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Observing physicians acting with different levels of empathy modulates later assessed pain tolerance

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Objectives. The patient–physician relationship is essential for treatment success. Previous studies demonstrated that physicians who behave empathic in their interaction with patients have a positive effect on health outcomes. In this study, we investigated if the mere perception of physicians as empathic/not empathic modulates pain despite an emotionally neutral interaction with the patients.

Methods. *N* = 60 women took part in an experimental study that simulated a clinical interaction. In the paradigm, each participant watched two immersive 360° videos via a head-mounted display from a patient's perspective. The physicians in the videos behaved either empathic or not empathic towards a third person. Importantly, these physicians remained emotionally neutral in the subsequent virtual interaction with the participants. Finally, participants received a controlled, painful pressure stimulus within the narratives of the videos.

Results. The physicians in the high compared with the low empathy videos were rated as more empathic and more likable, indicating successful experimental manipulation. In spite of later neutral behaviour of physicians, this short observation of physicians' behaviour towards a third person was sufficient to modulate pain tolerance of the participants.

Conclusions. The finding of this study that the mere observation of physicians' behaviour towards a third person modulates pain, despite a neutral direct interaction with the participants, has important clinical implications. Further, the proposed paradigm enables investigating aspects of patient–physician communication that are difficult to examine in a clinical setting.

Statement of contribution

What is already known about this subject?

- The patient–physician relationship affects treatment success
- Empathic physicians can have a positive effect on health outcomes

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- Social support affects experimental pain

What does this study add?

- A short observation of physicians that behave empathic or not is sufficient to modulate experimental pain
- This effect was found despite an emotionally neutral interaction with the study participants
- The proposed experimental paradigm allows to investigate the patient–physician relationship in a standardized, yet ecologically valid way

Background

The quality of the patient–physician relationship has long been considered an essential factor for therapeutic outcome (Hippocrates, edited by Houston, 1938; Jones, 1868). A first systematic literature review found empirical support that physicians who were warm and friendly or reassuring had significantly larger effects on health outcomes than more formal control conditions (Blasi, Harkness, Ernst, Georgiou, & Kleijnen, 2001). More recent studies demonstrated a positive association between clinicians' empathy and patient satisfaction (Kim, Kaplowitz, & Johnston, 2004; Menendez, Chen, Mudgal, Jupiter, & Ring, 2015; Pollak et al., 2011). In a study by Menendez et al. (2015), the patients' rated physician empathy accounted for 65% of the variance of patients' satisfaction. More importantly, several studies demonstrated positive effects of an empathic communication style on health outcomes (Chassany et al., 2006; Olson, 1995; Rakel et al., 2009; Vangronsveld & Linton, 2012, for a meta-analysis see Howick et al., 2018). For instance, osteoarthritis patients of physicians who underwent a training program on relationships, communication, pain evaluation, prescription, and negotiation of a patient contract aimed at improving patient–physician relationships and communication skills reported lower pain ratings compared with the control group (Chassany et al., 2006). Reduced negative affect and pain were demonstrated in a group of patients with back pain following a validating (empathic, understanding) interview compared with the invalidating condition (Vangronsveld & Linton, 2012). Further, Rakel et al. (2009) found reduced duration of the common cold for patients who rated physicians' empathy as optimal with a standardized questionnaire.

These findings point to the importance of physician empathy to enhance treatment effectiveness. In the context of this study, empathy refers to empathic concern/compassion, which describes an other oriented motivation to improve the other's well-being (Decety, 2020). This motivational aspect of empathy, which is characterized by feelings of warmth, concern, and care for a person in need, is of particular importance in the context of medicine (Decety, 2020). Apart from this prosocial concern, empathy encompasses two other major facets, described as affective/emotional and cognitive empathy (Zaki and Ochsner, 2012). The former refers to the sharing of another's internal state (experience sharing), the latter to intentionally adopting the other's perspective to consider and potentially understand the target's internal state, sometimes referred to as 'theory of mind' (Zaki and Ochsner, 2012).

