



Understanding Public Perspectives in Germany Towards Illegal Stimulant Use for Neurocognitive Enhancement in Professional Roles: The Case of Doctors

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Abstract The use of neurocognitive enhancement is controversial. Some social actors and scholars support its application in professions like medicine, while others view it as morally problematic and suggest prohibitive policies. To examine how the public perceives the use of substances for performance enhancement in professional contexts, together with the motivations and consequences of this behavior, we conducted two 2×2×2 between-subjects design scenario-based experiments. The experiments build upon the Agent–Deed–Consequence (ADC) model of moral judgment. A Germany-wide random sample of adults was used in Experiment 1 ($N=1,346$) and Experiment 2 ($N=2,161$). Both experiments involve scenarios in which a surgeon with either egoistic or altruistic motivation (agent–component) decides either to prepare for the surgery or to use the

illegal substance “speed” for performance enhancement (deed–component) before failing or succeeding in surgery (consequence–component). Results show that the illegal substance use condition negatively impacted moral judgment, which statistically accounted for part of the association between the deed and the willingness to undergo surgery. The effect of the Deed on moral judgment and the indirect association of the deed with willingness via moral judgment were moderated by the agent and the consequence components. In summary, this research provides evidence that respondents perceive illegal substances for performance enhancement as morally problematic and that this judgment hinders acceptance of medical services. These results offer support for key assumptions of the ADC model within a healthcare scenario involving illegal enhancement, which could be investigated across a wide range of

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technologies. They also point to implications for professional bodies to maintain public trust.

Keywords Moral judgment · Cognitive enhancement · Neuroenhancement · Agent-Deed-Consequence (ADC) model · Vignette experiment · Substances misuse

Introduction

Various forms of neurotechnology have emerged in recent decades, creating new socio-technological conditions and sparking the development of neuroethics [1]. For example, advanced functional neuroimaging – although still far from achieving its ambitious goal – is being developed with the potential to infer or predict human thoughts and behaviors [2, 3]. A more established neurotechnology, deep brain stimulation (DBS), is now widely used to treat Parkinson's disease and essential tremor [4], and is being tested to treat various neuropsychiatric conditions [5].

One of the most controversial issues surrounding modern neurotechnology concerns its use for performance enhancement [6]. Although the idea of improving various cognitive functions such as memory or concentration may seem unrealistic to some, others express high expectations. Various neurotechnologies are being investigated and marketed for this purpose [7]. While DBS – requiring neurosurgery – is too invasive for enhancement in healthy individuals, developers are already promoting non-invasive brain-stimulation, such as transcranial magnetic stimulation (TMS) and transcranial Direct Current Stimulation (tDCS) directly to consumers as performance-enhancing tools [8]. Even more widespread is the instrumentalization of neuropharmacological technologies for enhancement (including psychostimulants such as amphetamines, which can be also viewed as pharmacological neurotechnologies) [9–11]. Surveys indicate that employees and university students are notably employing prescription and illegal drugs to enhance cognitive performance [12–16, 104]. Reported rates of use vary and remain controversial, prompting concerns among academic institutions, health authorities, and professional groups concerned about the implications of this behavior [17–19].

Medicine represents a professional domain in which the use of neurotechnology – including pharmacological substances – for performance enhancement has drawn particular attention. Numerous studies have reported substance use for enhancement among medical students [20–23]. Physicians themselves face strenuous work demands, long and irregular working hours, and stressful clinical environments, all of which can cause exhaustion and burnout [24–26]. The pressures have been intensified by a global physician shortage [27]. The current work conditions of healthcare professionals may push greater numbers to feel the need to engage in performance-enhancement given the tremendous burden, also exemplified by increasing rates of burnout worldwide [25, 26], with the compounding effect of the COVID-19 pandemic. Several surveys indicate that physicians have used illegal and prescription drugs for neuroenhancement when experiencing more pressure to perform at work [28–30]. Work demands carry over to medical practice, where doctors often need to work with high levels of concentration and executive functioning, and for long and sometimes irregular shifts, thus causing fatigue that may contribute to medical errors [31, 32]. In this context, neuroenhancement drugs can be seen as a time-saving and easy coping strategy [33]. Moreover, students and professionals in medical fields tend to have more positive attitudes toward medication and greater knowledge of pharmacological effects [34, 35]. It is reasonable to assume that this also applies to medical doctors, who may have easier access than other populations, though this social phenomenon is not well understood.

To assess the implications of pharmacological performance enhancement for medical practice, it is crucial to understand the technological and sociological work context of physicians as well as public attitudes toward these practices. Public trust and perceptions of professional integrity are central to the doctor–patient relationship. The use of illegal substances for performance enhancement by clinicians may undermine confidence in physicians and decrease patients' willingness to seek treatment. Despite the importance of this issue, little research has examined how such behaviors are morally evaluated and how moral judgments influence social interactions in medical contexts

[36, 37]. Some commentators suggest that public opinion may become more favorable toward performance enhancement once its potential benefits are understood [33], but these remain speculative claims rooted in pro-technology optimism. As Rose and Curry caution: “whether the public and medical community will accept this brave new world of enhancing the physical and cognitive performance of physicians remains to be seen.” [32, p. 956.]

This paper addresses this gap by investigating how moral judgment mediates the relationship between professional behavior – specifically the illegal use of substances for performance enhancement as compared with ethically acceptable preparation – and patients’ willingness to accept treatment.

The circumstances in which a clinician takes a substance for performance enhancement likely influence people’s moral judgments. For instance, people might be more tolerant of a tired surgeon using a drug to enhance attention for a life-or-death operation than for a low-risk routine procedure. One study, for example, found that in a non-random sample of high school and undergraduate university students about 20%, and 17% respectively, approved of cognitive enhancement in physicians [38]. Additionally, cognitive enhancement was seen as more acceptable if the environment was less competitive and when it was not encouraged by authority figures [39]. Another survey showed that one-fifth of respondents agreed that neuroenhancement might be the way to cope with [40]. These findings suggest that contextual factors, such as the clinician’s motivation for using means of neuroenhancement and the consequences of its use, can influence the moral evaluation of their behavior, either exacerbating or mitigating negative judgments. As such, we investigate this issue further by examining how the consequences of such enhancement use and the perception of the clinician’s motivation moderate moral judgments of a doctor’s actions. To explore these questions, we rely on the Agent–Deed–Consequence (ADC) model of moral judgment [41, 42] as a framework.

The ADC model posits that moral judgment is based on simultaneous evaluations of three different components of a situation: the character of a person (the Agent component, A); their actions (the Deed component, D); and the consequences resulting from a situation (the Consequence

component, C). The three components provide complementary information about moral conduct: persistent character traits and underlying intentions illuminate the background and motivations that lead to an individual’s deed. The nature of the deed, in turn, explains why certain consequences materialized. When subjects consider a moral situation, they merge single evaluations into an overall moral judgment, which will be positive or negative according to the components’ valence. Furthermore, the components are aligned with three distinctive families of ethics theories: virtue ethics focuses on the A component, deontology on the D component, and consequentialism on the C component. Synthesizing these three ethical perspectives on a moral situation, the ADC model can be used to derive hypotheses about the moral factors modulating people’s willingness to be treated by doctors using substances for performance enhancement. The ADC model incorporates insights from several ethical theories and offers a more complex and robust understanding of moral judgment compared to previous models relying solely on the insights of one or two theories [e.g., dual process theory, [43, 44].

