and/or the orbitofrontal  
719 cortex. The behavioral changes of FTD patients seem to correlate with a decreased  
720 metabolism or perfusion in these regions as measured with PET or SPECT (Mendez  
721 2010). FTD patients show marked impairments in moral reasoning despite  
722 knowledge of moral and social rules, emotion recognition particularly for anger and  
723 disgust, empathy as rated by caregivers, and executive functions (Lough et al.

2006). FTD patients undergo a change in personality and behavior which is characterized by the following core features: transgression of social norms, sociopathic behavior, altered moral feelings, loss of emotional empathy, and disinhibited, compulsive acts. Although cognition remains largely intact, knowledge of moral behavior and of potential consequences of rule violations is preserved (Mendez 2010). Although they can make reasoned moral judgments, the emotional morality of FTD patients is altered, so that they respond to moral dilemmas in a calculated rather than an emotional fashion (Mendez and Shapira 2009). Typical examples of behavioral problems of FTD patients are loss of social tact and propriety, unacceptable physical contact, neglect of personal hygiene, and compulsive eating or hoarding. More than half of patients fail to conform to lawful behavior. Several reports describe stealing, unethical job conduct, indecent exposure, and inappropriate sexual behavior such as child molestation, illegal driving acts, and physical assaults or violence (Mendez 2010). According to Mendez, FTD patients have a “specific, brain-based impairment in moral reasoning”; their “sociopathic behavior is consistent with decreased emotional moral judgment plus a lack of empathy and disinhibited, compulsive drives” (Mendez 2010, p. 322).

In addition, the growth of brain tumors can affect personality and behavior on a longer timescale. Both tumor type and tumor location are significant influential factors for emotional and social dysfunctions such as anger, helplessness, fatigue, emotional dyscontrol, indifference, and maladaptive behavior (Andrewes et al. 2003,  $n = 69$ ). Tumors in the temporal lobes can be associated with behavioral problems, including aggression and rage attacks (Nakaji et al. 2003). The behavior of patients with lesions in the orbitofrontal and ventromedial PFC has been described as aggressive, lacking responsibility, and concern for social and moral rules (Eslinger and Damasio 1985; Damasio 1994).

#### 4 Ethical Pitfalls in Investigating Changes in Moral Behavior After Brain Lesions

So far, we have outlined the methodological problems when relating moral agency with the brain and provided a scheme to describe the complexity of brain lesion types and moral behavior changes that may result from these lesions. We now discuss the extent to which the investigation of changes in moral behavior after brain lesions poses ethical problems.

Why should it be ethically problematic to relate brain lesions with, in most cases, unwanted changes in moral behavior? Although his may sound like an odd question, the answers might contribute to novel therapies that prevent or reverse behavior changes. However, the impetus to find a neuronal cause for disturbed moral behavior aligns with a general tendency in popular culture to find brain-based explanations for behavior (Frazzetto and Anker 2009). Researchers and clinicians who investigate how changes in the brain lead to changes in moral behavior

764 propose to use their findings for interventions. For example, Fumagalli and Priori  
765 (2012, p. 2017) write: “From a clinical point of view, subjects manifesting  
766 abnormal moral behavior should be screened for neurological disorders to promote  
767 an early diagnosis. A potentially important issue arises when clinicians treat  
768 patients whose social position makes them responsible for others (including state  
769 leaders and politicians) with abnormalities of moral behavior or with other condi-  
770 tions (or treatment) that could influence their “moral brain.” In these cases, an early  
771 diagnosis and, whenever possible, effective treatment is important both for the  
772 patient and for the welfare of society.”

773 We think that the following questions should be considered in order to assess the  
774 ethics of moral behavior interventions based on findings in neuroscience:

- 775 1. On the grounds of which ethical theory should the borders between still toler-  
776 able behavior and morally blameful behavior be defined?
- 777 2. Does it make a difference when a change in moral behavior is caused by a brain  
778 lesion due to a pathological process, compared to a change in moral behavior  
779 that results as unwanted but maybe inevitable side effects of brain interventions  
780 to treat neurological disorders?
- 781 3. What do we owe persons who display unpleasant or even immoral behavior due  
782 to brain lesions?
- 783 4. Does tightening the link between brain damage and behavior aberration increase  
784 or decrease the stigmatization of these persons?
- 785 5. Given that there is a relation between the brain and moral behavior, what  
786 knowledge do we need to better understand this relation?
- 787 6. Is there a danger that we pathologize unwanted but legitimate moral  
788 standpoints?