Within this study, we wanted to investigate whether the mere perception of a physician as empathic/not empathic modulates later pain responses and reports, despite a neutral direct interaction. Standardizing the behaviour of physicians in a clinical setting is not possible and addressing this specific question in a clinical setting is ethically problematic. Prior experimental studies have investigated social modulation of pain (for reviews see Che, Cash, Chung, Fitzgerald, & Fitzgibbon, 2018; Krahé, Springer, Weinman,

& Fotopoulou, 2013). However, these studies addressed different questions, for example, if holding the hand of a romantic partner can alleviate pain (Coan, Schaefer, & Davidson, 2016; Goldstein, Shamay-Tsoory, Yellinek, & Weissman-Fogel, 2016) or if active and passive support in general influence pain (Brown, Sheffield, Leary, & Robinson, 2003). Experimental studies that specifically investigate the patient–physician interaction and its influence on pain are scarce. A more recent laboratory study investigated if overhearing either empathic or unempathic experimenters influenced the pain of study participants (Fauchon et al., 2017). For this, tape recordings of pre-recorded conversations were played while participants received a painful stimulus. Pain ratings were reduced when participants listened to empathic compared with neutral or unempathic comments (Fauchon et al., 2017, 2019).

For the present study, we implemented a new experimental paradigm that more closely resembles a clinical encounter. To standardize the behaviour of the physicians and allow for an immersive experience from the patient's perspective, we created scenarios using immersive 360° videos. Participants were immersed in a virtual scenario set in a doctor's office, which was displayed via a head-mounted display (HMD).

We investigated whether the perception of physicians in an immersive virtual environment as empathic or not is sufficient to modulate pain. First, participants observed physicians that acted either empathic or not empathic during verbal interaction with a third person. Later, these physicians behaved neutral in a direct communication with the study participants. Towards the end of the videos, the participants received a controlled, painful pressure stimulus embedded within the videos' narratives. The primary outcome measures of the study were pain tolerance (in seconds) and skin conductance responses (SCR). Based on the results of the experimental study (Fauchon et al., 2017, 2019) and based on findings from the clinical context (Vangronsveld & Linton, 2012, Chassany et al., 2006, for a meta-analysis see Howick et al., 2018) described above, we expected pain tolerance to be higher and SCR to be lower after seeing a high compared with a low empathy physician despite a later neutral direct interaction. We also assessed pain ratings (sensory and affective), which we expected to be smaller in the high empathy than in the low empathy condition.

Methods

Participants

The a priori calculated sample size was 60, which was calculated based on a small to medium effect size of $d = 0.4$ with a power of .9 for a one-tailed test ($\alpha = .05$) and to allow a counterbalanced order of task conditions. The final sample included in the data analysis consisted of 60 women with a mean age of 22.7 $\pm$ 3.0 years (range 18–32). In total, 65 women were recruited via an online database of local study participants, but five were excluded from data analysis (four due to technical problems during data acquisition, one did not meet inclusion criteria). The experiment was conducted by two female experimenters and the sample consisted of women to control for effects caused by the gender of the experimenters, as previous research has shown that men tend to report less pain in front of female experimenters, and pain tolerance was longer when participants were tested by an experimenter of the opposite sex (Aslaksen, Myrbakk, Høifødt, & Flaten, 2007; Chapman, Benedict, & Schiöth, 2018; Kállai, Barke, & Voss, 2004; Levine & Lee De Simone, 1991). All participants took part in a single session and were compensated for their participation with either 8 € or course credit. Inclusion criteria were checked via self-reports of the participants: No participant reported any neurological or psychiatric illness nor acute or chronic pain. None consumed alcohol or took pain medication 12 hr prior to the experiment. All participants signed informed consent before participation in accordance with the Declaration of Helsinki. The Ethical Review Board of the Institute of Psychology, University of Würzburg approved the study protocol.