Following the ADC model of moral judgment, a clinician’s use of an addictive stimulant for performance enhancement constitutes a deontological violation entailing the commitment of an unethical deed, which we expect will be perceived by subjects as a strongly negative action, causing a significant impact on moral judgment. This expectation is supported by studies among different populations showing that substances used for performance enhancement are oftentimes judged as morally problematic due to issues such as lower effort to perform in competitive settings, inauthentic performance, peer pressure, and concerns about medical safety [45, 46, review by 47–49]. Conversely, when a clinician demonstrates professional integrity by preparing well prior to treatment, this positive action is expected to result in a favorable moral judgment. Therefore, we hypothesize the following (see Table S1 in Supplementary Information and Fig. 1 for a conceptual overview, Panel a-c):

H₁ A negative deed (i.e., taking an illegal substance for performance enhancement compared to a positive deed, i.e., studying the patient’s files

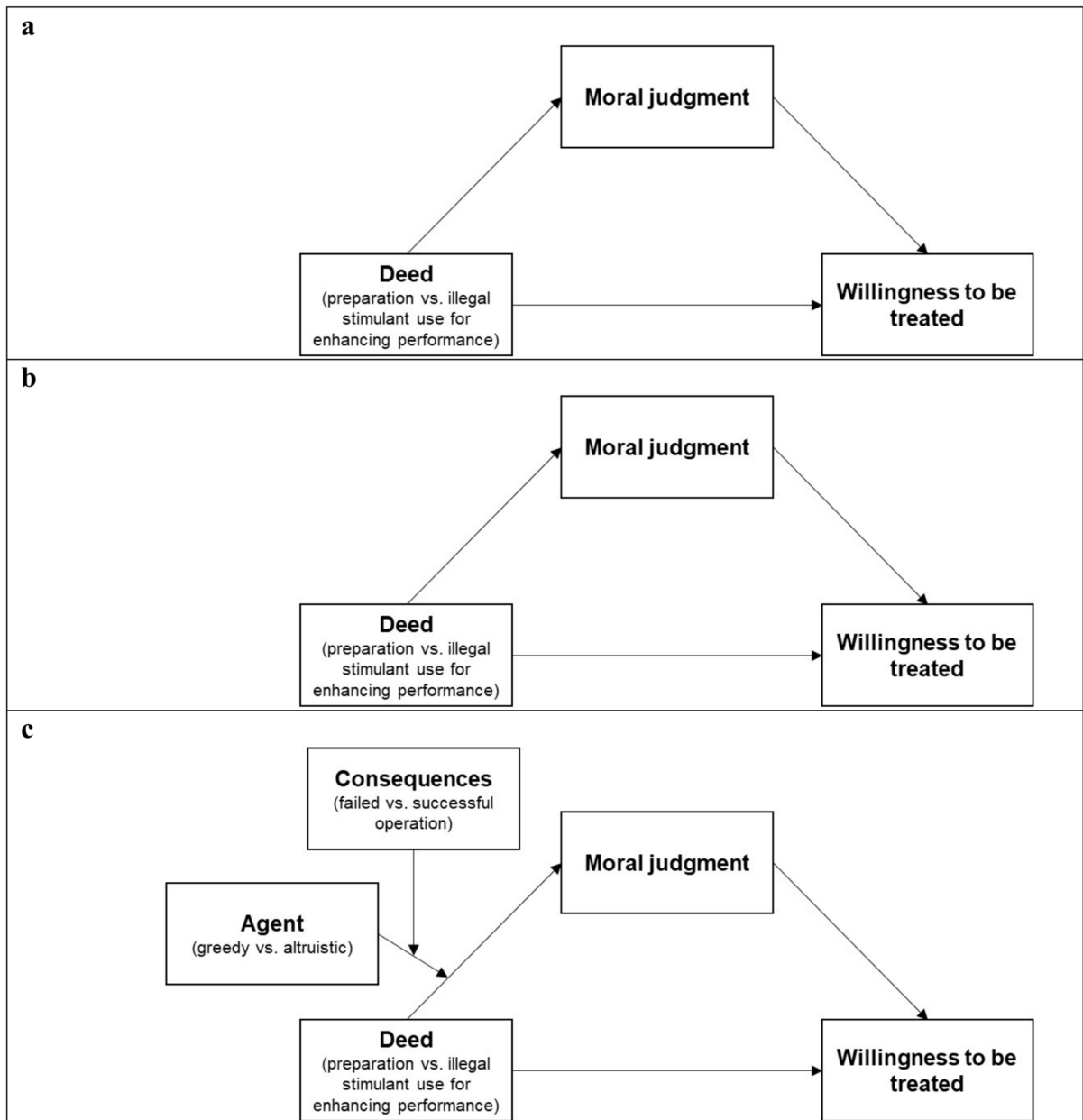


Fig. 1 Conceptual models

and charts before surgery) results in negative moral judgments.

Moral evaluations of a situation are known proximal antecedents of intended or actual behavior [50–53], since actions aligned with moral values can lower psychological costs and increase the

benefits of the action as well as guide decision-making unconsciously [54–57]. In the medical context, we expect that the moral evaluation of a doctor’s professional behavior will impact how the patient relates to that doctor. Specifically, we hypothesize:

H₂ A more positive moral judgment, compared to a negative moral judgment, is positively associated with a higher willingness to be treated (i.e., operated by the surgeon).

Taking H₁ and H₂ together, we assume that the negative deed (i.e., taking an illegal substance for performance enhancement) results in more negative moral judgments, and this decreases the willingness to be treated. By testing this assumption, further consequences of the ADC model are explored [58]. Thus, we hypothesize a negative indirect effect on the willingness:

H₃ Moral judgment serves as a mediator of the effect of the deed on the willingness to be treated.

Previous applications of the ADC model, which need further validation, suggest that congruence between components of the model, such as the deed and the agent's motivation to engage in the deed, reinforce each other's effect [41, 58]. For example, a positively motivated agent (e.g., caring about patients and being altruistic) and positively judged deed (e.g., preparing well prior to treatment) "may signal that a good behavior is not a singularity but part of a stable disposition" [41], suggesting moral integrity [59] and aligning with Kant's reasoning that the highest form of moral deed is that action that stems from good will [60]. The negatively-viewed deed of taking illegal substances should be judged more negatively if the agent has a motivation seen as negative (e.g., being greedy). Conversely, an incongruence between an agent's motivation and the deed may weaken moral evaluations: A negative deed committed with good intentions may be excused, while a good deed performed with bad intentions may be judged less favorably. Thus, the Agent's motivation is assumed to moderate the effect of the deed. Importantly, this moderation reflects differences in moral expectations. When the agent is already perceived as negative, immoral behavior is anticipated; a bad deed merely confirms these expectations, therefore producing a smaller change in moral judgment. By contrast, when the agent is viewed positively, a negative deed contradicts expectations of moral conduct, leading to a larger downward revision in moral evaluation. In

other words, a bad deed (i.e., taking an illegal substance for performance enhancement) committed by a good agent produces a stronger negative shift in judgment than the same deed committed by an agent whose motives are already bad. We therefore hypothesize that:

H₄ The negative indirect effect of a negative deed on willingness to be treated via moral judgment is stronger (more negative) when the agent's motivation is positive (e.g., altruistic help) than when the agent's motivation is negative (e.g., greed).

Similar to the relationship between agency and deed, a positive deed that results in good consequences (e.g., successful operation) and a negative deed combined with negative consequences (e.g., failing operation) signals moral congruence. Thus, the consequences are assumed to moderate the effect of the deed. When bad consequences follow a bad deed, the result is expected and, therefore, produces only a small additional impact on moral judgment. In contrast, when good consequences follow a bad deed, the outcome contradicts expectations and leads observers to assess the deed more stringently, producing a stronger negative shift in moral evaluation. Difficulties in moral judgment might arise if a bad deed results in good consequences [61, 62], as positive outcomes can partially excuse or complicate the assessment of wrongdoing. However, given the relevance of medical professional behavior, such a moral conflict might be smaller if positive deeds result in negative consequences, since well-intentioned professional actions might be evaluated more leniently when adverse outcomes occur despite appropriate conduct. Hence, the magnitude of the deed's effect on moral judgment is expected to be larger when the consequences are positive and violate moral expectations than when they are negative and confirm them. We, therefore, hypothesize that:

H₅ The negative indirect effect of a negative deed on willingness to be treated via moral judgment is stronger (more negative) when the consequence is positive (e.g., successful surgery) than when the consequence is negative (i.e., unsuccessful surgery).

Table 1 Vignettes and experimental manipulations

Study 1: Lower stakes

A surgeon is just about to carry out a routine operation on a foot. The operation is very important for the patient. Just like on other days, the surgeon wants to treat as many patients as possible in order to [**Agent (-): *make as much money as possible*** | **Agent (+): *selflessly do everything he can to help***]. Before the operation, [**Deed (+): *he studies the patient's files and charts*** | **Deed (-): *he takes a small dose of the illegal amphetamine "speed"***]. **He then performs the operation** [**Consequence (-): *making a huge error in treatment*** | **Consequence (+): *with great success***].

