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ORIGINAL PAPER

Should Neuroscience Inform Judgements of Decision-Making Capacity?

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Abstract In this article, I present an argument that suggests neuroscience should inform judgments of decision-making capacity. First, I review key behavioral and neurocognitive data to demonstrate that neuroscientific tests might be predictive of decision-making capacity, and that these tests might inform clinical judgments of capacity. Second, I argue that, consistent with the principles of autonomy and justice, such data should inform judgements of decision-making capacity. While the neuroscience of decision-making capacity still requires time to mature, there is strong reason to believe that neuroscience might assist clinicians in adjudicating difficult cases in the future. This article focuses on the assessment of capacity in brain injury patients who have profound communication impairments, however, the overarching aim of the article is to highlight the potential use of neuroscience to improve our understanding of the relationship between cognition and decision-making capacity.

Keywords Decision-making capacity · Competence · Autonomy · Informed consent · Disability · Brain injury · Neuropsychology · Neuroscience · Neurology

1. Mr. S

Mr. S is a 30-year-old male who sustained a traumatic brain injury and spinal cord injury in a diving accident (Case adapted from [1]). A comminuted fracture of the cervical vertebrae with spinal cord involvement resulted in quadriplegia. Neuroimaging showed right-sided cerebellar infarcts and diffuse axonal injury. Electrophysiological examination was suggestive of moderate diffuse encephalopathy. Mr. S survived but sustained profound motor and cognitive impairments.

Two months after injury, a speech-language pathologist evaluated Mr. S to determine his ability to verbally communicate, and to make recommendations regarding optimization of non-verbal communication. Evaluation revealed limited head movement with inconsistent, single-word verbalization after extensive cueing. Attempts were made to develop a reliable method for non-verbal communication. The speech-language pathologist determined that Mr. S could respond to questions with facial gestures; sticking out his tongue would indicate "no", while closing his eyes would indicate "yes". Using this method, Mr. S responded to questions related to his history. Answers were verified by family members. Once reliable communication was determined, Mr. S was asked questions related to symptom management, including, "Are you feeling short of

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breath?" and "Do you feel discomfort?". Responses to these questions informed medical decision making.

Mr. S continued to respond to questions in the weeks that followed, but his ability to communicate did not improve beyond yes/no questions, and there were episodes in which Mr. S became fatigued and his responses appeared to be inconsistent. Mr. S's spouse was appointed as his surrogate decision maker. Throughout Mr. S's recovery, his spouse wished to incorporate him in the medical decision-making process, but it was not clear whether Mr. S retained decision-making capacity, nor how to evaluate this given his communication impairment.

Is it possible to harness the power of neuroscience to evaluate decision-making capacity in patients like Mr. S? If so, should we use neuroscience for this purpose? The relationship between cognition and one's ability to make healthcare decisions autonomously is a central assumption in the clinical model of decision-making capacity. Evaluation of cognition through neuroscientific tests could improve the assessment of decision-making capacity in patients like Mr. S. Moreover, such tests might also address the broader variability observed in capacity determinations across healthcare institutions [2–4]. Despite these potential benefits, neuroscientific tests have not yet been incorporated in the routine clinical assessment of decision-making capacity. This is due, in part, to the received view that decision-making capacity is normatively constrained; namely, that capacity is decision specific not global, and thus cannot be determined merely by examining the functions of the brain [5]. Neuroscientific tests could improve assessments of decision-making capacity, but this assertion must be reconciled with these normative constraints.

This article argues that behavioral and neurocognitive data derived from neuroscience should inform judgements of decision-making capacity, particularly in cases like Mr. S. When the results of standard assessment methods are incomplete, neuroscientific data might serve as compensatory information for judgements of capacity. I support this claim with the following argument. First, I argue that the principle of autonomy directs clinicians to seek out and promote patient liberty interests if a patient has decision-making capacity. In cases like Mr. S, clinicians ought to be sensitive to the reemergence of these interests and decision-making capacity throughout recovery. Second, I argue that the principle of justice requires clinicians to ensure that all patients have equitable access to opportunity, regardless of their situation in life. When applied to assessments of decision-making capacity, this might obligate clinicians to look beyond irrelevant factors, such as a patient's motor impairment, and focus instead on the essential cognitive abilities that support capacity. Neuroscientific tests might assist clinicians in satisfying these duties.

This article is divided into three sections. §1 provides an overview of the standard theory of decision-making capacity and methods for clinical assessment. §2 reviews key behavioral and neurocognitive data and describes how such data might inform judgements of decision-making capacity in clinical practice. Finally, §3 advances the argument that neuroscience should inform judgements of decision-making capacity. This article focuses on cases like Mr. S, however, the application of neuroscience to judgements of capacity might extend beyond brain injury populations. Indeed, following the guidance of the recent Presidential Commission reports on the ethical conduct of neuroscience research [6, 7], the overarching aim of this article is to highlight the potential use of neuroscience in improving our understanding of the relationship between cognition and decision-making capacity. An improved understanding of the neurocognitive correlates of capacity might reveal how decision-making capacity emerges in adolescents, how it is influenced by age-related cognitive decline, and how it is distorted by psychiatric or neurological disease.

Why Do We Need a Theory of Decision-Making Capacity?

Individuals have the right to exercise self-determination in medical decision making. This right derives from the principle of autonomy and is associated with liberal notions of self-governance [8]. In defining autonomy, Beauchamp and Childress assert that patients "have unconditional worth…the capacity to determine [their] own moral destiny…the right to choose…[and] the right to accept or decline information" [9]. The 1982 Presidential Commission adopts a similar stance, stating that patients have the intrinsic ability to "form, revise, and pursue personal plans in life" [10].

The doctrine of informed consent is integral to promoting self-determination. This doctrine derives from both English and U.S. common law relating to battery and negligence. Battery includes "harmful or offensive non-consensual touching" [10], while negligence results from a failure to perform a dutiful action, or the careless performance of an action that leads to harm [11]. Laws preventing battery and negligence reflect the view that clinicians have a range of duties to their patients, including the duty to respect patient liberty interests while balancing protection of patient welfare [12].

Informed consent consists of three components: disclosure, voluntariness, and decision-making capacity. Disclosure requires that clinicians reveal all relevant medical information to the patient. Voluntariness requires that the patient be free from coercion, external manipulation, or interference. Decision-making capacity requires that the patient understands the medical information presented to her, can rationally deliberate upon it, and grounds her decision in a reasonably consistent set of values. Decision-making capacity is one of the most important features of informed consent, as it serves to balance the interests of patients with the duties of clinicians [13]. Clinicians have fiduciary duties to protect patients, yet patients also have interests in their own liberty and welfare. Clinician duties and patient interests will often align. However, in some circumstances a patient's decision to decline otherwise safe and effective treatment may challenge the clinician's duty to protect. Whether a patient has capacity can provide guidance as to which party retains decision-making authority.