Algesimetry

Painful pressure stimuli were applied with an electronically driven device based on the apparatus described by Ellermeier & Westphal (1995) and consists of a lever that can lower a rubber-tipped stylus (diameter of 3 mm) to exert a constant pressure yielding constantly rising pain ratings (Ellermeier & Westphal, 1995; Göbel & Westphal, 1987). The weight of the lever can be continuously adjusted between 0 and 970 g and the device has previously been used in several studies to apply painful and non-painful stimuli to the fingers of participants (Arnold et al., 2008; Gerdes, Wieser, Alpers, Strack, & Pauli, 2012; Höfle, Kenntner-Mabiala, Pauli, & Alpers, 2008; Kenntner-Mabiala, Weyers, & Pauli, 2007; Wieser, Gerdes, Greiner, Reicherts, & Pauli, 2012). In our study, the fixed weight was 800 g resulting in a pressure of 1,110 kPa. In previous studies with women, this weight yielded moderate to high pain ratings for a stimulation period of 20 s (Ellermeier & Westphal, 1995; Höfle et al., 2008). During the main study, the pressure was applied to the middle phalanx of the ring, middle or index finger of the non-dominant hand of the participants, and the lever was controlled by the software Presentation® (Version 20, Neurobehavioural Systems Inc.). During each experimental condition, a different finger was stimulated and the order was counterbalanced across participants. During a test trial to accustom participants with the device, a button press of the experimenter controlled the lever, and the pressure was applied to the middle phalanx of the middle finger of the dominant hand. In all conditions, we measured pain tolerance as the time (in seconds) from the onset of the stimulus until participants indicated that they could no longer tolerate the pain (stimulation was stopped at this time point). The maximum stimulation duration was set to 60 s. If participants reached maximum stimulation time, their time was recorded as 60 s. This was the case for $n = 14$ participants, of these, $n = 5$ reached maximum stimulus time in the high empathy condition, $n = 1$ in the low empathy condition and $n = 8$ in both.

Electrodermal activity

Skin conductance was measured with two Ag/AgCl electrodes of 1 cm diameter (filled with 0.5% NaCl paste) attached to the dominant hand (thenar and hypothenar) and a constant voltage of 0.5 V. Data were recorded with a V-Amp amplifier (Brain Products GmbH) and the recording software Brain Vision Recorder at a sampling rate of 1,000 Hz.

We calculated the amplitudes of SCR with an onset between 1 and 3 s after stimulation as the change in the electrical conductivity of the skin (in microsiemens). SCRs below 0.02 μS were coded as null responses. The amplitudes were log-transformed for normalization.

Video material and presentation

For this study, 360° Videos were recorded with a Samsung Gear 360 Camera (Samsung Electronics Co., Ltd.) with a resolution of 2,560 × 1,280 pixels and a frame rate of 60 Hz.

The videos were presented via an head-mounted display (HTC Vive) that allows for an immersive video experience, as the 360° scenes can be explored by natural head-movements.

For the videos, we had two actors (a man and a woman) each follow a script to embody the role of two physicians. The physicians differed in their empathic behaviour towards a third person, hence a total of four videos were produced (male doctor and female doctor: both empathic/not empathic). The setting for the videos was a doctor's office and the camera was positioned where a patient would sit, such that the participants could later observe the scene from a patient's (first person) perspective (Figure 1). The course of action of the four videos was as follows: The physician entered the room, greeted the 'patient', uttered that he needed a moment, sat at his desk and talked on the phone. This interaction on the phone with a fictitious doctor's assistant and the tone of voice of the physicians differed between the conditions. In the high empathy videos, the physicians express empathic concern for a patient by asking the assistant to regularly check on a particular patient (that they refer to by her name) to make sure that she would not develop bedsores and to ensure that the patient asks for help if she is in pain. In the following exchange with the assistant, they also express concern for the welfare of the assistant by asking whether she was able to cope with the work-related stress. They state all this with a warm, calm and understanding tone of voice. In the low empathy videos, the physicians direct the assistant to turn down the TV of a patient (that they refer to as old woman from room 107) who has turned up the volume of her TV so that the physician is annoyed by it. They accuse the assistant of drinking coffee instead of working and complain about a recent patient as being snivelling and annoying. Their tone of voice is loud, harsh, and short-tempered. In the second part of each video, the physician sat in front of the patient and addressed the patient in a neutral manner (the second part of the video was attached to the first part for each condition, hence the second part for each doctor was identical across the conditions). Within the scenario of the video, the physicians gave the same instructions for the pain stimulus as given by the experimenter during the baseline condition and the physician in the video pressed the same button that was held by the experimenter during the test trial. At the time of the button press, the pressure stimulation