789 In the following, we will briefly discuss these questions and outline some ethical  
790 risks that are associated with them.

#### 791 ***4.1 Which Ethical Theory?***

792 The first question relates to the basic problem that there is disagreement on what  
793 counts as moral behavior. Although we do not support moral relativism, we agree  
794 with its observation that moral issues are evaluated very controversially and that the  
795 controversies depend significantly on cultural and societal differences. A notable  
796 example is the field of sexual morality, where the controversy is enormous. Prac-  
797 tices such as prostitution, child marriage, intermarriage, homosexuality, premarital  
798 sex, extramarital sex, promiscuity, divorce, polygamy, etc., are socially fully  
799 accepted in some cultures and condemned or even illegal in others. This variability  
800 may explain the large prevalence differences of hypersexuality, from 2 to 10 %  
801 (Chiang et al. 2012) when comparing different countries. The cultural differences in  
802 sexual morality probably influence which criteria are used for the diagnosis of  
803 **hypersexuality** and thus the prevalence rates.

804 For a scientific investigation of brain disorders that cause disorders of moral  
805 behavior, a universalistic ethical approach would be optimal, as many ethical theo-  
806 ries consider universalizability to be a distinguishing feature of moral judgments  
807 and a substantive guide to moral obligation: Moral imperatives should be regarded  
808 as equally binding on everyone. However, in philosophy, many arguments have  
809 been developed against the feasibility of a **universalistic ethic**. For example,  
810 Beauchamp and Childress' principle-based ethics (2013) that is often considered to  
811 be a gold standard in bioethics is exposed to critics from several sides. First, the  
812 deductivists (e.g., Clouser and Gert 1990) criticize eclecticism and the lack of a  
813 universal, applicable ethical theory. Second, defendants of casuistic ethics (e.g.,  
814 Jonsen 1995) criticize a too schematic application of principles to particular cases  
815 (Harris 2003), and claim that it blocks substantive ethical inquiry (Callahan 2003).  
816 Third, the social science critique of bioethics claims that bioethics grounded in  
817 philosophy and moral theory gives a dominant role to idealized, rational thought  
818 and tends to exclude social and cultural factors, so that it is isolated from practice  
819 (overview: Hedgcock 2004). The dominance of the principle of respect for auton-  
820 omy in particular has been criticized by many authors from different ideological  
821 backgrounds (critical overview: Gillon 2003). In spite of the diversity of these  
822 criticisms, they converge in giving collective benefits more weight than individual  
823 rights.

824 In summary, the question of "which morality?" does not only refer to the  
825 commonplace, that there is disagreement concerning the morality of certain  
826 behaviors. The point is that the relationship of brain lesions with moral behavior  
827 tends to blur this variability and that this may happen on a level where this effect is  
828 difficult to be discerned, for example, on the level of diagnostic criteria. This  
829 impetus to universalize morality is not based on grounds of an elaborated theory of  
830 ethical universalism, but is implicitly embedded in the methodology that investi-  
831 gates the phenomenon. Therefore, we identify as the first ethical risk of the neu-  
832 roscience of ethics that it may suppress legitimate controversies on moral theories.

## 833 ***4.2 What Is Causing the Brain Lesion?***

834 At first glance, there seems to be a fundamental difference between changes of  
835 moral behavior caused by pathological processes such as strokes or tumors, and  
836 those caused by medical interventions. This distinction may hold when the inter-  
837 vention directly targets the behavior as in psychiatric neurosurgery, but it is less  
838 clear for lesions that occur as unintended or unavoidable consequences of thera-  
839 peutic interventions such as tumor resection.

840 For dealing with this problem, it is necessary to accumulate knowledge on  
841 sequelae that may result from particular interventions. This knowledge then can be  
842 used for the shared decision-making process between patient and medical experts.  
843 The problem, however, is that changes in moral behavior that are caused by



844 interventions are often hard to measure, whereas their relative life impact is high  
845 (Müller and Christen 2011).