What Is the Standard Theory of Decision-Making Capacity?

Decision-making capacity is the ability of a specific individual to make a specific medical decision, at a specific point in time, and under specific conditions. Decision-making capacity is often bound up with the medico-legal concept, competence. While the concepts of decision-making capacity and competence overlap substantially, readers should note that they are distinct clinical constructs [14]. In what follows, I focus on the received philosophical theory of decision-making capacity [5, 10]. I then turn to clinically-oriented conceptions of capacity in the following sections. Broadly, philosophical accounts of decision-making capacity hold that it is mediated by several cognitive abilities. These include: understanding, appreciation, reasoning, values, and communication.

Understanding

Understanding is the ability to receive and retain relevant medical information. One must be able to comprehend language, grasp sophisticated concepts related to disease and treatment options, and recall information for application in future medical decisions.

There are different interpretations of understanding in informed consent. One interpretation holds that the patient must be *fully* informed to give consent. Being fully informed means that the patient has an exhaustive understanding of the medical information provided to her. But this suggests that a patient would need to know just as much as her clinician to provide consent. This requirement is unfeasible for patients that lack medical training. Moreover, it is widely reported that patients often fail to comprehend medical terms [15] and are unable to accurately recall the content of a consent interview [16].

A different interpretation of understanding considers what sort of information is essential for a patient to be held responsible for consent [17]. This curtails the amount and kind of information that is disclosed. Ultimately, clinicians desire that patients are reasonable in their decision-making process. Thus how much medical information is disclosed to a patient is determined by what clinicians believe would support a responsible decision maker. For example, the extent of information provided, and the understanding required, to consent to a novel chemotherapy treatment for stage-4 breast cancer might be considerably greater than the information provided, and the understanding required, for the use of a routinely prescribed antibiotic. This difference is due to the extent of understanding required to hold a patient responsible for her medical decisions. Understanding need only extend to information relevant to responsible medical decision making. Understanding does not require taking a "mini-course in medical science" nor a "lengthy polysyllabic discourse on all possible complications" [18].

Appreciation

Appreciation is the ability to imagine what future states will be like based on consent or refusal of treatment. If a patient is faced with a medical decision, she should be able to reasonably foresee the consequences of accepting or refusing therapy.

A defining feature of appreciation is clinical insight. Clinical insight is the ability to recognize that the disclosed medical information relates to one's own condition and treatment [19]. A variety of circumstances might diminish clinical insight. A patient might remain unaware of her illness due to a causal connection between the illness and lack of awareness. Some stroke survivors, for example, suffer from somatoparaphrenia, which is characterized by denial of ownership of bodily limbs [20, 21]. Remarkably, this delusion cannot be corrected through proof or explanation. The deficiency of appreciation in these patients is a false belief. False beliefs are a hallmark of deficient decision-making capacity.

While discussions of understanding and appreciation often overlap, appreciation differs from understanding in important ways. Both abilities involve retention and manipulation of medical information, but appreciation requires the patient to recognize that the information relates to *her own situation* and to *imagine what future states will be like* given her treatment options [13]. It is possible for a patient to understand medical information while, at the same time, fail to appreciate that she is the subject of the medical decision. Understanding does not entail appreciation. Appreciation must be demonstrated independently.

Reasoning

Reasoning is the ability to consider the potential outcomes of a medical decision and to assess how those outcomes will affect goals and life plans. This ability requires one to consider probabilities, assign those probabilities to various outcomes, and weigh the importance of outcomes based on personal values.

Reasoning is distinct from understanding and appreciation in that it captures the synthesis of information in the decision-making process. Deficiencies in appreciation may generate false beliefs, yet a patient might still reason appropriately with this information. Likewise, a patient may hold true beliefs about her medical situation but fail to reason appropriately. Reasoning is thus the way in which a patient incorporates medical information with her conception of the good. Failure to use information in a way that promotes one's conception of the good will call a patient's reasoning into question.

It is sometimes (wrongly) assumed that medical decisions are irrational if they contradict a clinician's recommendations [22]. Evaluation of reasoning allows clinicians to determine if a patient has arrived at the decision through a logical process or through delusion. If the patient can explain her decision in a way that is consistent with her own goals and life plans, even if that explanation is inconsistent with medical recommendations, then the patient has decision-making capacity. This reinforces the view that capacity is determined by the *process* of decision making, not the *content* of a patient's decision [23].

Values

A fourth component of decision-making capacity is the possession of a reasonably stable set of values. A set of values identifies the patient's conception of the good and provides a framework according to which subjective weight can be assigned to decision outcomes. Such values needn't be entirely consistent. It is not expected that a patient will have her entire life plan worked out in detail. All that is required is a set of values that is sufficiently stable to allow a patient to make a decision, follow through with it, and accept responsibility for it.

Patient values are often folded into an analysis of reasoning. One explanation for this is that patient values are not, strictly speaking, cognitive abilities. As we shall see, standard tests for decision-making capacity do not contain explicit probes for values [24]. Instead, assessment of patient values is subsumed under the evaluation of reasoning. For a patient to reason adequately, she must explain why the decision is best for her. Reference to one's own values typically occurs in such explanations.

Some question this approach. These criticisms are motivated by the concern that standard tests of decision-making capacity do not account for harmful shifts in patient values. For example, it is possible for a patient to satisfy all the conditions of decision-making capacity yet still be incapable of making medical decisions autonomously because her values are pathological. In a study conducted by Tan and colleagues, it was demonstrated that a group of anorexia nervosa patients could describe their condition with remarkable insight and clarity [25]. Study participants showed strong comprehension of the health implications of their eating disorder as measured by standard tests of decision-making capacity. Yet they still maintained a distorted body image and erroneous attitudes about the role of anorexic behaviors in alleviating mood alterations. This suggests that values can play a pivotal, yet unobserved role in the decision-making process. Pathological values can lead to poor decision making even if all other components of decision-making capacity are present.

Evidently there is a need for a more accurate picture of how values contribute to medical decision-making [26]. Indeed, some have framed this turn toward values as a tension between *cognitive* and *non-cognitive* models of decision-making capacity [27]. Proponents of the non-cognitive model suggest that a narrow focus on cognition eclipses important insights on the value-laden rationale for medical decisions. As we shall see, this could be a limitation to using neuroscience to inform judgements of decision-making capacity.

Communication

Communication is the ability to indicate, verbally or otherwise, a medical decision. If a patient lacks the ability to communicate, due to a neurodegenerative disease, for example, she will most likely be deemed incapable. A surrogate decision maker will be appointed in such cases.

