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

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Keywords (separated by '-')	Brain injury - Brain lesion - Neurodegenerative diseases - Moral agency - Neuroscience of ethics - Neuroethics	

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

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

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

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

We structure the investigation as follows:

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

The structure of our contribution to this volume follows this basic outline: In Sect. 2, we introduce the notion of moral agency both with respect to its normative and empirical dimension. In Sect. 3, we provide a typology on effects of brain lesions on moral behavior. In Sect. 4, we discuss ethical pitfalls of relating brain lesions with moral behavior changes. Section 5 concludes our contribution with some preliminary thoughts on using knowledge on the relation between brain and 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.

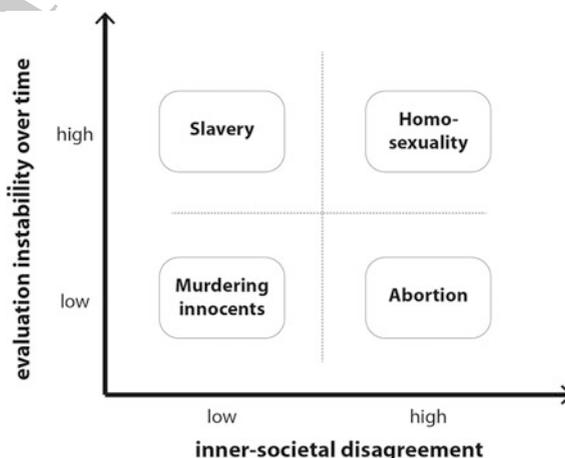
The first thing to specify is what the term **moral** should denote. A simple fact about **morality** is that people are disposed to react to issues according to what they

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

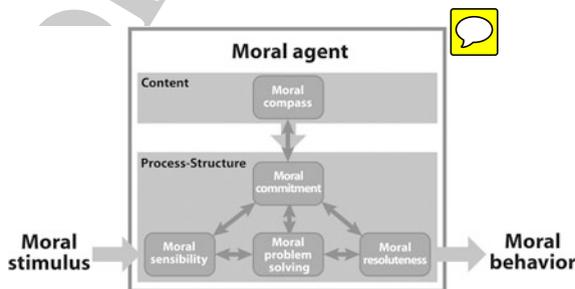


Fig. 2 The five building blocks representing competencies of moral intelligence in relation to the multistage model of moral functioning (adaptation from Tanner and Christen 2013)

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

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

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

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

2.3 Problems in Interrelating the Brain with Moral Agency

Our current knowledge on the neuroscience of ethics supports the expectation that 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



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

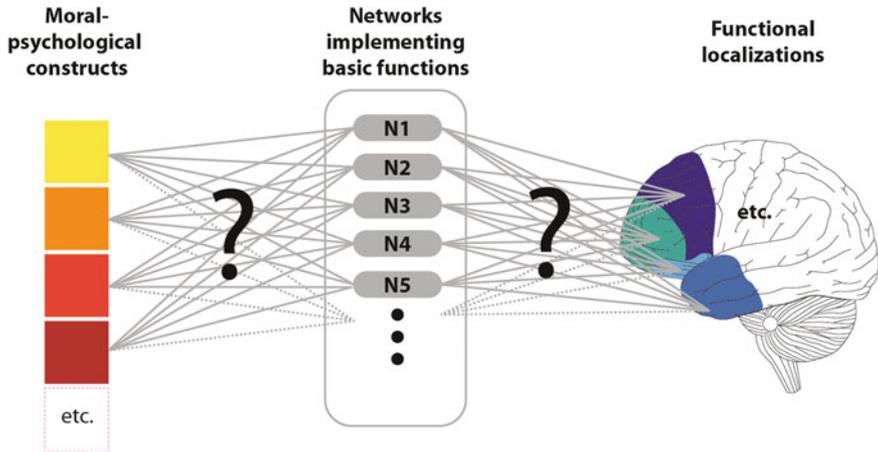


Fig. 3 Illustrating the problem of connecting moral–psychological constructs that describe relevant and usable moral competencies (*left side*) and functional localizations (*right side*) that actually involve many networks (N1, N2, N3, etc.) that may be affected by a lesion

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.