846 However, a fundamental problem remains, namely the large individual vari-  
847 ability of human brains (e.g., functional connectivity; Barch et al. 2013) as well as  
848 of regeneration processes. Therefore, clinical outcome studies that average across  
849 patients to provide a unitary measure of outcome are not sufficient. Because of the  
850 large outcome variability, it is necessary to report both good and poor outcomes  
851 separately. Cross-sectional group research does not reveal the different individual  
852 trajectories and provides only limited clues about which factors are most relevant in  
853 effecting positive change for an individual. It is important to study individual  
854 outcomes, particularly by identifying subgroup patterns that can become lost in  
855 whole-group analyses. To overcome this systematical shortcoming, long-term fol-  
856 low-up studies of outcome, particularly of neuropsychological and socio-psycho-  
857 logical outcome, are necessary (Wilson et al. 2005). Particularly cases with  
858 unfavorable or unexpected outcome should be investigated, since they offer  
859 extraordinary chances for scientific discovery and improving the techniques used  
860 (Kubu and Ford 2012). Besides clinical studies, case studies contribute much to  
861 clinical experience and to scientific understanding. For example, the knowledge of  
862 adverse effects of deep brain stimulation has been spread mainly via case reports  
863 (Christen and Müller 2011). The careful documentation and publication of  
864 extraordinary single cases are important for scientific progress. This highlights the  
865 importance of case studies in addition to knowledge based on statistical evidence.

866 Given this caveat, an approach in therapy and rehabilitation that focuses on the  
867 individual case seems appropriate. However, this approach conflicts with an  
868 increasing involvement of knowledge based on statistical evidence and a regulatory  
869 or legal structure that more and more relies on such knowledge, for example, in  
870 addressing insurance claims. This pinpoints a second ethical risk: Restricting  
871 clinical research on the relationship between brain and moral behavior may  
872 undermine the value of special case studies involving outliers.

### 873 ***4.3 What Do We Owe Brain Lesion Patients with Socially*** 874 ***Aberrant Behavior?***

875 The care of frontal lesion patients is challenging and demonstrates constraints of  
876 classical principles of medical ethics like autonomy and beneficence. Disabilities  
877 that directly affect social interactions with others pose more challenges to family  
878 and caregivers compared to physical disabilities or pure cognitive disabilities. The  
879 main reason for this is probably that the disability caused by the brain lesion  
880 directly influences morally questionable behaviors like boasting, egocentrism, or  
881 obstinacy; or even uncontroversial immoral behaviors like habitual lying, child  
882 molestation, or violence. Empathy or even sympathy for these patients is much  
883 harder to sustain.

884 Most people who suffer from brain lesions are not responsible for their lesions,  
885 and they are significantly disadvantaged. Therefore, we think that society has the  
886 moral duty to support their reintegration. Besides a good medical treatment, reha-  
887 bilitation programs are necessary, and for some patients a protected environment.  
888 Furthermore, we think that research on the responsibility of people with brain  
889 lesions for aberrant or even criminal behavior is necessary. This research has to  
890 consider both medical and normative issues and therefore requires interdisciplinary  
891 programs.

#### 892 ***4.4 Will Research Increase the Stigmatization of Patients*** 893 ***with Brain Lesions?***

894 It is tempting to believe that a better understanding of how damage to the brain  
895 leads to changes in moral behavior will increase the understanding of such patients  
896 and enhance their social reintegration. However, we suspect that this hope is  
897 misleading for two reasons. First, experimental ethics has shown that the majority  
898 of people judge in an incompatibilist way, that is, they believe that determinism  
899 excludes moral responsibility. But many people tend toward compatibilism if the  
900 cases they have to judge trigger emotions; then most people blame others and hold  
901 them morally responsible despite knowing that the person was determined to act in  
902 a specific, immoral way (Nichols and Knobe 2007). Second, research on **stigma-**  
903 **tization** has shown that biological explanations of psychiatric disorders have  
904 complex effects on stigmatization which depend on several aspects of a given  
905 disorder. Biological explanations of psychiatric disorders increase stigmatization  
906 particularly if the disorder is explained as irreversible or as genetically based, or if it  
907 makes the patients dangerous for third persons (Müller and Heinz 2013). Therefore,  
908 we expect that a better biological understanding of how brain lesions cause aberrant  
909 behavior and changes in personality might decrease the stigmatization of principally  
910 curable or reversible diseases but increase the stigmatization of irreversible brain  
911 disorders.

912 From a theoretical point of view, a deeper understanding of how brain lesions  
913 cause social aberrant behavior is likely to support the view that brain lesion patients  
914 also deserve help and understanding when they behave immorally. However, it is  
915 likely that for many patients the practical effect will be the opposite—namely more  
916 stigmatization and discrimination. Thus, the third ethical risk of a neuroscience of  
917 ethics is that a better understanding of how brain lesions cause moral behavior  
918 changes might undermine people's willingness to support lesion patients to rein-  
919 tegrate in the society.

