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Using virtual reality to understand mechanisms of therapeutic change

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Establishing causality is crucial to understanding the mechanisms that underlie effective treatments for mental health disorders. Virtual reality environments enable manipulation and control of participants' attributes in a therapeutic session, which could potentially revolutionize research on mechanisms of change.

Mental health interventions are effective for about half the patients who receive them[1]. This percentage has not changed over the past four decades, despite the fact that hundreds of clinical trials have been conducted with the overarching aim of improving treatment efficacy[1]. A better understanding of what underlies change in psychotherapy and psychopharmacotherapy can help researchers and clinicians to devise and deliver better treatments, intensify and refine active therapeutic components, and discard inactive or redundant ones. But decades of empirical research on mechanisms of treatment-induced change have resulted in few consistent findings[2].

Several factors might have contributed to the lack of substantial progress in understanding mechanisms of therapeutic change. The gold standard for studying causal inference is randomized controlled trials (RCTs), in which patients are randomized to one of two or more treatment conditions so that researchers can rigorously compare and evaluate their efficacy and underlying mechanisms. Psychotherapy RCTs include two typical scenarios: either different or the same therapists provide the different treatments. Thus, RCT design rests on the ability of therapists to provide the treatment in the conditions they are assigned to. However, the differences between treatment conditions might also be influenced by differences between therapists. For example, observed differences in efficacy between emotion-focused treatment and behavioural activation (and underlying mechanisms) might be due to experts in each of these treatments holding different views of mental health and having different personalities and interpersonal tendencies, preferences and skills that influence how they conduct therapy.

If the same therapist provides the two treatments in an RCT, the underlying assumption is that they can adapt and update how they work with patients to match the treatment condition. However, this assumption has been repeatedly challenged[3]. Even when distinguished therapists (chosen for their expertise in a specific treatment orientation) show how a prototypical session should be conducted, their demonstration sessions also include elements of other treatment orientations[4]. Currently, these shortcomings have no solution because neither therapists' characteristics nor the type of treatment they chose to receive training in can be directly manipulated.

Virtual reality as a potential solution

A potential game-changer in the ability to understand mechanisms associated with therapeutic change is virtual reality (VR), defined as the computer simulation of an environment that can imitate a physical presence in real or imagined worlds[5]. VR enables the systematic presentation of visual and haptic stimuli in a tightly controlled environment while accurately tracking human behaviour. Technological advances have enabled the presentation of virtual agents (digital entities preprogrammed to perform particular actions) and avatars (digital representations of real people), which co-exist in the virtual environment. These environments are already used in gaming, industry and education, and their use has been spreading to clinical settings[6], a process that was accelerated by the COVID-19 pandemic.

There are two main options for manipulating therapeutic components in a virtual environment. The first option is manipulating interactions with a virtual therapist. This is the more traditional mode of interpersonal interaction in virtual environments and requires a digital agent (preprogrammed or not) to interact with a patient. In this paradigm, the visual and auditory representation of the digital agent (age, sex, race, movement and other characteristics), as well as the therapeutic technique (type of therapy and therapists' competence and adherence to the treatment manual), can be manipulated. For example, an artificial intelligence can be trained to use a specific therapeutic technique, such as challenging patients' distorted thoughts or interpreting maladaptive repetitive interpersonal patterns, at different levels of competence (low, medium or high) while being visualized in a virtual environment with specific demographic characteristics, such as an older Black woman or a young white man. Similarly, the age and experience characteristics of the virtual therapist can be manipulated to disentangle the effects of these two factors on treatment success.

The integrated use of VR and artificial intelligence might further promote the ecological validity of VR-based methods by creating a simulated clinical setting, which facilitates the experience of being in a real face-to-face therapy session. For example, text-based or auditory interactions with a deep learning-based language model (such as ChatGPT) could be supplemented by a virtual therapist's non-verbal gestures (facial expressions, movement and tone of voice) in a virtual environment.