The importance of communication to decision-making capacity is sometimes overlooked. Theorists often focus on the cognitive components of capacity, while communication is treated merely as a *mode of demonstration*. This results in a narrow and demanding conception of communication. The cognitive components of decision-making capacity—understanding, appreciation, and reasoning—are operationalized in such a way that requires complex, verbal communication. The problem with this conception is that, arguably, it places more weight on the mode of demonstration than the cognitive components themselves. For example, a patient might retain all cognitive components of capacity, yet be determined incapable because she is unable to verbally communicate. To be sure, some form of communication is necessary to evaluate decision-making capacity. This is due to the normative constraints of decision-making capacity. Nevertheless, a more flexible interpretation of communication might allow for alternative, compensatory evidence of decision-making capacity if a patient has a communication impairment. I return to this point in §3.

How Is Decision-Making Capacity Determined?

A patient's decision-making capacity is determined by three factors: the patient's medical condition; the patient's process of deliberation; and the demands placed on the patient by her medical situation [23]. Various neuropsychological tests have been developed to assess the second of these factors. The MacArthur Competence Assessment Tool for Treatment (MacCAT-T) is one of the most authoritative and rigorous instrument for assessing decision-making capacity in clinical research and practice [24]. Variations of assessment instruments all share common features enumerated in the MacCAT-T.

The MacCAT-T is a structured interview, lasting between 15 and 20 minutes, which evaluates a patient's deliberation against an operational model of decision-making capacity. This model comprises four subcomponents: understanding, appreciation, reasoning, and expressing a choice. These subcomponents are broadly consistent with the above-outlined cognitive abilities (Note, however, that explicit probes of patient values are not included in this model. For further discussion, see [27]).

The MacCAT-T begins with a structured disclosure of the patient's medical condition and treatment options. Questions probing understanding are posed during disclosure. The patient's ability to paraphrase the medical information and risks and benefits of each treatment are evaluated. The clinician will also ask questions that probe appreciation. Appreciation is evaluated by a patient's ability to acknowledge her condition and the benefits of treatment, or if she disagrees with the medical information for non-delusional reasons, such as, “another doctor told me something else” [23]. The patient is then asked to express a preliminary choice. Reasoning is evaluated with respect to this choice. Patient values are considered here, but they are not probed explicitly. The ability to express a choice is evaluated at the culmination of the interview. Clinicians will observe whether the patient makes exactly one choice, fails to express a choice, or vacillates between choices.

Scores for each subcomponent are aggregated and compared against results from both healthy and clinical populations. The MacCAT-T provides no cutoff score for any of the four subcomponents. Rather, these scores are subjected to the clinician's judgement to determine whether the patient's performance justifies the ascription of decision-making capacity for a particular medical decision [23]. Importantly, determinations of decision-making capacity cannot—and should not—be reduced to the mere evaluation of these cognitive subcomponents. This is due to the normative constraints of decision-making capacity.

Decision-making capacity is normatively constrained in two important ways [5]. First, decision-making capacity is not global. Some individuals are capable of making some decisions but not others. Additionally, a patient's capacity may change over time. This suggests that a patient has (or lacks) decision-making capacity with respect to a *particular medical decision* at a *particular time*. Failure to demonstrate decision-making capacity for a particular decision does not entail that one is globally incapable.

Second, it is generally recognized that different medical decisions have varying stakes, which are determined by the risk-benefit ratio of the decision outcome. Low-stakes medical decisions involve a choice with a risk-benefit ratio *substantially better* than alternatives, whereas high-stakes decisions involve a choice with a risk-benefit ratio that is *substantially worse.* Some argue that a patient's capacity needs to be calibrated to these stakes [5]. High-stakes medical decisions require greater decision-making capacity, while low-stakes decisions require less decision-making capacity. Determinations of decision-making capacity seek to harmonize neuropsychological data with these stakes.[1]

As we shall see, these normative features could delimit the role that neuroscience might play in informing judgements of decision-making capacity. The assessment of cognition with neuroscientific tests gestures toward a global evaluation of decision-making capacity, while the stakes of a medical decision are simply unaccounted for. Nevertheless, neuroscience might still provide valuable insight into the cognitive building blocks of capacity. This information might verify whether the neurocognitive background conditions of decision-making capacity obtain in any given patient. In the following section, I address the question of whether neuroscience can inform judgments of decision-making capacity. I review key behavioral and neurocognitive data that suggest neuroscientific tests are predictive of capacity. I then identify several ways in which such data might be applied in clinical practice.

2. Can Neuroscience Inform Judgements of Decision-Making Capacity?

Neuroscience and cognate fields, including cognitive- and neuropsychology, investigate cognitive functions and associated structural and functional changes in the brain. Cognitive functions are neuronal operations that contribute to one's performance in cognitive and motor tasks. Common examples include executive functions, memory functions, and language functions. Executive functions are involved in the synthesis, processing, and application of information. Memory functions are involved in the encoding and retrieval of information. Finally, language functions are involved in comprehension and communication.

Observations in healthy and clinical populations inform our understanding of cognitive functions and their relation to the brain. Research participants might be instructed to perform a task while brain activity is recorded with neuroimaging. Data collected from these studies reveal how task performance is related to functional or structural changes in the brain. Task performance might also be assessed with behavioral survey methods. Outputs of these measures are used to determine associations between certain cognitive functions and tasks, and their relation to changes in the brain. Deficiencies in task performance might indicate pathological or age-related changes in cognition.

Standard accounts of decision-making capacity hold that cognition plays a critical role in autonomous decision making. As reviewed above, decision-making capacity is believed to be mediated by several cognitive abilities. These cognitive abilities, however, might in turn be supported by more basic cognitive functions. Investigation of these cognitive functions could provide further evidence of decision-making capacity. In what follows, I argue that some functional and structural changes in the brain, as evidenced by behavioral and neurocognitive data, might be predictive of decision-making capacity. This account derives from recent empirical work on neurocognitive models of decision-making capacity. As we shall see, selective deficits in cognition are strongly associated with deficits in one or more components of decision-making capacity.

Before proceeding, readers should be alerted of two critical points. First, the predictive relationships outlined below are, at present, unidirectional. The empirical literature demonstrates that *deficiencies* in certain cognitive functions are predictive of *deficiencies* in decision-

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[1] This approach has been criticized in the literature. Critics argue that it leads to a risk asymmetry, wherein a decision to accept a clinician's recommendation could be deemed less risky (and thus requires less capacity) than a decision to refuse therapy [28, 29]. Nevertheless, the notion that medical decisions have varying stakes continues to be a feature of the received framework of decision-making capacity [30]. For the purposes of this article, I accept this framework.

making capacity. The data do not show that intact cognitive function is predictive of intact decision-making capacity. As described above, this is due, in part, to the normative constraints of decision-making capacity. Deficiencies in essential cognitive functions, such as language processing, will suggest that a patient might lack decision-making capacity. Yet evidence of essential cognitive functions alone does not suffice for the ascription of decision-making capacity. Future research might reveal a quantitative probability of preserved decision-making capacity based on neurocognitive changes. Even so, clinical judgement will likely still be required for a capacity determination. I return to this point below.