Study 2: Higher stakes

A surgeon in a private clinic is about to perform a complicated heart operation. The operation is vitally important for the patient. Just like on other days, the surgeon wants to treat as many patients as possible in order to [**Agent (-): *make as much money as possible*** | **Agent (+): *selflessly do everything he can to help***] make as much money as possible. Before the operation, [**Deed (+): *he studies the patient's files and charts*** | **Deed (-): *he takes a larger dose of the illegal amphetamine "speed"***]. [**Consequence (+): *The operation succeeds in saving the patient's life*** | **Consequence (-): *The patient dies during the operation***].

Text in square brackets indicates the three experimentally varied vignette dimensions with negative and positive valence of Agent, Deed, and Consequence. In the survey, the text was neither bolded nor italicized

While the ADC model suggests that congruence between its three components may reinforce each other's effects, the strength of these relationships likely depends on observers' moral expectations. When all components align in valence (e.g., a good agent performing a good deed that leads to good consequences or a bad agent performing a bad deed with bad consequences), evaluations are consistent with expectations and, therefore, can produce smaller incremental changes in moral judgment. In contrast, incongruence between components violates expectations and prompts stronger evaluative reactions. It can be assumed that a negative deed performed by a positively-perceived agent that nevertheless results in good consequences may trigger more stringent assessment of moral judgment as observers reconcile conflicting moral signals. Accordingly, when both the agent and the consequence are negative, the deed's negative effect on moral judgment should be relatively smaller because the outcome confirms the expectations of poor moral conduct. However, when either the agent or the consequence (or both) is positive, a negative deed contradicts expectations and elicits a stronger negative shift in moral evaluation. But research on three-way interaction effects between Agent, Deed, and Consequences is mixed. A three-way interaction was found in one low-stakes situation but not in another; however, it was not statistically significant in the high-stakes situation [41, 58]. Thus, further research should investigate this. We hypothesize that:

H₆ The negative indirect effect of a negative deed on willingness to be treated via moral judgment is stronger (more negative) when the agent's character is positive and the consequence is positive than when both are negative.

To test the hypotheses, we designed two experiments using textual vignettes describing a surgeon performing an operation. The vignettes vary according to positive or negative stimuli of the motivation of the doctor, their deed, and the consequences of the operation. The first experiment featured lower stakes (the patient's life is not in danger), whereas the second experiment featured higher stakes (the patient's life is in danger). The experiments were conducted in random samples of the adult population in Germany.

Methods

Study 1

Design and Participants

Study 1 used a web-based vignette experiment with 2 (deed: negative vs. positive) by 2 (agent: negative vs. positive) by 2 (consequences: negative vs. positive) between-subjects designs (Table 1). It was implemented in a larger annual panel study (called *ENHANCE*) to achieve greater heterogeneity and more representative samples compared to frequently

used crowdsourcing samples. For this study, a nationwide sample of German-speaking adult residents (age 18 and above) in Germany were recruited via forsa.omninet. This offline-recruited panel is representative of the German population regarding sex, age, education, and federal state with Internet access (applying to 92% of the households in Germany [63]). This panel uses a multi-stage, random process based on the telephone master sample of the Association of German Market and Social Research Institutes (Arbeitskreis Deutscher Markt- und Sozialforschungsinstitute e.V., ADM). Every household in Germany has the same chance to be approached, and the sampling frame captures infrequent Internet users, while self-selection is not possible. The gross sample included 47,406 individuals. Thereof, 27,149 (57.3%) consented to participate, and 24,809 (91.4%) completed the first wave. Participants were financially compensated for their participation (worth 2 euros). The current experiment was randomly assigned to a subsample of 1,353 respondents who are currently employed (e.g., full- or part-time), undergoing training (e.g., professional training or retraining), or in service (e.g., voluntary service in the social sector or the military) – excluding respondents temporarily (e.g., parental leave) or permanently (e.g., retired or out of the workforce) unemployed. Thereof, 1,346 (99.5%) completed the experiment (48.1% females; mean age: 48.47; $SD=12.272$; mixed educational background). This study was approved by the ethics committee of the University of Erfurt (reference number: EV-20190917 on September 17, 2019). We also adhere to the Code of Ethics of the World Medical Association (Declaration of Helsinki) to protect human research participants. Informed consent was obtained from all participants at the beginning of the study (from 11 October 2019 to 24 May 2020) after providing information about the purpose of the study, procedures, confidentiality of data and the right to withdraw.

Materials and Procedure

Respondents were randomly assigned to one short description of a hypothetical situation (so-called vignettes) [64–66]. In the lower-stakes vignette (see Table 1), respondents were asked to carefully read about a situation in which a surgeon is about

to carry out a routine foot operation. In the positive deed condition, the surgeon was described as studying the patient’s files and charts before the surgery. In the negative deed condition, the surgeon was described as using a small dose of the illegal amphetamine “speed” before the surgery, thus engaging in so-called microdosing. Common explanations for such microdosing are to expand awareness, coping, and general neuroenhancement [67].¹ The agent dimension was manipulated by describing him either as being greedy for money (negative) or as altruistically wanting to help others (positive). In the negative consequences condition, the surgery failed, while it succeeded in the positive condition. Due to the factorial design, all factors are uncorrelated with a maximum correlation of $r < 0.0051$ (Table S2).

After reading the scenarios, moral judgment was assessed by asking: “Considering all of the circumstances, how morally acceptable do you find what the surgeon did in this situation?” [for similar measures, see [41, 46, 72]. Then participants indicated their willingness to be treated by the surgeon if needed: “If at some point in your life you had to be subjected to a foot operation, would you be willing to be operated on by this surgeon if you had the choice?”. For both questions, response options ranged from “not at all” [1] to “completely” [10], plus the option “no response”.

¹ In the neuroethics literature, some authors claim that the use of amphetamines for cognitive enhancement is not only acceptable but a matter of social justice (e.g., Flanigan in “Adderall for All” [68]. Others raise concerns about addictive properties of amphetamines and warn about the social pressure to enhance [36]. Bioethics and neuroethics debates are connected to this reality – currently the majority of stimulant use in the United States is some form of amphetamine (as opposed to methylphenidate and modafinil), notably given its use in certain occupations or certain conditions [69–71]. The situation in Germany is somewhat different, and most uses of amphetamine are illegal, so most respondents would not know brand names (such as Adderall). This is partly why we opted for clarity in our stimuli. Additionally, as per the theoretical model, each component needs to be described in clear positive and negative terms. Thus, discharging a duty is a positive deed, whereas seeking a boost with the use of an illegal amphetamine is clearly a negative deed. We thank an anonymous reviewer for prompting us to make this clearer.

Figure S1 provides descriptive information for these measures.

Pretesting

All materials have been evaluated through cognitive pretesting ($N=9$) using the think-aloud technique and probing questions [73] and under naturalistic conditions ($N=72$). The results showed that the materials were generally clear and understandable, and the situations were considered realistic by the majority of respondents in the qualitative interviews. Only minor edits were made to increase understanding: for example, we added “if you had the choice” in the willingness question, because it was mentioned that people may not always be able to choose the surgeon (e.g., in an emergency).

Study 2

Design and Participants

Similar to Study 1, Study 2 employed a web-based vignette experiment with a similar 3²-between-subjects design (Table 1). This experiment was implemented in a later wave of the panel study. Completers of the survey were again financially compensated (worth 2 euros). This experiment was randomly assigned to a subsample of 2,179 respondents (while Study 1 excluded respondents temporarily [e.g., parental leave] or permanently [e.g., retired or out of the workforce] unemployed, they were included in Study 2 along with the groups in Study 1)² of which 2,161 (99.2%) completed the experiment (46.5% females; mean age: 50.48; $SD=15.452$). This study received approval from the ethics committee of the University of Erfurt

² As a robustness check, we re-ran the analyses for Study 2 without the respondents temporarily or permanently not working to align the sampling strategy to Study 1. With about 30% fewer cases, the results remain relatively stable (see Tables S5–S8). One exception is the interaction effect between Deed and Consequences, which still has the same pattern but seems to lose strength and becomes statistically insignificant, thereby rendering respective index of moderated mediation statistically insignificant. This may suggest that different sociodemographic groups may partially differ in their moral judgment. Reasons for these different patterns deserve attention in future research.