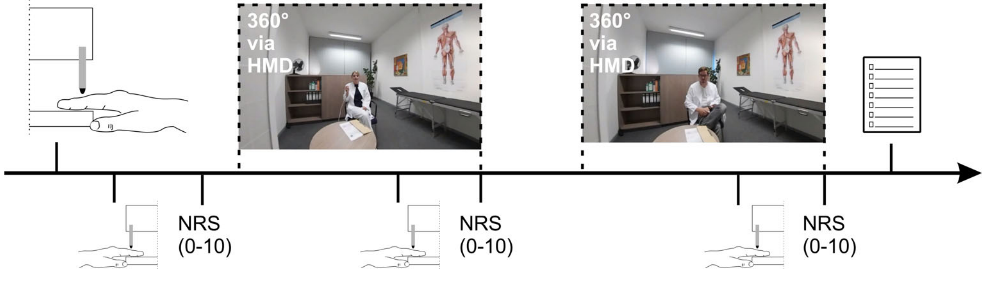

Figure 1. Experimental Procedure. Each participant watched two 360° videos with a head-mounted display (showing an empathic/not empathic physician) and received a painful pressure stimulus on a predefined finger (index, middle or ring) of the non-dominant hand during the video – pain tolerance was measured (time in seconds). At the beginning of the experiment, participants were familiarized with the pressure device with a stimulus on their dominant hand. As a baseline measurement, participant received a pressure stimulus on a finger of their non-dominant hand prior to wearing the HMD and watching the videos. After each of the three conditions, participants rated their experience verbally on different numerical rating scales (NRS)

started, and the video continued while the doctor remained silently seated for a maximum of 60 s. On average, the videos had a duration of 202 $\pm$ 6 s.

Experimental procedure

To accustom participants with the device for the pressure application, the participants received an initial stimulus on the middle finger of their dominant hand. We measured the time until participants indicated that they could no longer tolerate the pain. Afterwards we asked participants to indicate verbally how painful (sensory rating) and how unpleasant (affective rating) the stimulus was on scales from 0 to 10 (not painful/unpleasant at all to extremely painful/unpleasant) (Price, McGrath, Rafii, & Buckingham, 1983). Next, as a baseline measure for explorative analysis, we measured pain tolerance on a finger (ring, middle or index) of the non-dominant hand followed by pain ratings (sensory and affective). Before participants were equipped with the head-mounted-display, they were instructed to observe the following scenes carefully. They were informed that they would take place in a doctor's office, which they would attend in the role of a patient and were asked to follow the instructions in the video. They were further instructed that they would receive a painful stimulus at the time indicated in the video and, therefore, a predefined finger (ring, middle or index) was positioned under the pressure device. In the following, each participant watched two videos, one with a female physician and the other with a male physician of which one was empathic in the interaction with a third person in the video and the other was not. The order and combination of empathy conditions were pseudo-randomized and counterbalanced across participants. The finger to be stimulated was changed before the beginning of the second video. As soon as participants indicated that they could no longer tolerate the stimulus, pressure stimulation and the videos were stopped. Participants were asked to rate their experience on a total of six 11-point scales (0–10) following each video presentation, while they were still immersed in the scene (freeze image). They were asked to rate sensory and affective pain, as described above. Further, they were asked to separately judge the empathy and likability of the doctor (not empathic/likable at all to extremely empathic/likable) and indicate to which degree they felt present in the virtual world (as if they were there) from 'not at all' to 'very strongly' and their mood from 'extremely bad' to 'extremely well'.

After the two videos, the HMD was removed and participants answered several questionnaires described in the next section.

The procedure is schematically depicted in Figure 1.

Questionnaires

We used the *IGroup Presence Questionnaire (IPQ)* (Schubert, 2003; Schubert, Friedmann, & Regenbrecht, 2001) as an external validation of the presence ratings we administered after each condition. The questionnaire consists of 14 items that have to be rated on 7-point Likert scales from -3 to $+3$. It assesses the components sense of spatial presence, involvement and experienced realism and includes one general item that loads on all three subscales and is phrased similar to the general definition of the sense of presence: 'In the computer generated world I had a sense of *being there*' (Slater & Usoh, 1993).