A second critical point is that generalizations from the below-reviewed data are vulnerable to equivocation. The aim of this article is to gesture toward generalizable inferences about the relationship between cognition and decision-making capacity, but this line of reasoning is constrained in at least two ways. First, it is well known that the terms used in cognitive psychology, such as "memory", have various operational definitions, and that the neuronal referents of these terms may vary across research programs [31]. Studies that seek predictive relationships between cognition and decision-making capacity could inadvertently employ inconsistent meanings of key terms, and this could be misleading. Second, the predictive relationships outlined below might also raise the problem of multiple realizability. The problem of multiple realizability holds that there is not a one-to-one mapping between a brain state and a mental state. Rather, these relationships are many-to-one (or one-to-many); a single brain state might be involved in all components of decision-making capacity, or one component of decision-making capacity might recruit a variety of brain states. Equivocations can follow from both of these complexities. Generalizations beyond the below-reviewed data might yield a broader account of the relationship between cognition and decision-making capacity, but these generalizations should be made with caution.

Behavioral Data

Behavioral data demonstrate that deficiencies in certain cognitive functions are strongly associated with deficiencies in one or more of the components of decision-making capacity. In what follows, I review key findings in the empirical literature that demonstrate a predictive relationship between certain behavioral tasks and decision-making capacity.

Vocabulary

Vocabulary comprehension is positively correlated with decision-making capacity. Vocabulary comprehension is understood as "semantic knowledge," or the ability to pair concepts with words [32]. Taub and Baker [33] and Taub and colleagues [34] found that understanding in consent procedures varied with performance on the vocabulary subset of the Wechsler Adult Intelligence Scale in elderly populations. In the vocabulary subset, individuals are presented with either pictures or words and asked to identify or define them. The vocabulary subset is intended to assess vocabulary knowledge and verbal concept formation.

Gerstenecker and colleagues [35] and Dreer and colleagues [36] also found that verbal memory and fluency, as assessed with the Hopkins Verbal Learning Test-Revised, were highly correlated with understanding in patients with diagnosed brain metastases. Patients were presented with 12 words over 3 learning trials. Phonemic verbal fluency was assessed by instructing patients to name as many words as possible that begin with the letters "C," "F," or "L" in a one-minute period. Semantic verbal fluency was assessed by instructing patients to name as many animals as possible in a one-minute period. In both cases, performance was positively correlated with understanding medical information.

These data are broadly consistent with the assertion that memory is critical to communication. Memory is recruited in communication in both expressive and receptive contexts. Communication is expressive in that a patient must tell clinical staff what her decision is. Communication is receptive in that a patient must understand what clinical staff communicate to her. This expressive-receptive distinction is consistent with findings from lesion studies. Damage to the left lateral temporal cortex can lead to comprehension deficits of single words or full sentences, while damage to Broca's area can inhibit speech production even if language comprehension remains intact [37].

Memory

Memory is also critical to understanding, appreciation, and reasoning. Dreer and colleagues [36] reported that short-term verbal memory, as assessed by the Wechsler

Memory Scale-R Logical Memory I, was correlated with understanding and reasoning during acute impairment following traumatic brain injury. Participants were read two short stories and were instructed to retell one of the stories through free recall. At initial screening, brain injury patients who performed poorly during recall also showed deficient understanding and reasoning in medical decision making.

Six months following brain injury, a patient's ability to reason was also associated with auditory working memory, as assessed with the Wechsler Adult Intelligence Scale Arithmetic Working Memory Subset [36]. This test requires participants to solve a series of verbally disclosed arithmetic problems under time pressure. Using the Rey Auditory Verbal Learning Test, meanwhile, Dreer and colleagues also observed that reasoning was associated with verbal learning and memory. Poor performance on this task was positively correlated with overall diminished decision-making capacity.

In their systematic review, Palmer and Salva [38] reported that appreciation and reasoning were also associated with memory functions in schizophrenic patients. They observed that:

> "Relative to neuropsychological tests of other cognitive abilities, working memory scores had the highest bivariate correlations with appreciation in three of the five schizophrenia studies, [39–41] and the highest bivariate correlations with reasoning in two of the five studies [39, 40]" [38].

Based on these data, it is hypothesized that impaired working memory—particularly verbal working memory—is a "red flag" for diminished decision-making capacity following brain injury and in psychiatric populations [38, 42].

The relationship between memory, understanding, and reasoning is unsurprising. Indeed, the very operational definitions of understanding and reasoning suggest that memory plays some, likely critical, role in medical decision-making. But suppose, for the sake of argument, that memory was not involved in understanding. If this were true, a patient would not be required to encode and store novel medical information when making autonomous medical decisions. This, however, is a counterintuitive view of understanding. If memory was not involved in understanding, then it is unclear whether consent would ever be informed.

A more complicated relationship is that between memory and reasoning. Declarative memory, including semantic and episodic memory, might be related to reasoning just as working memory is. On a strong interpretation of the relationship between declarative memory and reasoning, episodic and semantic memory would be involved in making choices that are consistent with one's own values. One's values motivate medical choices and are often derived from personal history. Jehovah's Witnesses forgo blood transfusions—a common and otherwise safe medical intervention—because they are inconsistent with their religious beliefs. Likewise, when faced with stage-4 breast cancer, some might choose a less aggressive therapy because they value quality rather than quantity of life. The values that motivate these decisions are rooted in personal history. Judgements of decision-making capacity often hinge on one's the ability to make these values explicit. Episodic memory is likely involved in recalling episodes in one's life that support these value judgements.

A weaker interpretation might emphasize the role of semantic memory in capacity. According to this view, semantic memory could play a compensatory role in expressing values if episodic memory is diminished. Explanations of the values that motivate a medical decision could hinge on an internalized conceptual framework. The Jehovah's Witness could merely rehearse the rules for refusal of blood transfusions without also recognizing that such rules derive from *her* values.

One potential way to identify how semantic and episodic memory are involved in reasoning is to distinguish the *application* of values from the *justification* of values. For example, it is possible that an Alzheimer's Dementia patient with diminished episodic memory could apply certain values in decision-making despite her disease. Yet, if asked to justify those values, she might be incapable of appealing to episodes of personal history. This tension between episodic and semantic memory, and how they are involved in decision-making capacity, speaks to the importance of identifying the authenticity of patient values [26]. Further empirical work could help determine how declarative memory bears on decision-making capacity.