(reference number: EV-202110813 on August 13, 2021), and we adhere to the Code of Ethics of the World Medical Association to protect human research participants. Informed consent was obtained from 20 October to 8 December 2021, as in Study 1.

Materials and Procedure

Respondents were randomly assigned to one short description of a higher-stakes situation (see Table 1), describing a surgeon who is about to conduct a complicated heart surgery, which is vitally important for the patient. The experimental conditions were worded almost identically to Study 1, with the difference being that in this higher-stakes situation, the deed was using a larger dose of speed (as compared to small in Study 1) and more drastic consequences in Study 2 (see Table 1). The maximum correlation of the factors is $r<|0.009|$ (Table S2). After reading the scenarios, moral judgment and willingness to be treated by the surgeon if needed were assessed as in Study 1, while the willingness measure referred to a heart surgery (see Fig. S1 for descriptive statistics).

Pretesting

Similar to study 1, cognitive pretesting ($N=11$) using the think-aloud technique and probing questions [73] and a pretest under naturalistic conditions ($N=49$) were conducted and showed that the materials were clear and understandable, and the majority of respondents in the qualitative interview considered the vignette scenario realistic.

Results

Study 1

First, we examined the bivariate effects of the experimental treatments (Agent, Deed, and Consequences) on moral judgment and willingness to be treated. A *t*-test showed a statistically significant more negative moral judgment if the surgeon used a small dose of an illegal stimulant substance prior to the surgery ($M=1.83$, $SD=1.722$, $N=671$) as compared to preparing himself by studying the patient’s files and charts ($M=5.13$, $SD=3.314$, $N=676$, $t=22.899$, $p<0.001$,

Table 2 Mediator variable and dependent variable models for Study 1 ($N=1,346$) and Study 2 ($N=2,161$), PROCESS Model 4

	Study 1: Lower stakes			Study 2: Higher stakes		
	Effect	SE	95%-CI	Effect	SE	95%-CI
<i>Direct effect of deed on moral judgment</i>						
Deed—(Ref. +)	-3.303***	0.144	[-3.586,-3.021]	-3.428***	0.115	[-3.654,-3.202]
Constant	5.132***	0.128	[4.881,5.382]	5.675***	0.096	[5.487,5.963]
$R^2 (F_{HC3})$		0.281 (526.625***)			0.292 (884.436***)	
<i>Direct effect on willingness</i>						
Deed—(Ref. +)	-0.571***	0.126	[-0.818,-0.323]	-0.456***	0.103	[-0.658,-0.253]
Moral judgment	0.749***	0.024	[0.702,0.795]	0.754***	0.018	[0.719,0.790]
Constant	0.835***	0.135	[0.570,1.100]	0.732***	0.113	[0.510,0.954]
$R^2 (F_{HC3})$		0.705 (1291.896***)			0.694 (2160.328**)	
	<i>Effect</i>	<i>SE (Boot)</i>	<i>95%-CI (Boot)</i>	<i>Effect</i>	<i>SE (Boot)</i>	<i>95%-CI (Boot)</i>
<i>Indirect effect of deed on willingness</i>	-2.473	0.146	[-2.757,-2.193]	-2.586	0.115	[-2.816,-2.364]

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; CI=confidence interval; SE=Standard error; indirect effects in bold indicate the 95%-CI does not contain zero

Cohen's $d=1.248$ with a 95%-CI=1.310;1.364, see also Table S3). Also, the willingness to be treated was lower for the negative deed ($M=1.63$, $SD=1.482$, $N=671$) rather than the positive deed ($M=4.68$, $SD=3.290$, $N=676$, $t=21.860$, $p < 0.001$, Cohen's $d=1.189$ with a 95%-CI=1.073;1.305). An altruistic agent motivation ($M=4.20$, $SD=3.360$, $N=676$) resulted in a more positive moral evaluation of the situation compared to a greedy agent ($M=2.77$, $SD=2.665$, $N=671$, $t=8.671$, $p < 0.001$, Cohen's $d=0.473$ with a 95%-CI=0.581;0.364). Willingness to be treated was also higher when the agent's motivation was positive ($M=3.78$, $SD=3.264$, $N=676$) instead of negative ($M=2.53$, $SD=2.496$, $N=671$, $t=7.898$, $p < 0.001$, Cohen's $d=0.431$ with a 95%-CI=0.539;0.322). Similarly, a successful surgery caused a more positive moral judgment ($M=4.36$, $SD=3.390$, $N=673$) than a failing surgery ($M=2.61$, $SD=2.532$, $N=674$, $t=10.703$, $p < 0.001$, Cohen's $d=0.583$ with a 95%-CI=0.692;0.474). Likewise, the willingness to be treated was higher when the consequences were positive ($M=4.10$, $SD=3.339$, $N=673$) compared to negative ($M=2.22$, $SD=2.180$, $N=674$, $t=12.266$, $p < 0.001$, Cohen's $d=0.669$ with a 95%-CI=0.778;0.559). Thus, the deed showed the nominally largest effect on both moral judgment and willingness to be treated.

A mediation analysis with Model 4 of the SPSS macro PROCESS [74] tested whether moral judgment mediates the effect of the deed on willingness to be treated. We used heteroscedasticity consistent standard errors (HC3) [75] and for higher accuracy of the indirect effects, percentile bootstrapping (with $N=10,000$ bootstrap samples) and 95% confidence intervals (CI) were used [74, 76]. This model shows that the deed, illegal stimulant use, leads to a more negative moral judgment ($B=-3.303$, $p < 0.001$, 95%-CI=-3.586;-3.021, supporting H_1 , see Table 2). The postulated mediator, moral judgment, was positively associated with the willingness to be treated, thus higher moral acceptability increased this willingness ($B=0.749$, $p < 0.001$, 95%-CI=0.702;0.795 supporting H_2).

When controlling for moral judgment, the deed had a remaining negative direct effect on willingness ($B=-0.571$, $p < 0.001$, 95%-CI=-0.818;-0.323). Conditional on the assumed mediation structure, the indirect path through moral judgment was statistically significant (*indirect effect*=2.473, 95%-CI_{boot}=2.192;2.764, supporting H_3).

PROCESS Model 9 tested for a first-stage moderated mediation process, namely whether agent motivation and consequences moderated the effects of the deed on the mediator moral judgment. The

mediator variable model with moral judgment as the outcome variable (Table 3) shows statistically significant interactions between deed and agent ($B = -1.885$, $p < 0.001$, $95\%-CI = -2.371; -1.398$, visualized in Panels a and b in Fig. 2) and between deed and consequences ($B = -2.296$, $p < 0.001$, $95\%-CI = -2.782; -1.809$) (see Panels c and d). We found that moral judgment statistically accounted for part of the association between deed and willingness depending on the agent (the confidence interval for the index of moderated mediation did not include zero, $95\%-CI_{boot} = -1.793; -1.031$, against H_4) and on the consequences (the confidence interval for the index of moderated mediation did not include zero, $95\%-CI_{boot} = -2.119; -1.321$, against H_5). An examination of the conditional indirect associations of deed via moral judgment on willingness to be treated indicates negative indirect associations of the deed across all four combinations of agent and consequences, that is, when agent and consequences were both negative (*indirect effect* = -0.910 , $95\%-CI_{boot} = -1.200; -0.634$), when the agent was negative combined with positive consequences (*indirect effect* = 2.629 , $95\%-CI_{boot} = -3.033; -2.262$), when the agent was positive combined with negative consequences (*indirect effect* = 2.321 , $95\%-CI_{boot} = -2.695; -1.951$), and when agent and consequences were both positive (*indirect effect* = 4.040 , $95\%-CI_{boot} = -4.492; -3.593$). A pairwise comparison shows that the strongest conditional indirect association existed when both agent and consequences were both positive rather than negative (*contrast* = -3.130 , $95\%-CI_{boot} = -3.668; -2.578$). No statistically significant difference in the conditional indirect associations existed when the valence of the agent and consequences did not align (*contrast* = 0.308 , $95\%-CI_{boot} = -0.229; 0.882$).