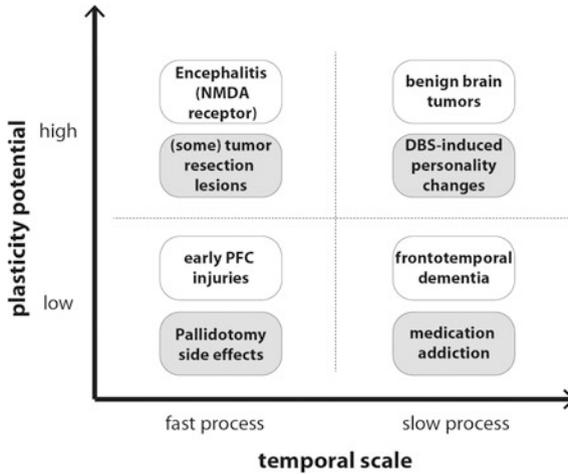


Fig. 4 Examples of pathological processes or interventions side effects influencing the brain. The examples are structured along the dimensions temporal scale of the process and the plasticity potential (potential of functional reversibility of the lesion sequelae). The *white boxes* denote changes due 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 blameworthy 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 rosience 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 of Therapy

948

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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980 References

- 981 Abend G (2013) What the science of morality doesn't say about morality. *Phil Soc Sci* 43:157–200
- 982 Absher JR, Vogt BA, Clark DG et al (2000) Hypersexuality and hemiballism due to subthalamic
983 infarction. *Neuropsych Neuropsychol Behav Neurol* 13(3):220–229
- 984 Andrewes DG, Kaye A, Murphy M et al (2003) Emotional and social dysfunction in patients
985 following surgical treatment for brain tumour. *J Clin Neurosci* 10(4):428–433
- 986 Appiah KA (2010) *The honor code: how moral revolutions happen*. W.W. Norton & Company,
987 New York
- 988 Barch DM, Burgess GC, Harms MP et al (2013) Function in the human connectome: task-fMRI
989 and individual differences in behavior. *NeuroImage* 80:169–189
- 990 Batts S (2009) Brain lesions and their implications in criminal responsibility. *Behav Sci Law* 27
991 (2):261–272
- 992 Beauchamp TL, Childress JF (2013) *Principles of biomedical ethics*, 7th edn. Oxford University
993 Press, Oxford
- 994 Björklund F, Björnsson G, Eriksson J et al (2012) Recent work: motivational internalism. *Analysis*
995 72:124–137
- 996 Burns JM, Swerdlow RH (2003) Right orbitofrontal tumor with pedophilia symptom and con-
997 structio-nal apraxia sign. *Arch Neurol* 60:437–440