Executive Functions

Behavioral data also show that executive functions are positively correlated with decision-making capacity. Executive functions include the ability to selectively attend to a stimulus, and the ability to manipulate abstract information during problem solving. In their systematic review, Palmar and Salva observed that, “measures sensitive to executive functions were frequently among the strongest correlates of understanding, appreciation, or reasoning” in non-psychiatric populations [38]. Okonkwo and colleagues made similar observations. They found that:

> “The convergent evidence from our neurocognitive models, across consent standards and study groups, suggest that treatment consent capacity…is primarily subserved by two broad domains of cognitive abilities—memory and executive function” [32].

The executive functions correlated with capacity in these studies are attention, concentration, processing speed, and the ability to perform a task with divided attention. In a similar study including patients with diagnosed brain metastases, Gerstenecker and colleagues [35] applied the Digit Span and Digit Symbol Subsets of the Wechsler Adult Intelligence Scale. Performance on these scales was positively correlated with participants’ understanding of medical information. In a more sophisticated assessment of executive function, Dreer and colleagues [36] applied the Token Test [43] to a group of traumatic brain injury patients with varying levels of impaired capacity. Dreer and colleagues found that, “at baseline assessment, poorer performance on the…Token Test…was related to poorer… performance on appreciation” in consent procedures [36].

Neurocognitive Data

The above-reviewed data are derived from behavioral studies. These data provide an overview of the cognitive functions that are predictive of decision-making capacity. This analysis can be taken further, however, by determining how structural and functional changes in the brain modulate these cognitive functions. In what follows, I review key findings from the cognitive neuropsychology literature. This domain of research is still in its infancy, yet the data already reveal strong associations between structural and functional changes in the brain and decision-making capacity. This literature extends beyond medical decision making to analogous decision-making contexts, such as economic decision making.

In a functional neuroimaging study of schizophrenic patients with impaired capacity, Eyler and colleagues [44] compared scores on the MacArthur Competency Assessment Tool for Clinical Research to brain activation during a verbal learning task. Whole-brain analysis showed significant correlations between understanding and activity in the bilateral parahippocampal gyri and midline culmen of the cerebellum, which extended to the bilateral thalamus. These regions are commonly associated with memory, and confirm the authors’ hypothesis that understanding is supported by cognitive functions related to a patient’s ability to learn and remember. A similar neuroimaging study by Griffith and colleagues [45] evaluated brain metabolic correlates of decision-making capacity in patients with amnestic mild cognitive impairment. Participants’ capacity was compared to proton magnetic spectroscopy scans of the posterior cingulate cortex. Indicators of metabolism for this region—namely, ratios of N-acetylaspartate, Choline, and myo-Inositol with Creatine—were abnormal in patients as compared to healthy controls. Metabolic abnormalities were positively correlated with deficiencies in understanding and reasoning.

Additionally, Hooper and Chiong [46] have argued that structures associated with value attribution might play a crucial role in decision-making capacity. The ventral striatum and the ventral prefrontal cortex have been implicated in several economic tasks, including value attribution to the outcomes of actions [47] and the probability that those outcomes will occur [48]. Changes to these structures from Huntington’s disease or ventromedial prefrontal lesions result in marked abnormalities in decision making [49, 50]. Hooper and Chiong observed, however, that although deficient executive function is clear evidence of impaired capacity, lack of the ability to attribute value to, and judge the probability of, action outcomes is often overlooked. This suggests that frontal brain structures likely play a crucial, yet underappreciated role in applying one’s values in medical decision making. As noted in §1, pathological shifts in values are poorly accounted for in cognitive models of capacity. Examination of frontal brain structures might be a promising avenue for exploring the neurocognitive correlates of these value shifts.

These data are representative of a growing body of research on the neurocognitive correlates of decision-making in financial settings—so called, “financial capacity” (See detailed review in [51]). This work is motivated by a desire to understand and prevent circumstances that lead to exploitation of populations with age-related cognitive changes. Deficient performance on neuropsychological instruments that evaluate one's ability to make financial decisions has been associated with cortical volume of the angular gyrus in amnestic cognitive impairment patients [45], and dorsal medial prefrontal volume in Alzheimer's Dementia patients [52]. Investigators note that these regions are recruited in abstract and future-oriented thinking.

Hypotheses regarding the neurocognitive correlates of financial capacity are also supported by studies examining the functional integrity of the default mode network. The default mode network comprises the medial prefrontal cortex, the lateral frontal cortex, and the medial and lateral aspects of the parietal and temporal cortices. The default mode network is involved in a wide range of functional domains, including memory, future thinking, and social cognition [51, 53]. Age-related changes in the default mode network are associated with the loss of financial management skills, the ability to problem solve, and the ability to plan for one's future [45, 54, 55]. Indeed, some researchers argue that these neuronal changes inhibit one's social skills, including the ability to evaluate social cues of trustworthiness and deception, and the ability to evaluate risky decisions in novel contexts [56–58].

This latter aspect of impaired social cognition has complex implications for medical decision making. High-stakes medical decisions can occur in unfamiliar situations and this might motivate patients to entrust their care and wellbeing to clinical staff. Patients might seek out trustworthy advice. However, traumatic or age-related impairment of the default mode network might undermine aspects of social cognition that allow for recognition of trustworthy relationships. This could render patients susceptible to undue influence, as observed in cases of elder abuse, or resistant to a clinician's recommendations for delusional reasons. In either case, this breakdown in trust can erode the very foundation of the patient-clinician relationship [59].

This body of research provides compelling reasons to consider neurocognitive data in judgments of decision making capacity. However, this work is still in its infancy and it is subject to various methodological challenges. First, in many studies, sample sizes remain small and are often restricted to a particular age range. Restricted age ranges can result from study design, or from the fact that some exclusion criteria can lead incidentally to selecting participants of a particular age. Small sample sizes and restricted age ranges can complicate generalizable inferences about the relationship between neurocognitive changes and capacity.

Second, participants that are unable to provide consent might not be enrolled in some studies. This might prevent researchers from making qualitative comparisons between clinical populations that have decision-making capacity versus those with impaired capacity. For example, Eyler and colleagues [44] noted that, of the schizophrenia patients they interviewed, a proportion ($N = 5$) did not display adequate capacity for consent to research participation. These participants were excluded from the neuroimaging component of their study. Eyler and colleagues suggest that, in future studies, surrogate consent might be required for research participation.

Eyler and colleagues' observation raises a deeper philosophical issue for research programs investigating the neurocognitive correlates of capacity. Psychiatric and neurological patients, in virtue of their medical conditions, constitute ideal research populations for neuroimaging studies of capacity. Yet these conditions also suggest that decision-making capacity might be impaired and that surrogate consent might be required. Whether surrogate consent for research participation is *itself* ethical is a matter of debate (see, for example [60, 61]) and lack of consensus over this issue is reflected in different institutional review board practices [62]. A detailed analysis of this issue is beyond the scope of this article, however, theorists should consider how the ethics of surrogate consent for research participation might influence this domain of research in the future.