PROCESS Model 11 tested for the existence of a first-stage moderated moderated mediation process. Therefore, the three way-interaction between deed, agent, and consequences on moral judgment was tested. However, this effect was not statistically significant ($B = -0.110$, $p = 0.824$, $95\%-CI = -1.084; 0.864$, see Table S4). Moreover, the confidence interval for the index of moderated moderated mediation included zero ($95\%-CI_{boot} = -0.801; 0.637$), suggesting no such effect, against H_6).

Study 2

Similar to Study 1, the bivariate effects of the experimental treatments showed a statistically significantly more negative moral judgment if the surgeon used a large dose of an illegal substance ($M = 2.25$, $SD = 2.110$, $N = 1,089$) compared to preparing himself prior to the heart surgery ($M = 5.68$, $SD = 3.140$, $N = 1,073$, $t = 29.873$, $p < 0.001$, *Cohen's d* = 1.284 with a $95\%-CI = 1.192; 1.377$, see Table S3). The willingness to be treated was also lower for when the surgeon engaged in the negatively viewed deed ($M = 5.01$, $SD = 3.189$, $N = 1,089$) compared to the positive deed ($M = 1.97$, $SD = 1.900$, $N = 1,073$, $t = 26.965$, $p < 0.001$, *Cohen's d* = 1.16 with a $95\%-CI = 1.068; 1.251$). Being altruistically motivated ($M = 4.73$, $SD = 3.405$, $N = 1,081$) led to more positive moral judgments compared to a greedy agent ($M = 3.17$, $SD = 2.071$, $N = 1,081$, $t = 11.798$, $p < 0.001$, *Cohen's d* = 0.508 with a $95\%-CI = 0.593; 0.422$). The willingness was again higher for a positive ($M = 4.24$, $SD = 3.331$, $N = 1,081$) compared to negative agent motivation ($M = 2.72$, $SD = 2.474$, $N = 1,081$, $t = 11.985$, $p < 0.001$, *Cohen's d* = 0.516 with a $95\%-CI = 0.601; 0.430$). Moral judgments were more positive when the heart surgery succeeded ($M = 4.45$, $SD = 3.264$, $N = 1,086$) instead of failed ($M = 3.44$, $SD = 2.996$, $N = 1,076$, $t = 7.439$, $p < 0.001$, *Cohen's d* = 0.320 with a $95\%-CI = 0.405; 0.235$). The willingness to be treated was also higher for positive ($M = 4.00$, $SD = 3.165$, $N = 1,086$) compared to negative consequences ($M = 2.95$, $SD = 2.790$, $N = 1,076$, $t = 8.180$, $p < 0.001$, *Cohen's d* = 0.352 with a $95\%-CI = 0.437; 0.267$). Again, the deed had the nominally largest effect on both moral judgment and willingness.

Conditional on the same assumed model as in Study 1, PROCESS Model 4 tested the mediating role of moral judgment between the deed and the willingness to be treated. Similar to Study 1, the results show a more negative moral judgment when the deed was negative ($B = -3.428$, $p < 0.001$, $95\%-CI = -3.654; -3.202$, supporting H_1 , see Table 2) and a positive association between moral judgment on willingness to be treated ($B = 0.754$, $p < 0.001$, $95\%-CI = 0.719; 0.790$, supporting H_2). The deed had a remaining negative direct effect on willingness ($B = -0.456$, $p < 0.001$, $95\%-CI = -0.658; -0.253$)

Table 3 Dependent variable models of the conditional mediation models for Study 1 (N = 1,346) and Study 2 (N = 2,161), PROCESS Model 9

	Study 1: Lower stakes			Study 2: Higher stakes		
	Effect	SE	95%-CI	Effect	SE	95%-CI
<i>Dependent variable: Moral judgment</i>						
Deed—(Ref. +)	-1.216 ^{***}	0.190	[-1.588, -0.844]	-2.108 ^{***}	0.169	[-2.439, -1.777]
Agent+ (Ref. -)	2.368 ^{***}	0.211	[1.954, 2.782]	2.633 ^{***}	0.170	[2.301, 2.966]
Consequence+ (Ref. -)	2.904 ^{***}	0.211	[2.490, 3.319]	1.328 ^{***}	0.170	[0.995, 1.661]
Deed*Agent	-1.885 ^{***}	0.248	[-2.371, -1.398]	-2.061 ^{***}	0.211	[-2.474, -1.647]
Deed*Consequence	-2.296 ^{***}	0.248	[-2.782, -1.809]	-0.612 ^{**}	0.211	[-1.026, -0.199]
Constant	2.497 ^{***}	0.168	[2.168, 2.826]	3.706 ^{***}	0.141	[3.430, 3.982]
R ² (F _{HCS})		0.471 (235.823 ^{***})			0.409 (296.185 ^{***})	
<i>Dependent variable: Willingness</i>						
Deed—(Ref. +)	-0.571 ^{***}	0.126	[-0.818, -0.323]	-0.456 ^{***}	0.103	[-0.658, -0.253]
Moral judgment	0.749 ^{***}	0.024	[0.702, 0.795]	0.754 ^{***}	0.018	[0.719, 0.790]
Constant	0.835 ^{***}	0.135	[0.570, 1.100]	0.732 ^{***}	0.113	[0.510, 0.954]
R ² (F _{HCS})		0.705 (1291.896 ^{***})			0.694 (2160.328 ^{***})	
<i>Conditional direct effects of deed on moral judgment</i>						
Agent (-) & Consequence (-)	-1.216 ^{***}	0.190	[-1.588, -0.844]	-2.108 ^{***}	0.169	[-2.439, -1.777]
Agent (-) & Consequence (+)	-3.512 ^{***}	0.225	[-3.954, -3.069]	-2.721 ^{***}	0.186	[-3.085, -2.356]
Agent (+) & Consequence (-)	-3.101 ^{***}	0.221	[-3.534, -2.667]	-4.169 ^{***}	0.186	[-4.534, -3.804]
Agent (+) & Consequence (+)	-5.396 ^{***}	0.221	[-5.829, -4.963]	-4.781 ^{***}	0.188	[-5.151, -4.412]
<i>Conditional indirect effects of deed via moral judgment</i>						
Agent (-) & Consequence (-)	-0.910	0.143	[-1.200, -0.634]	-1.590	0.130	[-1.846, -1.335]
Agent (-) & Consequence (+)	-2.629	0.199	[-3.033, -2.262]	-2.052	0.148	[-2.338, -1.759]
Agent (+) & Consequence (-)	-2.321	0.187	[-2.695, -1.951]	-3.144	0.170	[-3.486, -2.809]
Agent (+) & Consequence (+)	-4.040	0.231	[-4.492, -3.593]	-3.606	0.180	[-3.950, -3.259]

Table 3 (continued)

	Study 1: Lower stakes			Study 2: Higher stakes		
	Contrast	SE (Boot)	95%-CI (Boot)	Contrast	SE (Boot)	95%-CI (Boot)
<i>Pairwise contrasts between conditional indirect effects of deed on moral judgment</i>						
Agent (-) & Consequence (+) vs. Agent (-) & Consequence (-)	-1.719	0.201	[-2.119, -1.321]	-0.462	0.157	[-0.767, -0.149]
Agent (+) & Consequence (-) vs. Agent (-) & Consequence (-)	-1.411	0.195	[-1.793, -1.031]	-1.554	0.171	[-1.892, -1.223]
Agent (+) & Consequence (+) vs. Agent (-) & Consequence (-)	-3.130	0.279	[-3.668, -2.578]	-2.016	0.228	[-2.462, -1.574]
Agent (+) & Consequence (-) vs. Agent (-) & Consequence (+)	0.308	0.282	[-0.229, 0.882]	-1.092	0.236	[-1.553, -0.637]
Agent (+) & Consequence (+) vs. Agent (-) & Consequence (+)	-1.411	0.195	[-1.793, -1.031]	-1.554	0.171	[-1.892, -1.223]
Agent (+) & Consequence (+) vs. Agent (+) & Consequence (-)	-1.719	0.201	[-2.119, -1.321]	-0.462	0.157	[-0.767, -0.149]
<i>Indices of partial moderated mediation</i>						
Agent	-1.411	0.195	[-1.793, -1.031]	-1.554	0.171	[-1.892, -1.223]
Consequences	-1.719	0.201	[-2.119, -1.321]	-0.462	0.157	[-0.767, -0.149]