- 998 Callahan D (2003) Principlism and communitarianism. *J Med Ethics* 29:287–291
- 999 Catsman-Berreoets C, Aarsen FK (2010) The spectrum of neurobehavioral deficits in the
1000 posterior fossa syndrome in children after cerebellar tumour surgery. *Cortex* 46:933–946
- 1001 Chiang HL, Huang YS, Chen ST et al (2012) Are there ethnic differences in impulsive/compulsive
1002 behaviors in Parkinson's disease? *Europ J Neurol* 19(3):494–500
- 1003 Cholbi MJ (2006) Belief attribution and the falsification of motive internalism. *Philos Psychol*
1004 19:607–616
- 1005 Christen M, Alfano M (2013) Outlining the field—a research program for empirically informed
1006 ethics. In: Christen M, Fischer J, Huppenbauer M, Tanner C, van Schaik C (eds) *Empirically*
1007 *informed ethics. Morality between facts and norms. Library of ethics and applied philosophy.*
1008 Springer, Berlin, pp 3–28
- 1009 Christen M, Müller S (2011) Single cases promote knowledge transfer in the field of DBS. *Front*
1010 *Integr Neurosci* 5 (Article 13)
- 1011 Imelli E, Muccioli M, Ládavas E et al (2007) Selective deficit in personal moral judgment
1012 following damage to ventromedial prefrontal cortex. *Soc Cog Affect Neurosci* 2:84–92
- 1013 Clouser KD, Gert B (1990) A critique of principlism. *J Med Philos* 15:219–236
- 1014 Cosgrove GR, Rauch SL (1995) Psychosurgery. *Neurosurg Clin North A* 6:167–176
- 1015 D'Astous M, Cottin S, Roy M et al (2013) Bilateral stereotactic anterior capsulotomy for
1016 obsessive-compulsive disorder: long-term follow-up. *J Neurol Neurosurg Psychiat* 84
1017 (11):1208–1213
- 1018 Dalmau J, Gleichman AJ, Hughes EG et al (2008) Anti-NMDA-receptor encephalitis: case series
1019 and analysis of the effects of antibodies. *Lancet Neurol* 7:1091–1098
- 1020 Dalmau J, Tuzun E, Wu HY et al (2007) Paraneoplastic anti-N-methyl-D-aspartate receptor
1021 encephalitis associated with ovarian teratoma. *Ann Neurol* 61:25–36
- 1022 Damasio AR (1994) *Descartes' error.* Putnam, New York
- 1023 Demetriades P, Rickards H, Cavanna AE (2011) Impulse control disorders following deep brain
1024 stimulation of the subthalamic nucleus in Parkinson's disease: clinical aspects. *Parkinson's*
1025 *Disease*, doi: [10.4061/2011/658415](https://doi.org/10.4061/2011/658415)
- 1026 De Ridder D, Langguth B, Plazier M et al (2009) Moral Dysfunction and potential treatments. In:
1027 Verplaetse J et al (eds) *The moral brain.* Springer, Berlin, pp 155–183
- 1028 Devinsky O, Barr WB, Vickrey BG et al (2005) Changes in depression and anxiety after resective
1029 surgery for epilepsy. *Neurology* 65:1744–1749
- 1030 Dougherty DD, Baer L, Cosgrove GR et al (2002) Prospective long-term follow-up of 44 patients
1031 who received cingulotomy for treatment-refractory obsessive-compulsive disorder. *Am J Psych*
1032 159:269–275
- 1033 Eslinger PJ, Damasio A (1985) Severe disturbance of higher cognition after bilateral frontal lobe
1034 ablation: Patient EVR. *Neurology* 35:1731–1741
- 1035 Eslinger PJ, Flaherty-Craig CV, Benton AL (2004) Developmental outcomes after early prefrontal
1036 cortex damage. *Brain Cog* 55:84–103
- 1037 Feinstein JS, Rudrauf D, Khalsa SS et al (2010) Bilateral limbic system destruction in man. *J Clin*
1038 *Exp Neuropsychol* 32(1):88–106
- 1039 Feldman RP, Alterman RL, Goodrich JT (2001) Contemporary psychosurgery and a look to the
1040 future. *J Neurosurg* 95:944–956
- 1041 Foong J, Flugel D (2007) Psychiatric outcome of surgery for temporal lobe epilepsy and
1042 presurgical considerations. *Epilepsy Res* 75:84–96
- 1043 Frazzetto G, Anker S (2009) Neuroculture. *Nature Rev Neurosci* 10(11):815–821
- 1044 Frías Ibáñez A, Malea Fernández A, Dorado García M et al (2008) Orbitofrontal syndrome after a
1045 cerebral aneurysm operation. A case report. *Actas España Psiquiátrica* 36(6):362–365
- 1046 Fumagalli M, Priori A (2012) Functional and clinical neuroanatomy of morality. *Brain* 135
1047 (7):2006–2021
- 1048 Gillon R (2003) Ethics needs principles—four can encompass the rest—and respect for autonomy
1049 should be “first among equals”. *J Med Ethics* 29:307–312
- 1050 Gorman DG, Cummings JL (1992) Hypersexuality following septal injury. *Arch Neurol*
1051 49:308–310