Evaluating the neurocognitive correlates of capacity also raises questions regarding a potential bias toward neurocognitive data in capacity determinations. Clinicians might be tempted to make claims about capacity based solely on neurocognitive changes, rather than also verifying whether these changes are borne out in behavior. Such a bias is reflected in a long history of treating certain clinical populations as though they lack decision-making capacity in virtue of their diagnosis. Individuals with Alzheimer's Dementia or psychosis, for example, were commonly believed to lack decision-making capacity on the presumption that the nature of these conditions entails an inability to make rational decisions [63]. But this view is false for at least two reasons. First, this approach fails to recognize the context-dependent nature of decision-making capacity. Some individuals diagnosed with conditions that are predictive of impaired capacity may indeed lack capacity, but others might retain the capacity to make some decisions [64]. Second, determinations of capacity based solely on diagnosis do not consider whether there is also a functional impairment in behavior. Faithful evaluations of capacity must appeal to ongoing changes in behavior as an individual recovers from—or succumbs to—a medical condition.

The forgoing challenges are not insurmountable, but they do highlight significant obstacles that clinicians and researchers might face when appealing to neuroscientific evidence in judgements of capacity. What does seem clear is that, as these research programs mature, there is a need for complementary theoretical analyses regarding how one ought to weigh neurocognitive versus behavioral evidence of capacity. Such work might help define the role of neuroscience in articulating the relationship between cognition and decision-making capacity, and it might assist clinicians as they adjudicate difficult cases in the future.

Clinical Implications

Behavioral and neurocognitive data provide compelling evidence that neuroscience could inform judgements of decision-making capacity. Yet it might remain unclear how neuroscientific methods would actually apply to clinical practice. In what follows, I identify three forward-looking applications of neuroscience to the assessment of decision-making capacity.

A first application, as implied by the case study of Mr. S, is to use neuroscientific data as compensatory information for patients in whom communication or cognitive impairment precludes—at least, full—participation in standard assessment methods (e.g., the MacCAT-T). A suite of behavioral or neurocognitive tests might be selected based on the patient's individual presentation, the findings of which could be incorporated in a clinician's broader judgement of capacity. This is a guarded approach to the use of neuroscience in judgments of capacity. It merely suggests that such evidence might *compensate* for the lack of standard evidence due to a patient's impairment.

By contrast, some have argued that neuroscientific evidence ought to *entirely replace* behavioral evaluation of decision-making capacity. Clarke [65], for example, argues that the adoption of highly accurate neural tests of capacity can assuage the practical and conceptual challenges generated by "status quo" behavioral tests. These challenges include the uncertainty in judgements of capacity in borderline cases and the presumptions regarding the emergence of capacity in children. Although Clarke is right to claim that neuroscience can benefit clinical practice by increasing the precision of capacity judgements, I am less sanguine about abandoning the received framework for determining decision-making capacity altogether. Here's why.

The above-reviewed data demonstrate that neuroscience could play a critical role in informing our understanding of the relationship between cognition and decision-making capacity. Neuroscience provides a granular account of the cognitive functions that mediate decision-making capacity, and it specifies pathological or age-related neurocognitive changes that predict impaired decision-making capacity. Nevertheless, neuroscience is limited in its ability to inform judgements of decision-making capacity. As Dreer and colleagues argue in their study of capacity following brain injury:

> "the present findings illuminate contributions of several neurocognitive domains to decisional capacity in traumatic brain injury. At the same time, judgments of capacity should not be founded solely, or even primarily, on neuropsychological test results. Neuropsychological test data by itself cannot be determinative of capacity questions, which involve issues of individual autonomy. A capacity judgment is ultimately a clinical judgment that draws upon a wide variety of evidence, including the clinician's interview of the patient and others, formal capacity measure results…cognitive test results, and the clinician's experience." [36]

Dreer and colleagues' observation highlights the fact that decision-making capacity is normatively constrained. Neuroscience can identify whether the neurocognitive background conditions for decision-making capacity obtain in a patient. However, determinations of decision-making capacity still require the judgement of a clinician. *This judgment seeks to harmonize the competing ethical principles of autonomy and beneficence in a context-dependent evaluation of capacity.* Although highly accurate neural tests might increase the precision of capacity determinations, their exclusive use threatens to jettison this normative interpretation of capacity. Arguably, normative constraints are essential to the received concept of capacity. Thus, abandoning them would likely require a conceptual revision of decision-making capacity that ignores the very ethical principles that the concept of capacity is designed to uphold.

Now it is plausible that, given future scientific developments, more precise neurocognitive correlates of decision-making capacity will be discovered, and that these correlates might provide grounds for assigning precise probabilities to preserved—or impaired—capacity in patients. This scenario raises a number of difficult epistemological questions: How strong must the correlations be between neurocognitive data and decision-making capacity in order to ascribe capacity to a particular patient? Should only extreme deviances from healthy neurocognitive function be used to determine impaired capacity and, if so, how do we operationalize "extreme"? And what if behavioral and neurocognitive data conflict—should clinicians err toward the brain or err toward behavior in their judgments of capacity?

The above-reviewed research has not yet sufficiently matured to yield conclusive answers to these questions. Nevertheless, as a preliminary response it is instructive to consider how clinicians interpret currently available behavioral data in determinations of capacity, and whether this could serve as a model for interpreting neuroscientific data. The standard approach is to compare patient test results to normative data. Grisso and Appelbaum's [23] seminal handbook for capacity assessment contains normative data tables for healthy and clinical populations according to which clinicians can compare aggregate results from the MacCAT-T. By the same token, researchers might build normative data sets that identify pathological- and age-related changes in cognition according to which neuroscientific tests might be compared. Comparison to normative data itself would not necessarily permit a capacity determination, but it might serve as a *screening* measure to ascertain whether certain patients—and indeed, certain clinical populations—are *at risk* for impaired decision-making capacity. The extent to which a patient's neurocognitive profile can deviate from the norm before one is judged to have impaired capacity might be a function of the stakes of the decision [5]. Greater deviation from the norm might be tolerated for low-stakes decisions, while little to no deviation might be required for high-stakes decisions. Tests that evaluate broad cognitive function, such as the Mini-Mental State Exam, are already understood as screening measures for decision-making capacity [66], and many of the above-reviewed research programs frame their projects in the language of "risk factors" for impaired capacity.