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. CI = 95% confidence interval; SE = Standard error; Boot = Bootstrap sample size = 10,000; indirect effects and indices in bold indicate the 95%-CI does not contain zero

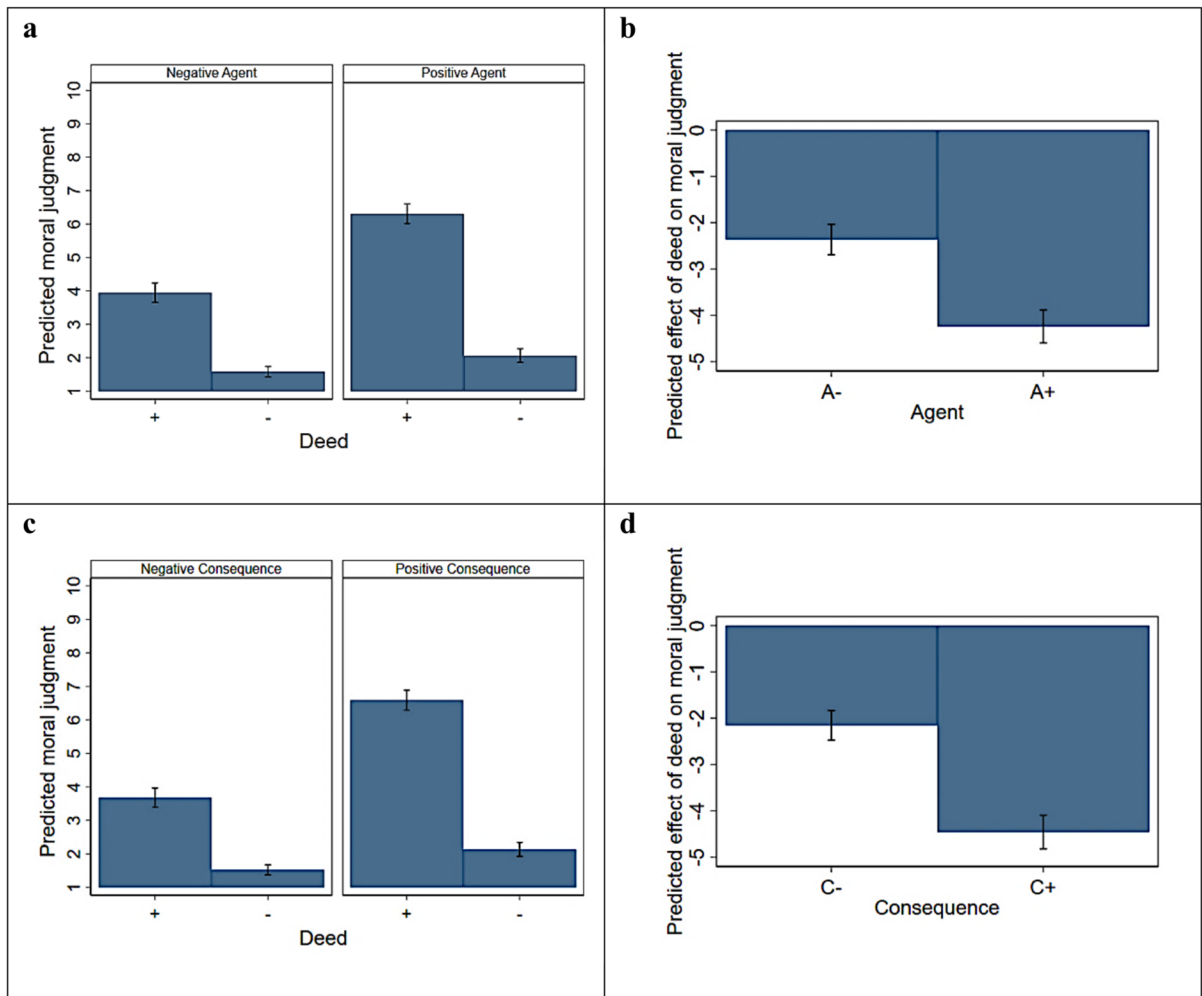


Fig. 2 The effect of deed on moral judgment, conditional on agent (Panels a and b), and consequences (Panels c and d) (Study 2, $N=2,161$). Notes: Based on Table 3, Panel a shows predicted values for moral judgment and Panel b the respec-

tive average marginal effects of deed at the two levels of agent. Panel c shows predicted values for moral judgment and Panel d the respective average marginal effects of deed at the two levels of consequences

when controlling for moral judgment. Thus, moral judgment statistically accounted for part of the shared variance between deed and willingness (*indirect effect* = -2.586 , $95\%-CI_{boot} = -2.816; -2.364$, supporting H_3).

Conditional on the assumed first-stage moderated-mediation model, results of PROCESS Model 9 showed that the interactions between deed and agent ($B = -2.061$, $p < 0.001$, $95\%-CI = -2.474; -1.647$, see Panels a and b in Fig. 2) and between deed and consequences ($B = -0.612$, $p < 0.001$, $95\%-CI = -1.026; -0.199$) (see Panels c and d) on moral judgment were statistically significant (Table 3), while

the latter effect appeared to be weaker. Results suggest a moderated mediation of the deed via moral judgment on willingness depending on the agent’s motivation (the confidence interval for the index of moderated mediation did not include zero, $95\%-CI_{boot} = -1.892; -1.223$, supporting H_4) and on the consequences of the surgery, but to a smaller degree (the confidence interval for the index of moderated mediation did not include zero, $95\%-CI_{boot} = -0.767; -0.149$, supporting H_5). The conditional indirect associations of deed via moral judgment on willingness were all negative for all combinations of agent and consequences: when agent and consequences were both negative (*indirect*

$effect = -1.590$, $95\%-CI_{boot} = -1.846; -1.335$), when the agent was negative combined with positive consequences (*indirect effect* $= -2.052$, $95\%-CI_{boot} = -2.338; -1.759$), when the agent was positive combined with negative consequences (*indirect effect* $= -3.144$, $95\%-CI_{boot} = -3.486; -2.809$), and when agent and consequences were both positive (*indirect effect* $= -3.606$, $95\%-CI_{boot} = -3.950; -3.259$). A pairwise comparison shows that the strongest conditional indirect effect again existed when both agent and consequences were both positive rather than negative (*contrast* $= -2.016$, $95\%-CI_{boot} = -2.462; -1.574$). Differences between conditional indirect associations were smallest when the agent and consequences were both negative compared to a negative agent combined with positive consequences and when the agent and consequences were both positive compared to a positive agent combined with negative consequences (*contrast* $= -0.462$, $95\%-CI_{boot} = -0.767; -0.149$) (Table 1).

PROCESS Model 11 shows that the three interactions between deed, agent, and consequences were not statistically significant ($B = 0.453$, $p = 0.283$, $95\%-CI = -0.374; 1.279$, see Table S4), and the confidence interval for the index of moderated moderated mediation included zero ($95\%-CI_{boot} = -0.274; 0.968$), suggesting no such effect (not supporting H_6).

Discussion

Neurotechnologies, including the use of pharmacological neurotechnology, raise important social and ethical questions due to their impact on human cognitive performance [36, 77]. These questions include the moral acceptability of enhancing cognitive performance in the context of various work-related tasks. The practice of medicine is under intense socio-economic pressure and is more strongly exposed to neuropharmaceuticals due to easier access to pharmaceutical resources in particular; it represents a social context where performance-enhancing neurotechnology could be used and is already being used to some extent. So far, proponents of performance-enhancing neurotechnology have heralded their beneficial outcomes on productivity [78–80] and educational outcomes [68]. However, moral acceptability looms larger than mere consequences and includes

considerations related to the moral acceptability of the deed and the trustworthiness of the agent [42]. Accordingly, this study aimed to understand how the morally controversial deed of a doctor using an illegal substance framed as performance enhancement and contrasted with professional preparation affects moral judgment and the willingness to be treated by such a doctor in the future, as well as whether the effect of the deed is moderated by the doctor's character and the consequences of his action in the situation. Therefore, we developed two scenario experiments: the first one about a lower-stakes situation and the second one about a higher-stakes situation. Both were conducted on a nationwide sample of the adult population in Germany.