The second option is manipulating interactions with a digital representation of a real therapist (avatar). This option requires the co-presence of a human therapist and a patient in the same virtual environment, although physical presence in the same physical space is not required. VR enables direct examination of the effect of concrete characteristics on therapy efficacy, because the visual and auditory representation of the therapist can be manipulated. For example, a young human therapist can be depicted in the virtual environment as an older virtual therapist to manipulate the effect of age while holding all other therapist characteristics constant. In this context, the content of the therapeutic session remains unchanged, so the effect of

some components on therapy efficacy can be isolated. For example, the strength of the therapeutic alliance between the patient and the therapist (which includes the emotional bond between the patient and therapist and agreement on the treatment goals and tasks) is a consistent predictor of treatment outcome[7] and is associated with the level of movement synchrony between therapist and patient. The effect of movement synchrony on the therapeutic alliance can be manipulated in VR by changing the extent to which the virtual representation of the therapist's movements matches those of the patient. The possibility of manipulating movement synchrony, among other factors that might underlie treatment success, could be revolutionary for determining the therapeutic effects of these factors[8,9].

Realizing the potential of VR for psychotherapy

So far, VR has been used extensively to treat a variety of mental health disorders mostly in exposure therapy[10], but its ability to assist in the exploration of mechanisms associated with therapeutic efficacy remains largely untapped.

Technological advances can propel research in psychotherapy forward by enabling more rigorous and accurate investigation of mechanisms of change. VR can be used to establish causality in the study of mechanisms of therapeutic change by manipulating the interactions between the patient and a virtual therapist, or between the patient and a digital representation of a real therapist (avatar). In VR environments, researchers can isolate a single component of the therapeutic relationship (synchrony, empathy or authoritarianism), the characteristics of the therapists, and their therapeutic behaviour in a series of separate experiments to create new knowledge about the effect of each of these factors that before seemed unattainable.

Identifying the components that have the largest effect on treatment success will be invaluable for intensifying and refining active therapeutic components in current and new treatments, which can then be implemented to increase the efficacy of clinical interventions. Similarly, less effective or ineffective components can be discarded to increase the cost-effectiveness of existing treatments. The results of a rigorous investigation into the active components of psychotherapy for different patients can be used to personalize treatments to individual patients' trait-like characteristics and to assist in matching each patient to the therapist's profile that is most effective for them.

Knowing whether a particular therapeutic scenario can produce entirely different outcomes if a single component is changed produces a high level of research rigour and precision. Such a high level of rigour and precision is distinctive to experimental laboratory studies and will enable researchers to directly test the effects of therapists' characteristics on treatment efficacy with real patients receiving mental health interventions. These possibilities are attainable with the present technological tools. In a reality in which technology is exponentially upgraded, one can only dream of how it will be possible to leverage VR in psychotherapy research in the future.

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References

1. Cuijpers, P. Four decades of outcome research on psychotherapies for adult depression: an overview of a series of meta-analyses. *Can. Psychol.* **58**, 7–19 (2017).
2. Cuijpers, P., Reijnders, M. & Huibers, M. J. H. The role of common factors in psychotherapy outcomes. *Annu. Rev. Clin. Psychol.* **15**, 207–231 (2019).
3. Herzog, P., Kube, T. & Rubel, J. Why some psychotherapists benefit from feedback on treatment progress more than others: a belief updating perspective. *Clin. Psychol. Sci. Pract.* **4**, 468–479 (2023).
4. Solomonov, N., Kuprian, N., Zilcha-Mano, S., Gorman, B. S. & Barber, J. P. What do psychotherapy experts actually do in their sessions? An analysis of psychotherapy integration in prototypical demonstrations. *J. Psychother. Integration* **26**, 202–216 (2016).
5. Howard, M. C. A meta-analysis and systematic literature review of virtual reality rehabilitation programs. *Comput. Human Behav.* **70**, 317–327 (2017).
6. Krasovsky, T., Lubetzky, A. V., Archambault, P. S. & Wright, W. G. Will virtual rehabilitation replace clinicians: a contemporary debate about technological versus human obsolescence. *J. Neuroeng. Rehabil.* **17**, 163 (2020).
7. Flückiger, C., Del Re, A. C., Wampold, B. E. & Horvath, A. O. The alliance in adult psychotherapy: a meta-analytic synthesis. *Psychotherapy (Chic.)* **55**, 316–340 (2018).
8. Zilcha-Mano, S. How getting in sync is curative: Insights gained from research in psychotherapy. *Psychol. Rev.* https://doi.org/10.1037/rev0000471 (2024).
9. Zilcha-Mano, S. Individual-specific animated profiles of mental health. *Perspect. Psychol. Sci.* https://doi.org/10.1177/17456916231226308 (2024).
10. Emmelkamp, P. M. G. & Meyerbröker, K. Virtual reality therapy in mental health. *Annu. Rev. Clin. Psychol.* **17**, 495–519 (2021).

Competing interests

The authors declare no competing interests.