Another way in which neuroscience might inform judgements of capacity is in the validation of new behavioral tests. New behavioral measures are validated currently by comparing their results to that of a reference test, such as the MacCAT-T. Jeste and colleagues [67], for example, developed a new instrument for assessing capacity, the UCSD Brief Assessment of Consent Capacity, by comparing its results to that of the MacCAT for Clinical Research. This is a standard approach to validation, yet it assumes that the MacCAT—or any other reference test—is itself a valid measure of decision-making capacity. Identification of precise neurocognitive correlates of decision-making capacity might allow researchers to triangulate results from a novel behavioral test, a reference test, and neurocognitive data. This can increase the robustness of a new behavioral measure.

A third way in which neuroscience might be applied in judgements of capacity involves the development of novel methods that could enhance decision-making capacity in clinical populations. Elucidating the neurocognitive correlates of capacity could lead to targeted interventions for mitigating a deficiency in one or more of the subcomponents of decision-making capacity. As an analogy, consider the behavioral interventions that are used to circumvent functional impairments that diminish capacity. Augmented and alternative communication methods, such as spelling or picture boards, are commonly used in populations with mild traumatic brain injury. These methods are said to *enhance* capacity. They target impairment in particular cognitive domains, such as memory or verbal concept formation, and allow individuals to participate in medical decisions who would otherwise be determined incapable.

By the same token, clinicians might also intervene on patients' brains to improve one or more of the subcomponents of capacity [65]. A plausible method of intervention is the use of drugs to enhance memory or attentional functions. Indeed, some pharmacological interventions for Alzheimer's Dementia might improve—or forestall the deterioration of—a patient's cognitive function and this could impact the capacity to consent in the early stages of disease progression [68, 69]. Whether enhancement of decision-making capacity is *itself* ethical raises a number of further difficult questions: Is surrogate consent adequate for enhancement of decision-making capacity? Must an individual have capacity in order to consent to interventions that enhance their capacity? And is there a duty to enhance capacity, where possible? These and related questions will likely be on the agenda of theorists for some time to come.

3. Should Neuroscience Inform Judgements of Decision-Making Capacity?

In §2, I argued that there is good reason to believe that neuroscience could inform judgments of decision-making capacity. However, the fact that neuroscience might inform judgements of capacity does not entail that it should inform judgements of decisions-making capacity. In what follows, I provide an argument that suggests neuroscience should inform judgements of capacity. First, I argue that the principle of autonomy directs clinicians to seek out and promote patient liberty interests if a patient has decision-making capacity. Second, I argue that the principle of justice requires clinicians to ensure that all patients have equal access to opportunity, regardless of their situation in life. When applied to assessments of decision-making capacity, this might obligate clinicians to look beyond irrelevant factors, such as a patient's motor impairment, and focus instead on the essential cognitive abilities that support capacity. Neuroscience might assist clinicians in satisfying these duties.

The following argument is intended to apply directly to patients like Mr. S in whom motor or communication impairments prevent capacity assessment with standard instruments. However, this argument also has more wide-ranging implications for the various clinical applications outlined in §2. In general, this argument is intended to highlight the potential obligations of clinicians and researchers to use neuroscience to empower clinical populations that are at the margins of autonomy.

Respecting and Promoting Autonomy

The principle of autonomy obligates clinicians to respect patient liberty interests. Respecting patient liberty interests amounts to a negative duty to not infringe upon a patient's right to choose. Yet merely refraining from infringing upon a patient's right to choose does not guarantee that she will be able to exercise her interests in healthcare. Persons with disabilities might express their interests in ways that deviate from the norm, and lack of sensitivity to these modes of expression might result in violations of autonomy [70]. The principle of autonomy, therefore, implies both negative and positive duties. Clinical staff must refrain from infringing upon patient interests, but they must equally seek out and promote patient liberty interests where possible [9].

The duty to promote patient liberty interests is particularly important in brain injury patients. Following injury, patients like Mr. S might have reemerging autonomy [71]. Reemerging autonomy coincides with the return of rational capacities during recovery; decision-making capacity might fluctuate during this time, and such patients might express their autonomy in ways that differ from the norms of capacity assessment. The principle of autonomy suggests that clinicians have a positive duty to seek out these individuals and, where possible, involve them in the decision-making process.

The use of neuroscientific data in capacity assessments might assist clinicians in meeting this ethical duty. As described in §2, behavioral and neurocognitive data might be brought to bear on capacity determinations when standard methods of assessment are incomplete. Whether these data ultimately show that a patient retains decision-making capacity is irrelevant to the argument advanced here. The ethically salient point is that, in appealing to neuroscientific data, a clinician attempts to seek out and exhaust all possible methods of assessment.

Actively promoting patient liberty interests, rather than merely respecting them, is consistent with the ethical treatment of other populations. Children, for instance, are generally believed to lack the mental maturity needed to participate in most medical decisions. Very young children have not yet achieved key developmental milestones and might lack certain rational capacities associated with autonomy. Some children, however, particularly those on the cusp of legal adulthood, might have the mental maturity to participate in some medical decisions. A positive duty to promote patient liberty interests suggests that these children should have some say in healthcare decisions that affect *their* bodies [72]. To be sure, most brain injury patients differ from children in that they were once autonomous. Children, by contrast, have incomplete autonomy. Nevertheless, promotion of patient liberty interests applies in both cases. Allowing children to have a say in their healthcare with parental oversight promotes their nascent autonomy, just as using neuroscientific data in assessments of capacity could promote reemerging autonomy following brain injury.

Any positive duty to promote patient autonomy must be balanced with a clinician's duty to protect. Patients with reemerging autonomy might be incapable of making some or all medical decisions. Such a conclusion, however, can only be reached by a thorough investigation of decision-making capacity. Using the methods of neuroscience in assessing capacity could ensure that patient liberty interests are respected, or that clinicians have good justification for protecting patient welfare if no evidence of capacity is found.

The principle of autonomy, then, obligates clinicians to respect and promote patient liberty interests when a patient is sufficiently autonomous. Whether a patient is sufficiently autonomous will depend on her decision-making capacity in a particular medical context. As we shall see, considerations of justice might be applicable if patients, due to motor or communication impairment, cannot demonstrate that they have decision-making capacity with standard methods. Clinicians might have a duty to modify standard methods of assessment to ensure that such patients have equitable access to opportunity.

Justice and Access to Opportunity

The principle of justice obligates clinicians to treat patients fairly. Fair treatment extends to a variety of circumstances, including distribution of healthcare resources and respecting patients' rights [73]. A foundational aspect of justice is the Aristotelian assertion that equals ought to be treated equally and unequals unequally. Thus, as Beauchamp and Childress write, "individuals who are unequal in the relevant respects should be treated differently in proportion to their differences" [9].