We found that the use of an illegal substance (negative deed) was considered more morally blameworthy compared to preparation by studying the patient's files and charts (positive deed, supporting H_1 , see also Table S1 for a summary). Moreover, a higher positive moral judgment was positively associated with an increased willingness to be treated by the doctor if being in a similar situation in the future (supporting H_2). Conditional on the assumed mediation model, moral judgment statistically accounted for part of the association between the deed and willingness (consistent with H_3), and a direct path from the deed to willingness remained significant.

Aligning with the core tenets of the ADC model, positive agent characterization (the altruistic motivation of the doctor) and positive consequences (successful surgery) had a positive effect on moral judgment as well. Conditional on the moderated-mediation model, the negative indirect association between the morally controversial deed and willingness was stronger when the doctor was depicted as altruistic (positive agent) rather than greedy (negative agent) (supporting H_4). This indirect association was also stronger if the consequences were positive (successful operation) instead of negative (failing operation) (supporting H_5). Thus, the results are consistent with moderated-mediation patterns involving both moderating factors. However, there was no support for a three-way interaction between deed, agent, and consequences on moral judgment. Therefore, the interactive effect between agent and consequences did not result in an additional moderation of the moderated

indirect association of the deed on the willingness to be treated via moral judgment (against H_0). These patterns were found in both experiments. However, there was a deviation for the two-way interaction effect between deed and consequences (see details in Footnote 2).

Theoretical and Conceptual Implications

The results of this study shed light on claims and assumptions made within the ongoing debate about the use of neurotechnology for enhancing cognitive performance, specifically in contexts where such use involves the consumption of illegal substances by healthcare professionals. Although performance-enhancing neurotechnology – especially the use of substances – has been widely debated in academic and public spheres [17, 19, 78, 81], its impact on the public's perception of healthcare professionals is still insufficiently explored. Our study contributes to this field by highlighting the negative public moral perception of work-related illegal substance use by healthcare professionals. Specifically, our findings reveal that the majority of participants disapprove of a doctor taking an illegal substance, even if it results in improved performance. This negative moral judgment contributes to patients' reluctance to seek treatment from these physicians, reinforcing the importance of professional conduct in healthcare. Our findings bring nuance to claims that the use of drugs to enhance cognitive performance is equivalent to other means such as education and good life habits [11]. While these authors emphasize the potential benefits of performance-enhancing substances (e.g., prescribed stimulants, modafinil, donepezil), for improving performance, our results suggest that public opinion may not be supportive of this perspective, at least not in Germany and for amphetamines.

This study also makes a significant contribution to understanding the interpersonal consequences of neuroenhancement. To date, much of the existing research focuses on personal use and moral evaluations of neurotechnology for performance enhancement, examining how these judgments influence individuals' own decisions to use such technology [45, 46, see also review by 47]. However, relatively little attention has been given to how this use of neurotechnology by others is morally judged and how

these judgments shape social interactions [36, 37]. This social dimension is particularly crucial in professions like medicine, where adherence to codes of conduct and ethical guidelines is essential to nurture and maintain trust and public confidence. Our study makes headway in this direction by showing that negative evaluations of substances used for performance enhancement can weaken the professional relationship between doctors and patients. This shift from a focus on personal to interpersonal moral judgment provides valuable insights into the broader implications of neuroenhancement in professional settings. Moreover, our results suggest that performance-centered ethical analyses [e.g., 11] may underestimate the social consequences of neuroenhancement, overlooking the complex interpersonal dynamics that are critical in fields like healthcare. Thus, the results imply the need to understand in great depth the sociological context of neuroenhancement before making strong arguments for or against their use as seen in some influential contributions [11, 68, 82]. Nevertheless, because the enhancement manipulation was intertwined with illegality and contrasted with diligent preparation, the present findings should be interpreted as reflecting moral responses to illegal enhancement in a professional medical context rather than to enhancement per se (see Limitations section).

Besides enriching the ethics of neuroenhancement, this study provides context-specific evidence consistent with the ADC model of moral judgment, which had been tested across various domains [41, 58], but never concerning the use of neurotechnology in healthcare. Our results highlight that in the medical domain, similar to other contexts, moral judgment appears to involve three fundamental components: the motivation of the doctor (i.e., the agent component), the use or refusal to use substances for performance enhancement as compared to behavior aligning with ethical standards (i.e., the deed component), and the outcome of the medical operation (i.e., the consequences component). Likely because of the negative evaluation of illegal substances used for performance enhancement and the importance of professional conduct in a codified domain like healthcare, the deed component exerted the largest effect in both the proposed scenarios. Nevertheless, both the doctor's motivation and the outcome of the operation play a moderating role, suggesting that the

same deed is judged differently depending on the characteristics of the situation.

Our experiments revealed a negative interaction effect between the deed and the agent component. That is, the use of an illegal substance for performance enhancement prior to surgery exerted a more pronounced negative effect on moral judgment when the surgeon was described as altruistically rather than egoistically motivated, which influenced the willingness to undergo surgery to a stronger degree. This finding supports the interpretation that moral evaluations depend on observers' expectations about the agent's moral character. When the surgeon is portrayed as altruistic, a norm-violating deed seems to contradict expectations of professional integrity and elicits sharper downward revision in moral judgment. In contrast, when the surgeon is described as egoistically motivated, immoral behavior is largely expected, therefore producing a smaller additional decrease in moral judgment. Consistent with previous applications of the ADC model [41, 58], congruence between positive components – such as an altruistic agent performing a professional good deed – was associated with especially favorable moral judgments. Such combinations may signal moral integrity and a stable virtuous disposition [41, 59, 60]. Conversely, when a positively-viewed deed was coupled with an egoistic and, therefore, negatively-viewed motivation, the deed could be perceived as less authentic and judged less positively. These findings also align with Anderson et al.'s [83] review showing asymmetries in moral praise and blame: Positive moral evaluations tend to be holistic and based on perceived character consistency (congruent positive agent and deed, in our framework), whereas negative moral evaluations are more situation-specific and sensitive to norm violations or bad intentions. Accordingly, our results demonstrate that a single immoral act can strongly tarnish the moral image of an otherwise virtuous agent, highlighting the role of expectation violation in moral judgment, which can influence further decision-making (in our context, undergoing surgery).

We found a negative interaction effect between the deed and the consequences component. It suggests that using illegal substances for performance enhancement exerted a stronger negative effect on moral judgment when the surgery ended with positive consequences, thereby shaping the willingness

to undergo surgery in such a situation to a stronger degree. This pattern supports the idea that when an unethical deed has a favorable consequence, observers feel a dissonance between the deed and the consequence. This inconsistency may intensify their moral disapproval of the deed. In contrast, when negative consequences follow a bad deed, the outcome confirms observers' expectations of wrongdoing and leaves less room for additional moral deterioration. The moderating role appeared more pronounced in the lower-stakes situation, possibly because observers had greater cognitive and emotional capacity to evaluate the moral inconsistency between deed and outcome. In the higher-stakes (life-or-death) context, the salience of saving a life may have overridden this expectation-violation effect, somewhat attenuating the deed's influence. However, this latter finding needs to be interpreted with caution as it seems to depend on who is asked (see footnote 2). Consistent with previous ADC research, congruent combinations of positive deeds and good consequences were associated with higher moral judgments, whereas negative deeds followed by harmful consequences produced particularly low moral evaluations. Together, these findings partially support the proposed expectation-violation mechanism and extend prior mixed evidence on deed–consequence interactions by showing that the strength and direction of the moderation depend on contextual factors, such as situational stakes and sociodemographic group [41, 58].

Taken together, these results suggest that the components of moral judgment – agents, deeds, and consequences – should not be considered in a simple additive way, as hypothesized in the early work on the ADC model [42]. By contrast, moral judgment can be shaped by some interactions between the components (i.e., $A \times D$ and $C \times D$). This holistic understanding of morality challenges a prominent body of research that frames moral reasoning as a conflict between action- and outcome-oriented cognitions [43, 84].