The German version of the *Interpersonal Reactivity Index* (Davis, 1980; Paulus, 2009) was administered as a measure of trait empathy since we were interested whether the scores of this test influenced empathy and likability ratings for the doctors. The questionnaire yields four subscores (empathic concern, fantasy scale, personal distress, perspective taking) and a total empathy score, which is the sum of all subscores except for the personal distress scale.

To assess symptoms of cybersickness, participants answered the *Simulator Sickness Questionnaire* (*SSQ*) that consists of a list of 16 symptoms and participants are asked to indicate the level of severity for the individual symptoms on a four-point scale from 'not existing' to 'strong' (Kennedy, Lane, Berbaum, & Lilienthal, 1993). A total score and subscores for nausea, oculomotor symptoms and disorientation can be calculated. Following the suggested mode of administration (Kennedy et al., 1993), we administered the SSQ only after the exposure, but excluded all participants that indicated to be 'sick' or in other than their 'usual state of fitness' before the experiment from the analysis.

Statistical analysis

As a manipulation check, we first tested whether the empathy and likability ratings differed for the empathic and less empathic doctors with paired *t*-tests.

We compared low and high empathy conditions with paired *t*-tests for each outcome variable. We calculated paired *t*-tests according to the formulated hypothesis (one-sided).

For all explorative analyses, *t*-tests were two sided with the significance level set at .05 and Bonferroni correction for multiple comparisons.

To investigate the relationship between the questionnaire scores and outcome variables described in the previous section, Spearman's ρ was calculated. The significance level for each correlation was Bonferroni corrected by dividing the alpha level of .05 by the number of comparisons. For all outcome measures, we report means and standard deviations.

The data that support the findings of this study are openly available on OSF at https://doi.org/10.17605/OSF.IO/GEYDR.

Results

The physicians in the high versus the low empathy condition were rated as more empathic (7.25 $\pm$ 1.98 vs. 2.58 $\pm$ 2.03) and more likable (7.40 $\pm$ 1.89 vs. 2.67 $\pm$ 1.79), empathy: $t_{(59)} = 14.9$, $d = 1.92$; likability: $t_{(59)} = 16.5$, $d = 2.14$; both $p < .001$.

Figure 2 depicts mean pain tolerance for the experimental conditions. Pain tolerance was higher in the high empathy condition (34.2 $\pm$ 18.4) than in the low empathy condition (31.3 $\pm$ 17.5), $t_{(59)} = 1.7, p = .047, d = 0.22$.

Figure 3 depicts average SCR for the experimental conditions. The SCR was only descriptively lower in the high empathy condition (0.43 $\pm$ 0.21) compared with the low empathy (0.45 $\pm$ 0.20) condition, $t_{(59)} = 1.34, p = .093, d = 0.17$.

We found no difference in the pain intensity ratings $t_{(59)} = 0.17, p = .433, d = 0.02$, but lower pain unpleasantness ratings in the high empathy condition (6.45 $\pm$ 2.14) compared with the low empathy condition (7.00 $\pm$ 2.01), $t_{(59)} = 2.32, p = .012, d = 0.3$.

The mood scores indicated more positive mood after the high empathy condition (7.53 $\pm$ 1.38) than after the low empathy condition (7.00 $\pm$ 1.70), $t_{(59)} = 4.28, p < .001$, $d = 0.55$.

There was no difference in the presence ratings between the high empathy (6.70 $\pm$ 1.52) and low empathy condition (6.68 $\pm$ 1.63), $t_{(59)} = 0.145$, $p = .885$,

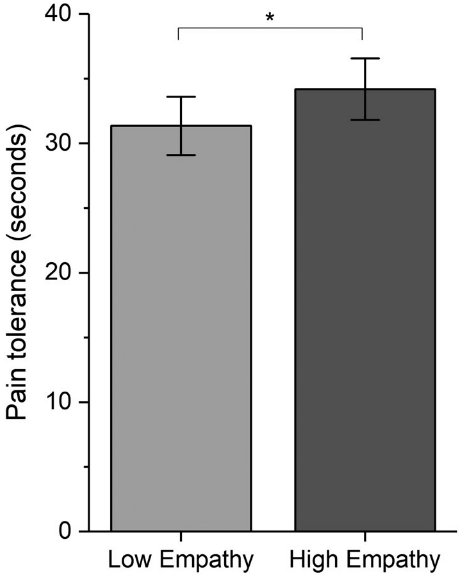

Figure 2. Pain tolerance (mean ± SE) for the experimental conditions. Horizontal lines and asterisks indicate significant differences for the planned comparisons between conditions, $^*p < .05$ (one-sided)