Patients like Mr. S are unequal in two relevant ways. First, such patients might have profound motor disabilities that impair complex, verbal communication. Second, such patients might also have profound cognitive disabilities, and these might be compounded or masked by communication impairments. These differences put patients like Mr. S at a disadvantage. Communication impairment could preclude one's ability to satisfy standard measures of decision-making capacity and express one's own notion of the good, while cognitive disability might impair one's performance even if verbal communication remains intact. The fact that patients like Mr. S are unequal in these respects suggests that they deserve unequal treatment in proportion to these differences. This unequal treatment is consistent with the ethical imperative that all individuals should have equitable access to opportunity in healthcare, regardless of their situation in life [74].

The duty to ensure equitable access to opportunity is encapsulated by various national and international disability policies. §12132 of The Americans with Disabilities Act states that, "no qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of services, programs, or activities of a public entity, or be subjected to discrimination by any such entity" [75]. Meanwhile, Article 12.1 of the United Nations Convention of the Rights of Persons with Disabilities states that, "persons with disabilities have the right to recognition everywhere as persons before the law" [76]. These policies are sharpened in the context of guardianships for persons with cognitive disabilities. Policy resolutions from the American Bar Association persuasively demonstrate that U.S. Federal and State Constitutions, the Guardianship, Conservatorship and Protective Arrangements Act [77], and arguably the Americans with Disabilities Act [75], are founded on the common principle that, where possible, the *least restrictive alternative* to guardianship should be adopted. This principle requires that:

> "all alternatives that might enable older persons, persons with cognitive limitations, and persons with intellectual disabilities, of whatever origin, to make their own decisions about personal and/or financial matters be considered and exhausted prior to the imposition of the 'last resort' of guardianship." [78]

These policies highlight circumstances in which the principles of autonomy and justice come into conversation. The principle of autonomy holds that clinicians should respect and promote patient liberty interests, while the principle of justice holds that patients should have equitable access to opportunity. When applied to assessments of decision-making capacity, this suggests that clinicians ought to exhaust all possible alternatives to relinquishing a patient of her decision-making authority. Not exhausting all possible alternatives could lead to violations of the principles of justice and autonomy.

The use of neuroscience to inform judgments of capacity in patients like Mr. S might constitute one such alternative. Some behavioral and neurocognitive tests might allow clinicians to circumvent, in part, a patient's impairment that would otherwise render her incapable. Indeed, this line of reasoning is consistent with the views expressed by Grisso and Appelbaum. They argue that, in cases of communication impairment, modifications to the rules of assessment for decision-making capacity might be permissible. They state that:

> "Patients who are on respirators or impaired by strokes may still be able to communicate using hand signals, letter boards, eye blinks, and the like. When evaluators are dealing with such patients, the evaluators usually will need to frame their questions in a 'yes-no' or multiple-choice format" [23].

They argue further that, in cases in which evaluation is incomplete:

> "the usual rules for determining whether a patient has [decision-making capacity] may have to be slightly modified" [23].

Grisso and Appelbaum's observation raises questions about the meaning of "slight modification". What is the scope of slight modification? And should neuroscientific methods fall within or outside this scope? One sense of slight modification could mean identifying other methods of communication that accommodate particular kinds of impairments. As discussed in §2, the use of augmented and alternative communication strategies is common in patients with mild traumatic brain injury. This sense of slightly modified, however, still implies the primacy of communication in eliciting evidence of decision-making capacity. The mode of communication has been modified, but the kind of evidence sought still corresponds to the standard operational model of capacity.

Another sense of slightly modified could mean that different kinds of evidence of decision-making capacity are admissible to compensate for a lack of evidence acquired from standard methods of assessment. If a patient with a communication impairment only can answer yes/no questions, then neuroscientific tests that do not require expressive communication might provide—at least, provisional—evidence that the background conditions of decision-making capacity obtain. Neurocognitive tests might be used as *screening measures* to identify patients at risk of impaired capacity, and behavioral tests might *fill in gaps in evidence* that result from communication impairment. To be sure, some of the behavioral tests reviewed in §2 do require expressive communication (although this is not true in all cases). Yet the kind of expressive communication required is not as complex as that required by the MacCAT-T and similar exams. Clinicians might reconcile these different senses of "slight modification" by appealing to the stakes of a medical decision. Low-stakes medical decisions might broaden the scope of admissible evidence for judgements of decision-making capacity, while high-stakes decisions would narrow it.

We are now in a position in which we can assemble the following argument. First, the principle of autonomy requires that clinicians respect and promote a patient's liberty interests. Second, the principle of justice requires that clinicians ensure that patients have equitable access to opportunity. Third, there is strong reason to believe that neuroscientific tests could provide compensatory evidence of decision-making capacity if standard methods of assessment cannot be applied in a patient, due for example to disability. Hence, consistent with the principles of autonomy and justice, there is strong reason to believe that neuroscience should inform judgements of decision-making capacity. As the science continues to mature, neuroscientific tests might assist clinicians in adjudicating difficult cases in the future. For patients like Mr. S, this could make the difference between participating in some medical decisions and complete loss of autonomy.

Some might have lingering concerns about the cost of neuroscientific tests. Many of the methods described in §2 have high cost-burdens, and it might not be clear what justifies the prioritization of healthcare resources for this purpose, particularly if weighed against alternative uses. A full analysis of this issue is beyond the scope of this article, however, it is worth sketching a preliminary response. It is plausible that using neuroscientific methods to assess capacity might have a prospective benefit for some patients. The use of neuroscientific tests could lead to greater autonomy for persons with disabilities, and this autonomy *itself* could have therapeutic benefits, ethical considerations notwithstanding [79]. Nevertheless, these benefits must be weighed against the competing use of healthcare resources.

Research programs that are developing neuroscientific methods for assessing capacity might improve the cost-effectiveness of these techniques. Short-term investments in these programs might be justified if they yield methods with lower cost-burdens.

Conclusion

In this article, I have presented an argument that suggests neuroscience should inform judgements of decision-making capacity. There is strong reason to believe that neuroscience can identify predictive relationships between cognition and decision-making capacity, and this might be used as compensatory information if standard assessment of capacity is incomplete. More broadly, neuroscientific investigation of decision-making capacity might also eventually shed light on the emergence of capacity during neurodevelopment, changes in capacity during age-related cognitive decline, or neuronal interventions that could enhance decision-making capacity in at-risk populations. The argument advanced here has implications for all such cases.

Throughout this article, I have highlighted several questions in need of further reflection as the neuroscience of decision-making capacity matures: Can we calculate a precise quantitative probability of decision-making capacity based on behavioral or neurocognitive data? Should research participants with impaired capacity be enrolled in studies investigating the neurocognitive correlates of capacity, and is surrogate consent sufficient for this purpose? And how might a neuroscientific approach to assessing decision-making capacity inform the evaluation of individuals who require neurotechnologies to communicate [80, 81]? Further evaluation of these questions will improve our understanding of the links between cognition and decision-making capacity, and the proper role of neuroscience in improving the ethics of informed consent.

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