However, we did not find a statistically significant three-way interaction ($A \times D \times C$), even in relatively large samples. To our knowledge, only one previous study has reported such an interaction among all ADC components, while others did not [41, 58], suggesting that such effects may be rare or highly context-dependent. Thus, our

results contribute to the debate by showing that moral judgments are primarily driven by pairwise congruence or conflict rather than full three-component alignment. Alternatively, the absence of a three-way interaction could reflect contextual factors specific to the medical domain – such as strong professional norms, the salience of ethical codes, or ceiling effects in moral condemnation of illegal substance use – that limit the variance needed to detect higher-order effects. We, therefore, interpret the non-significant three-way interaction not as evidence against the ADC framework but as an indicator of boundary conditions for when full congruence or incongruence across all three components meaningfully affect moral evaluation. Future research should systematically vary contextual strength and the moral ambiguity of the deed to clarify under which conditions three-way interactions emerge.

Finally, we found a similar pattern in Studies 1 and 2 despite the different stakes of the scenarios and the different doses used. Participants' negative judgments of the act (illegal drug use) were relatively similar, regardless of whether the patient's life was in danger (Study 2) or if the doctor was performing a routine operation (Study 1). This result suggests that public views of doctors in Germany may place greater weight on norm adherence, even in life-or-death scenarios. But this interpretation should be made cautiously given the specific framing of illegal substance use in the vignette.

Practical and Policy Implications

The findings of this study have practical implications regarding patient–doctor relationships and how to tackle illegal substance use framed as performance enhancement in healthcare professionals at the regulatory and policy levels. Public attitudes towards clinicians depend on the professionalism of their behavior, which plays a crucial role in shaping the therapeutic alliance between patients and doctors. To foster trust, it is essential that medical professionals not only demonstrate competence and productivity but also exemplify professional integrity and adhere to ethical standards, avoiding performance-boosting shortcuts such as illegal substance use. A loss of reputation in these foundational areas could severely

undermine public trust, especially at a time when confidence in health authorities is lower than ever [85]. Moreover, our findings indicate that professional behavior is most effective in strengthening the therapeutic alliance when coupled with genuine moral motivation. Clinicians should therefore go beyond mere compliance with professional codes, and instead embrace them as means for patient-centered care [86]. By doing so, healthcare professionals can reinforce trust and maintain the integrity that underpins effective medical practice.

Patient–doctor relationships can be enhanced not only through individual ethical behavior but also by addressing regulatory and policy dimensions. The code of the World Medical Association (WMA) states that “In order to provide care of the highest standards, physicians must attend to their own health, well-being, and abilities.” [Principle 28, 87]. The use of illegal substances for performance enhancement could undermine this principle by introducing risks related to drug misuse or dependency, impairing cognitive function, or raising concerns about professional behavior. Similarly, The Code of Medical Ethics of the American Medical Association (AMA) emphasizes the importance of physicians maintaining their health and well-being to ensure patient safety and quality of care. [88] (Opinion 9.3.1). Beyond these already established general principles, professional bodies should consider clarifying guidelines and ensuring appropriate oversight, as also argued by other scholars [21, 28]. Given that the present study focused on illegal amphetamine use, implications for legally prescribed or emerging enhancement technologies should be drawn cautiously and require further empirical investigation.

In addition to regulatory restrictions, educational efforts aimed at strengthening professional conduct and ethical standards may also be necessary to prevent the erosion of patient confidence associated with the use of illegal substances for performance enhancement in clinical contexts [89]. Moreover, addressing social aspects of the work conditions of physicians (e.g., work hour requirements, more staff) may contribute to a reduction in stress and an inclination to resort to stimulants for performance enhancement as well as treatment errors [32] which could be the root causes of such drug use. These

measures, together, could limit the exposure of the medical profession to avoidable reputational harm.

Limitations and Directions for Future Research

One limitation of this study is the use of a willingness measure (in this study, the willingness to be treated by a doctor) – which does not necessarily correspond to actual behavior [90–92]. However, research has shown that such measures are strong predictors of behavior [93, 94]. Moreover, treatment effects observed in factorial survey designs were similar to the effects using other study designs [92, 95], supporting the validity of this approach.

While we found that moral judgment statistically accounted for part of the association between a physician's illegal substance use and the willingness to accept treatment, a significant direct association of this deed remained. Two plausible hypotheses, not investigated in the present study, may explain this effect. The first factor concerns trust in professional clinicians, which is essential for building a strong therapeutic alliance. Illegal substance use for performance enhancement may negatively affect the cognitive and affective components of trust, leading to reluctance to pursue treatment. However, an alternative hypothesis could be that illegal substance use for neuroenhancement and unwillingness to be treated are mediated by the patient's attribution of diminished competence to the doctor. Observing a clinician relying on neuroenhancement might lead patients to perceive the physician as less capable, reducing their willingness to be treated by the doctor's skills. This hypothesis aligns with recent research examining how such substance use in professional contexts influences competence attributions [37, 49]. As this study did not measure trust or competence attributions, future research should investigate these factors to provide a more comprehensive understanding of how neuroenhancement impacts the therapeutic alliance.

There is an indication that some observed pattern could be group-specific: namely, an interaction effect between deed and consequences was only found when all sampled respondents were considered, but not in the robustness analyses when the sample of Study 2 did not consist of respondents temporarily or permanently not

working (as in Study 1). While all other patterns remained relatively identical in these additional analyses, future research may need to clarify and understand whether and which sociodemographic groups may differ in the appraisal of morally relevant features and their interplay.

A notable limitation of this study is that we only investigated one illegal substance used for performance enhancement (i.e., amphetamines). The explicit illegality of amphetamine use may have strongly shaped participants' moral evaluations, potentially amplifying negative judgments more than uninvestigated legal stimulants, such as coffee. Participants may therefore have reacted not only to enhancement per se, but also to criminality, norm violation, or inferred negligence. Accordingly, the findings do not allow us to disentangle moral reactions to enhancement from reactions to illegality or perceived professional misconduct. However, the difference between illegal amphetamine use and the non-medical or off-label use of prescription stimulants may be smaller, as both behaviors can be perceived as deviant or quasi-illegal (see related discussion, above, on the overlap between enhancement and illicit drug use). For the sake of the neuroenhancement debate, it would be relevant to examine substances that fall into a gray area – legally available pharmaceuticals that are unprescribed but used for enhancement (such as methylphenidate or modafinil) [46, 96–99] – as well as novel forms of non-substance methods (e.g., brain stimulation or brain–computer interfaces) which may be viewed differently [100–103].

Moreover, as a baseline condition, future studies could also test a “no information” (or neutral) condition as a benchmark for the effect of different deeds; it could be also interesting to examine how a rejection of neuroenhancement rather than explicit use would be judged. In addition, future research should orthogonally manipulate enhancement (vs. no enhancement), legality (legal vs. illegal substance use), and professional diligence (standard preparation vs. negligence), while holding competence cues constant. Including a manipulation check would further clarify whether participants interpret substance use as performance-enhancing or as impairing. Such designs would allow a cleaner test of the ADC model and reduce interpretive confounds present in the current study.

Conclusion

This study offers important insights into how the illegal use of substances for performance enhancement by healthcare professionals influences the general public's moral judgments and their willingness to seek treatment. While previous research has primarily focused on personal use of such – mainly pharmacological – neurotechnology or its effects on workplace collaboration, the present findings extend this work by examining the healthcare context and demonstrating that moral judgment plays a critical, model-consistent mediating role. The public evaluates a doctor based on the doctor's motivation (altruistic or egoistic), adherence to ethical standards, and the outcomes of their actions in a nuanced, complex, and non-additive way. These contribute to further development of the ADC model of moral judgment, demonstrating its usefulness as a conceptual framework to understand moral dynamics in healthcare ethics. However, because the enhancement manipulation was intertwined with illegality and potential norm violations, the results should be interpreted as reflecting moral responses to illegal enhancement in a professional context rather than to enhancement per se. The practical implications of this study concern public trust in medical professionals, which can be undermined by illegal substance use framed as performance enhancement. This study also highlights the relevance of regulation, education, and ethical accountability to maintain the integrity of the profession and ensure patient safety.

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Data Availability The data that support the findings of this study are openly available in "PUB-Publikationen an der Universität Bielefeld" [105].

Declarations

Competing interests The authors declare no competing interests.

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