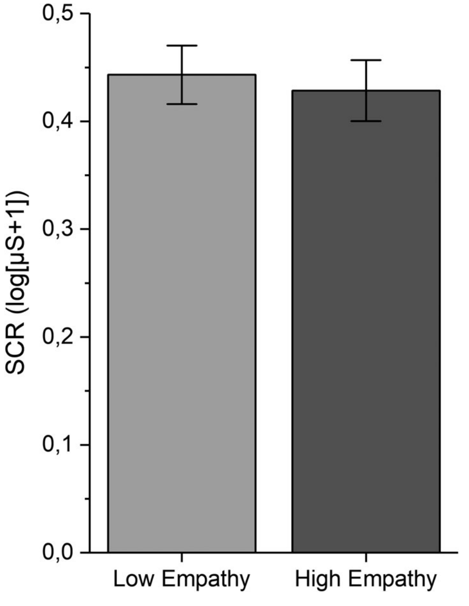

Figure 3. SCR for each experimental condition (mean ± SE)

$d = 0.019$. Higher average presence ratings from both conditions were associated with higher IPQ subscores for spatial presence ($\rho = .568, p < .001$) and the general presence item ($\rho = .505, p < .001$).

We correlated the total score of the IRI (Trait Empathy) and its subscores with the ratings of the physicians (empathy and likability), but found no significant correlation that survived the correction for multiple comparisons (all $p > .004$ (0.05/12). Empathy and likability ratings were highly correlated ($\rho = .776, p < .001$).

The low total score of the Simulator Sickness Questionnaire (19.34 ± 20.26, $n = 58$) and its subscales (nausea: 5.57 ± 10.13; oculomotor: 19.86 ± 18.28; disorientation 27.84 ± 34.59) indicate that there were no serious side effects caused by the immersive video presentation.

To minimize possible order effects and effects of differences in the pain sensitivity of individual fingers, the conditions were pseudo-randomized and counterbalanced across participants in our study design. To check if order effects and finger (ring, middle, index) could affect pain tolerance, we calculated repeated measures ANOVAs. The finger had no effect on pain tolerance, $F_{(2,\ 118)} = 1.71$, $p = .186$, $\eta_p^2 = 0.028$ (index: 30.0 ± 16.4, middle: 33.0 ± 18.7, ring: 30.4 ± 18.4). The time of testing had an effect on pain tolerance, $F_{(2,\ 118)} = 6.24$, $p = .003$, $\eta_p^2 = 0.096$. The pain tolerance was higher during video 2 (33.8 ± 18.2) and video 1 (31.7 ± 17.7) than in the baseline condition (27.9 ± 17.2), $p = .008$ and $p = .04$, respectively. Pain tolerance did not differ between the videos displayed first and second ($p = .647$).

We also checked whether pain tolerance differed depending on the gender of the actor in the videos, but found no significant difference between male (32.0 ± 17.7) and female actors (33.5 ± 17.8), $t = .91$, $p = .365$, $d = 0.118$. Likewise, empathy ratings did not differ for male (4.7 ± 3.1) and female (5.0 ± 3.1) actors, $t = .55$, $p = .583$, $d = 0.071$.