- 1052 Grafman J, Schwab K, Warden D et al (1996) Frontal lobe injuries, violence, and aggression: a
1053 report of the Vietnam Head Injury Study. *Neurology* 46:1231–1238
- 1054 Guangming Z, Wenjing Z, Guoqiang C et al (2009) Psychiatric symptom changes after
1055 corticoamygdalo-hippo-campectomy in patients with medial temporal lobe epilepsy through
1056 Symptom Checklist 90 Revised. *Surgical Neurol* 72:587–591
- 1057 Guarnieri R, Araújo D, Carlotti CG Jr et al (2005) Suppression of obsessive-compulsive symptoms
1058 after epilepsy surgery. *Epilepsy Behav* 7:316–319
- 1059 Hannan S, Cross JH, Scott RC et al (2009) The effects of epilepsy surgery on emotions, behavior,
1060 and psychosocial impairment in children and adolescents with drug-resistant epilepsy: a
1061 prospective study. *Epilepsy Behav* 15:318–324
- 1062 Harlow JM (1868) Recovery from the passage of an iron bar through the head. *Publ Mass Med Soc*
1063 2:327–347
- 1064 Harris J (2003) In praise of unprincipled ethics. *J Med Ethics* 29:303–306
- 1065 Hawkins KA, Trobst KK (2000) Frontal lobe dysfunction and aggression: conceptual issues and
1066 research findings. *Aggr Viol Behav* 5(2):147–157
- 1067 Hedgecoe AM (2004) Critical bioethics: beyond the social science critique of applied ethics.
1068 *Bioethics* 18(2):120–143
- 1069 Hill D, Pond DA, Mitchell W et al (1957) Personality changes following temporal lobectomy for
1070 epilepsy. *J Med Sci* 103:18–27
- 1071 Hornak J, Bramham J, Rolls ET et al (2003) Changes in emotion after circumscribed surgical
1072 lesions of the orbitofrontal and cingulate cortices. *Brain* 126:1691–1712
- 1073 Irle E, Exner C, Thielen K et al (1998) Obsessive-compulsive disorder and ventromedial frontal
1074 lesions: clinical and neuropsychological findings. *Am J Psych* 155:255–263
- 1075 Jonsen AR (1995) Casuistry: an alternative or complement to principles? *Kennedy Inst Ethics J*
1076 5:237–251
- 1077 Koenigs M, Young L, Adolphs R et al (2007) Damage to the prefrontal cortex increases utilitarian
1078 moral judgments. *Nature* 446:908–911
- 1079 Kohlberg L (1981/1984) *Essays on moral development*, vol I/II. Harper & Row, San Francisco
- 1080 Kubu CS, Ford PJ (2012) Beyond mere symptom relief in deep brain stimulation: an ethical
1081 obligation for multi-faceted assessment of outcome. *AJOB Neurosci* 3(1):44–49
- 1082 Lendt M, Helmstaedter C, Kuczaty S et al (2000) Behavioral disorders in children with epilepsy:
1083 early improvement after surgery. *J Neurol Neuro-surg Psych* 69:739–744
- 1084 Lough S, Kipps CM, Treise C et al (2006) Social reasoning, emotion and empathy in
1085 frontotemporal dementia. *Neuropsychologia* 44(6):950–958
- 1086 Mace CJ, Trimble MR (1991) Psychosis following temporal lobe surgery: a report of six cases.
1087 *J Neurol Neurosurg Psych* 54:639–644
- 1088 Macmillan M (2000) An odd kind of fame. *Stories of phineas gage*. MIT-Press, Cambridge, Mass
- 1089 Mataró M, Jurado MA, García-Sánchez C et al (2001) Long-term effects of bilateral frontal brain
1090 lesion: 60 years after injury with an iron bar. *Arch Neurol* 58(7):1139–1142
- 1091 Mendez MF, Shapira JS (2011) Pedophilic behavior from brain diseases. *J Sex Med* 8:1092–1100
- 1092 Mendez MF (2010) The unique predisposition to criminal violations in frontotemporal dementia.
1093 *J Am Acad Psych Law* 38(3):318–323
- 1094 Mendez MF (2009) The neurobiology of moral behavior: review and neuropsychiatric
1095 implications. *CNS Spectrum* 14(11):608–620
- 1096 Mendez MF, Shapira JS (2009) Altered emotional morality in frontotemporal dementia. *Cogn*
1097 *Neuropsych* 14(3):165–179
- 1098 Meyers CA, Berman SA, Scheibel RS et al (1992) Acquired antisocial personality disorder
1099 associated with unilateral left orbital frontal lobe damage. *J Psych Neurosci* 17(3):121–125
- 1100 Müller S, Heinz A (2013) Stigmatisierung oder Entstigmatisierung durch Biologisierung
1101 psychischer Krankheiten? *Nervenheilkunde* 12:955–961
- 1102 Müller S, Christen M (2011) Deep brain stimulation in Parkinsonian patients—ethical evaluation
1103 of cognitive, affective, and behavioral sequelae. *AJOB Neurosci* 2(1):3–13
- 1104 Nakaji P, Meltzer HS, Singel SA et al (2003) Improvement of aggressive and anti-social behaviour
1105 after resection of temporal lobe tumors. *Pediatrics* 112(5):e430–e433