#### 920 **4.5 What Should We Investigate?**

921 This leads to the problem of deciding on which side of the interrelation between the  
922 brain and moral behavior the emphasis of research should be. Here, we are con-  
923 fronted with a fundamental impetus of the scientific method—namely that it aims to  
924 generate causal knowledge that is as precise and as deterministic as possible. The  
925 neuroscience of ethics proceeds from documenting correlations between brain  
926 lesions and social behavior to experimenting by noninvasive interventions with  
927 transcranial magnetic stimulation or by drugs. This should allow for finding pos-  
928 sible causal relationships underlying the correlations—for example, that inhibition  
929 of a certain brain region causes lack in impulse control. However, as our overview  
930 in Sect. 3 has shown, there is a surprising lack of knowledge on the reversibility of  
931 such behaviors. We propose that future research in the neuroscience of ethics  
932 should focus on three issues: the spectrum of behavior aberrations following brain  
933 lesions including their interrelation with the social environment, the chances of  
934 regeneration, and the development of effective therapies.

#### 935 **4.6 Danger of Pathologizing Ethical Theories**

936 We also pinpoint a fourth ethical risk of the neuroscience of ethics, namely to relate  
937 different ethical standpoints or ethical theories like deontology or utilitarianism to  
938 specified neuronal differences, or even to certain neurological disorders. It is pos-  
939 sible to detect different activation patterns during different forms of moral thinking.  
940 But what is the function of such findings in the meta-ethical discourse? We suspect  
941 that they are sometimes misused for debunking ethical theories, that is, for dis-  
942 crediting ethical theories not by normative arguments, but by pinpointing inop-  
943 portune or emotional processes that cause certain types of moral argumentations.  
944 An example is the discretization of deontology compared to utilitarianism based on  
945 neuroscientific findings (Singer 2005). In extremis, this could subserve a patholo-  
946 gization of ethical theories.

### 947 **5 Summary and Outlook: Moral Behavior as Target** 948 **of Therapy**

949 The central aim of our contribution is to outline the complexity of the interrelation  
950 between the brain and moral behavior relation when seen from a neuroscientific  
951 standpoint. We have argued that dynamic and temporal factors on both sides of the  
952 equation—the stability of moral evaluations across time and society or across  
953 neuronal plasticity—structure this complexity, but also explain why we cannot  
954 expect clear-cut relations between specific brain lesions and specific behavior

955 aberrations. But to achieve feasibility for therapy and rehabilitation, we will need  
956 models that have an intermediate degree of complexity, like the model of moral  
957 intelligence we have proposed. These models must be complex enough to capture  
958 the relevant phenomenon, but simple enough to be understandable for practical  
959 purposes. In that way, basic researchers and therapists can approach the question of  
960 how to interrelate the brain with moral agency in a more structured way.

961 However, one has to be aware of ethical risks that accompany this endeavor. The  
962 most urgent risk is a lack of knowledge about the spectrum of behavioral aberrations  
963 that accompany specified brain lesions, or about the potential of regeneration  
964 and its dependence on the social environment. The problem is aggravated by the  
965 difficulties in everyday life when dealing with patients that show aberrant social  
966 behavior, where one has to balance demands for responsible behavior and lenience  
967 due to their disability.

968 We close by remarking that the complexity outlined in our contribution also calls  
969 for caution with respect to recent claims for **moral enhancement**—the idea that  
970 knowledge of the biological foundation of human moral behavior may allow for  
971 interventions into the neuronal infrastructure of morality in order to improve the  
972 behavior of people or, at least, to diminish some forms of evil (De Ridder et al.  
973 2009; Shook 2012; Persson and Savulescu 2012). Although we are optimistic that  
974 more sophisticated and individualized research will certainly help to bear the  
975 behavioral burdens caused by some brain lesions, we do not support policies of  
976 moral enhancement through brain interventions that disregard the autonomy and  
977 dignity of the patients concerned.

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Insert double quotation marks	(As above)	ƶ or Ʒ and/or ƶ or Ʒ
Insert hyphen	(As above)	⊥
Start new paragraph	┌	┌
No new paragraph	┐	┐
Transpose	└┐	└┐
Close up	linking ○ characters	Ⓞ
Insert or substitute space between characters or words	/ through character or ∧ where required	Υ
Reduce space between characters or words		↑