Discussion

The experimental manipulation was successful since participants rated the physicians as significantly more empathic and likable in the high empathy condition than in the low empathy condition. Further, their ratings indicate that they experienced a strong feeling of presence while being immersed in the 360° video scenario independent of the empathy condition. Importantly, pain tolerance was increased after seeing the high empathy condition as compared with the low empathy condition. The revealed effect is small but noteworthy, considering that it is due to seeing only a short empathic or not empathic interaction of the physician with a third person preceding a later neutral direct interaction. Previous studies in the clinical context demonstrated a positive effect of empathic interactions with a physician on health outcomes and satisfaction ratings (Kim et al., 2004; Menendez et al., 2015; Pollak et al., 2011; Robin DiMatteo & Hays, 1980). The present findings extend these results by demonstrating that the observation of emphatic versus non-empathic behaviour of a physician towards another person also modulates health outcomes, here pain tolerance, despite a neutral direct interaction. This finding is in line with a recent laboratory study that demonstrated that pre-recorded empathic comments can influence pain (Fauchon et al., 2017, 2019). Thus, our findings strengthen previous claims that psychological factors in general and the patient–physician relation in particular significantly affect acute pain. The difference in pain tolerance together with the pain ratings indicate that the experimental manipulation mainly influenced the motivational-affective component of pain since unpleasantness but not intensity ratings were affected.

It was previously demonstrated in a clinical context using questionnaires as outcome variables (Kim et al., 2004) that empathic communication of physicians improves patient satisfaction and adherence to a medical regimen. Adherence to medical or health advice is related to better health outcomes (Robin DiMatteo, Giordani, Lepper, & Croghan, 2002;

Horwitz, 1993). In our study, physicians asked participants to tolerate the painful stimulus as long as possible. Physicians that were perceived as empathic were associated with higher pain tolerance. Therefore, it is possible that the differences in pain tolerance, were at least partially caused by higher adherence to the instructions of the physicians that were perceived as empathic.

It was previously suggested that the positive influences of social support in general and empathic physicians in particular (Decety, 2020; Decety & Fotopoulou, 2015) could be explained with the social baseline theory (Beckes & Coan, 2011). The presence of supportive others could help people save metabolically costly neural resources usually needed for emotion regulation through social regulation of emotions (Beckes & Coan, 2011). This theory goes hand in hand with predictive coding theories, such as the free energy principle (Friston, 2010) that postulate that the brain continuously generates and optimizes probabilistic models of the world based on sensory input. Concerning the social modulation of pain, it was previously argued that the interactions with others serve as predictive signals of threat or safety (Krahé et al., 2013). For a patient, an empathic physician can signal safety and consequently reduce the salience of a noxious stimulus via bottom-up sensory input (e.g., verbal comments) and top-down expectancies (e.g., based on prior experiences with empathic physicians) (Decety, 2020). This theoretical framework provides an explanation for the pain modulating effects of social context in general and, in particular, for the pain reducing effect of higher perceived empathy of physicians (found in this study) or of experimenters (Fauchon et al., 2017). It can also help to explain, why in different social contexts or under certain conditions, higher perceived empathy of another person leads to the opposite effect. For instance, empathic and reassuring behaviour of mothers in the interaction with their daughters in response to a painful stimulus led to increased pain ratings in a previous study (Chambers, Craig, & Bennett, 2002), possibly by increasing the perceived salience of the noxious stimulus. Likewise, in an experimental study with romantic partners, higher perceived empathy of the romantic partner yielded higher pain ratings (Hurter, Paloyelis, de C. Williams, & Fotopoulou, 2014). In line with the theories mentioned above and based on their findings, Hurter et al. (2014) speculated that the perceived empathy functions as an interpersonal signal of interoceptive salience, which results in increased attention to the painful stimulus. Individual factors were not considered in this study, but have been found to influence pain in previous studies investigating the influence of the social context. For instance, cognitive–affective response tendencies, such as pain catastrophizing (tendency to perceive pain as threatening) or attachment styles influenced pain perception (Karos, Meulders, Goubert, & Vlaeyen, 2018; Peeters & Vlaeyen, 2011; Sambo, Howard, Kopelman, Williams, & Fotopoulou, 2010; Wilson & Ruben, 2011). In a study by Peeters and Vlaeyen (2011), high pain catastrophizing participants reported more pain in a condition with high social threat to physical integrity, that is, in a situation in which participants thought that another person intentionally inflicted more pain than required. In the predictive coding framework described by Krahé et al. (2013) for the social modulation of pain, these individual factors would influence interoceptive predictions about the threat value of a noxious stimulus in a top-down manner along with other top-down and bottom-up factors.