- 1106 Narvaez D (2005) The neo-Kohlbergian tradition and beyond: schemas, expertise and character.
1107 In: Carlo G, Pope-Edwards C (eds) *Moral motivation through the lifespan*. University of
1108 Nebraska Press, Lincoln, pp 119–163
- 1109 Nichols S, Knobe J (2007) Moral responsibility and determinism: the cognitive science of folk
1110 intuitions. *Noûs* 41(4):663–685
- 1111 Nyffeler T, Regard M (2001) Kleptomania in a patient with a right frontolimbic lesion. *Neuro-psy-*
1112 *ch Neuro-psycho-l Behav Neurol* 14(1):73–76
- 1113 Parkinson C, Sinnott-Armstrong W, Koralus PE et al (2011) Is morality unified? Evidence that
1114 distinct neural systems underlie moral judgments of harm, dishonesty, and disgust. *J Cog*
1115 *Neurosci* 23(10):3162–3180
- 1116 Pascual L, Rodrigues P, Gallardo-Pujol D (2013) How does morality work in the brain? A
1117 functional and structural perspective of moral behavior. *Front Integr Neurosci* 7:65
- 1118 Persson I, Savulescu J (2012) *Unfit for the future: the need for moral enhancement*. Uehiro series
1119 in practical ethics. Oxford University Press, Oxford
- 1120 Piaget J (1932) *The moral judgment of the child*. Kegan Paul, Trench, Trubner and Co., London
- 1121 Pierre-Kahn A, Recassens C, Pinto G et al (2005) Social and psycho-intellectual outcome
1122 following radical removal of craniopharyngiomas in childhood: a prospective series. *Child's*
1123 *Nerv Sys* 21:817–824
- 1124 Rest JR (1986) *Moral development: advances in research and theory*. Praeger, New York
- 1125 Roskies A (2006) Patients with ventromedial frontal damage have moral beliefs. *Philos Psychol*
1126 19:617–627
- 1127 Rück C, Karlsson A, Steele D et al (2008) Capsulotomy for obsessive-compulsive disorder. *Arch*
1128 *Gen Psych* 65(8):914–922
- 1129 Sade B, Budur K, Lee DK et al (2006) Major depression with psychosis after resection of a giant
1130 middle fossa hemangiopericytoma. *Surg Neurol* 65:290–292
- 1131 Sands SA, Milner JS, Goldberg J et al (2005) Quality of life and behavioral follow-up study of pe-
1132 dia-tric survivors of craniopharyn-gioma. *J Neurosurg* 103(4 suppl):302–311
- 1133 Schneider F, Habel U, Volkmann J et al (2003) Deep brain stimulation of the subthalamic nucleus
1134 enhances emotional processing in Parkinson disease. *Arch Gen Psych* 60(3):296–302
- 1135 Shamay-Tsoory SG, Tomer R, Goldsher D et al (2004) Impairment in cognitive and affective
1136 empathy in patients with brain lesions. *J Clin Exp Neuro-psycho-l* 26(8):1113–1127
- 1137 Shannon KM, Penn RD, Kroin JS et al (1998) Stereotactic pallidotomy for the treatment of
1138 Parkinson's disease. Efficacy and adverse effects at 6 months in 26 patients. *Neurology*
1139 50:434–438
- 1140 Shook JR (2012) Neuroethics and the possible types of moral enhancement. *AJOB Neurosci* 3
1141 (4):3–14
- 1142 Singer P (2005) Ethics and intuitions. *J Ethics* 9:331–352
- 1143 Spencer S, Huh L (2008) Outcomes of epilepsy surgery in adults and children. *Lancet Neurol*
1144 7:525–537
- 1145 Steinlin M, Imfeld S, Zulauf P et al (2003) Neuropsychological long-term sequelae after posterior
1146 fossa tumour resection during childhood. *Brain* 126:1998–2008
- 1147 Stelling MW, McKay SE, Carr A et al (1986) Frontal lesions and cognitive function in
1148 craniopharyngioma survivors. *Am J Dis Child* 140:710–714
- 1149 Tanner C, Christen M (2013) Moral intelligence—a framework for understanding moral
1150 competences. In: Christen M, Fischer J, Huppenbauer M, Tanner C, van Schaik C (eds)
1151 *Empirically informed ethics. Morality between facts and norms*. Library of ethics and applied
1152 philosophy. Springer, Berlin, pp 119–136
- 1153 Téllez-Zenteno JF, Dhar R, Hernandez-Ronquillo L et al (2007) Long-term outcomes in epilepsy
1154 surgery: antiepileptic drugs, mortality, cognitive and psychosocial aspects. *Brain* 130:334–345
- 1155 Tranel D, Bechara A, Denburg NL (2002) Asymmetric functional roles of right and left
1156 ventromedial prefrontal cortices in social conduct, decision-making, and emotional processing.
1157 *Cortex* 38:589–612
- 1158 Uttal WR (2001) *The new phrenology. The limits of localizing cognitive processes in the brain*.
1159 MIT Press, Cambridge

- 1160 Varadkar S, Bien CG, Kruse CA et al (2014) Rasmussen's encephalitis: clinical features,
1161 pathobiology, and treatment advances. *Lancet Neurol* 13(2):195–205
- 1162 Welt L (1888) Über Charakterveränderungen des Menschen infolge von Läsionen des Stirnhirns.
1163 *Deutsches Archiv für klinische Medizin* 42:339–390
- 1164 Wilson SJ, Bladin PF, Saling MM et al (2005) Characterizing psychosocial outcome trajectories
1165 following seizure surgery. *Epilepsy Behav* 6:570–580
- 1166 Witt JA, Hollmann K, Helmstaedter (2008) The impact of lesions and epilepsy on personality and
1167 mood in patients with symptomatic epilepsy: a pre- to postoperative follow-up study. *Epilepsy*
1168 *Res* 82:139–146

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