To summarize, this means that a multitude of factors influences if and how active or passive social support influence acute pain (for a review of studies on social support and pain see Che et al. (2018) and the results of this study cannot be generalized to all clinical encounters.

In this study, we found a pain reducing effect of perceived empathy, while the direct interaction was kept emotionally neutral. In light of the small effect size revealed and since little research addressed the impact of (indirectly) perceived empathy on acute pain (Fauchon et al., 2017, 2019), future studies need to investigate if this effect can be replicated and should investigate which individual factors and circumstances influence the results.

As a direct response to pain, the (empathic) reaction of a physician might lead to a re-evaluation of the experienced pain as more serious than initially thought (Goubert et al., 2005), because its threat value is increased. In particular, this might be the case if patients have the tendency to catastrophize or if the pain experienced and empathy perceived goes along with a serious medical diagnosis. To draw concrete conclusions about the impact of empathy on pain in the clinical setting, further studies should investigate which individual and contextual factors influence the results.

As a baseline measurement, pain tolerance was assessed at the beginning of the study, and as expected, pain tolerance was lower than in the following video conditions in which participants were wearing an HMD and immersed in a virtual scenario. This effect, likely due to distraction, has repeatedly been demonstrated in studies showing the analgesic effects of virtual reality in acute pain (Chan, Foster, Sambell, & Leong, 2018; Kenney & Milling, 2016; Malloy & Milling, 2010). However, because the baseline pain assessment was always tested first, habituation effects cannot be excluded.

Taken together, our findings suggest that 360° videos displayed via an HMD can be an efficient way of simulating a clinical setting. With growing evidence for positive effects of empathic physicians (Howick et al., 2018) but low empathy expressed by physicians in general (Howick, Steinkopf, Ulyte, Roberts, & Meissner, 2017), finding optimal strategies to enhance how physicians express empathy is important. During this process of finding optimal strategies to express empathy, the method proposed in this study could serve as an ecologically valid option to test physician–patient communication experimentally in a standardized way in future studies, that is, using immersive 360° videos presented via an HMD to simulate clinical settings and interactions. It is particularly suited because there were no side-effects of the immersive stimulation revealed in this study and since testing different strategies in an experimental setting is generally less ethically problematic compared with clinical trials.

A recent review reported that female physicians are rated as more empathic than men in clinical studies (Howick et al., 2017). Our study did not reveal any gender effects of the physicians on empathy ratings or pain tolerance. Previous studies demonstrated that male participants reported less pain when tested by female experimenters (Aslaksen et al., 2007; Levine & Lee De Simone, 1991), and following this and similar findings, it was proposed to control for and report experimenters gender (Chapman et al., 2018). For this reason, our sample consisted only of women, which limits the generalizability of the findings of the study, which remain to be replicated with men.

Given that the revealed difference in pain tolerance between empathy conditions was found for one-sided testing and a two-sided test would not yield a significant result ($p = 0.094$), future studies need to replicate the findings before strong conclusions can be drawn and should seek to validate the methodology (Open Science Collaboration, 2015). A potential limiting factor for the external validity of the results is that the interaction was simulated with virtual physicians and healthy participants.

To conclude, we have extended previous findings demonstrating the importance of psychological factors in clinical care by experimentally showing that the mere observation of physicians' behaviour (empathic/not empathic) can modulate pain tolerance.

We have proposed a method to investigate the physician–patient interaction in a standardized and efficient way that might serve as an ecologically valid option to simulate a clinical setting. It can help to further investigate important aspects of patient–physician relation that has long been considered one of the most critical factors in treatment success.

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Conflicts of interest

All authors declare no conflict of interest.

Author contribution

Ivo Käthner: Conceptualization (equal); Data curation (equal); Formal analysis (equal); Investigation (equal); Project administration (equal); Visualization (equal); Writing – original draft (equal). **Matthias Eidel:** Writing – review & editing (equal). **Anne-Sophie Häge:** Investigation (equal); Writing – review & editing (equal). **Annika Gram:** Investigation (equal); Writing – review & editing (equal). **Paul Pauli:** Resources (equal); Supervision (equal); Writing – review & editing (equal).

Data availability statement

The data that support the findings of this study are openly available on Open Science Framework at https://doi.org/10.17605/OSF.IO/GEYDR.

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