



# Visuospatial game in PTSD symptoms alleviation: intervention overview and clinical studies results<sup>1</sup>

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**Abstract:** The aim of this article is to present the possibility of using the puzzle game Tetris as an aid in treating people suffering from post-traumatic stress disorder (PTSD). This intervention was first proposed Holmes and her team (2009), who postulate its high effectiveness, especially when alleviating one of hallmark symptoms of PTSD – intrusions. It was assumed that the visuospatial nature of the game would interfere with the formation of the perceptual and sensory memory trace of the traumatic event, as both processes compete for a limited pool of visual working memory resources. In principle, this should translate into a reduced number of intrusions and the intensity of symptoms of post-traumatic stress disorder, while not damaging the volitional, verbal memory of the event itself. The effectiveness of the intervention has been confirmed by the team in laboratory setting using real-life trauma analogues (trauma film paradigm). This paper discusses the results of studies involving clinical groups, testing the effectiveness of the intervention, and thus the validity of the proposal itself. In each of the studies cited, after memory reactivation, people who experienced an actual trauma and/or had a diagnosis of post-traumatic stress disorder were asked to play Tetris for a short time (approx. 15-20 minutes). The number of intrusions occurring in the following days was tracked along with, in some cases, other indicators of psychological well-being. Regardless of the type of traumatic event, the time elapsed since it occurred, and the protocol used, each of the cited studies reported a reduction in the number of intrusions and a corresponding decrease in the severity of PTSD symptoms. The intervention turned out to be easy to use, universally effective and not interfering with other therapeutic approaches, therefore making it a valuable and noteworthy addition to treatment programs for people suffering from post-traumatic stress disorder, leading to an improvement of their mental health and general functioning.

**Keywords:** intrusions; PTSD; Tetris; trauma; visuospatial games

## Introduction

Since their creation in the late 1950s, early 1960s, and further commercialization in the 1970s, the popularity of computer games has been steadily rising. In particular, the intensive growth of player numbers in recent years is related to factors such as affordability of home gaming systems (e.g. consoles), more powerful computers and graphics capabilities of mobile devices (e.g. smartphones), the emergence of digital game distribution platforms (e.g. Steam) and universal internet access. The Google for Games report (2021) estimates that the total number of gamers around the world currently oscillates around 3 billion, which is over 40% of the world's population. Given their popularity, it is not

surprising that computer games are also of interest to the scientific community, raising numerous questions about the possible consequences of gaming as well as the general usefulness of such activity. Some of the research has focused on the possible negative effects, exploring, among other things, the issues of aggression in players (e.g. Anderson, Shibuya, Ihori, Swing, Bushman, et al., 2010) or the possibility of addiction (e.g. Stevens, Dorstyn, Delfabbro, King, 2021). Currently, however, games potential is more frequently being harnessed to improve functioning of various groups of individuals. Computer games have been successfully used e.g. to help deal with obesity in children and adolescents (e.g. Andrade,

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Correia, Coimbra, 2019) or to increase mobility and balance of the elderly (e.g. Pacheco, de Medeiros, de Oliviera, Vieira, de Cavalcanti, 2020). Particular attention is currently being paid to the possibility of using games to improve mental health, such as to reduce the level of anxiety or depression (e.g. Ioannou, Papastavrou, Avraamides, Charalambous, 2020) or symptom intensity in specific phobias (e.g. Freitas, Velosa, Abreu, Jardim, Santos, et al., 2021). The purpose of this article is to characterize in more detail one of such proposals, aimed at reducing the severity of symptoms of post-traumatic stress disorder, and to review data from clinical trials proving its effectiveness.

## 1. Post-traumatic stress disorder (PTSD) and intrusions

Post-traumatic stress disorder (PTSD) may occur in response to an extremely stressful experience that poses a threat to the health, life or bodily integrity of a person. Such an event, called traumatic, may affect the individual directly or indirectly, when they witness it without participation. Most common examples of traumatic events include warfare, a natural cataclysm or catastrophe, being involved in a car accident or a victim of assault, kidnapping or imprisonment. Both the diagnostic manual of the American Psychiatric Association DSM-V (2018) and the WHO medical classification ICD-11 (2022) indicate similar diagnostic criteria for the syndrome. The symptoms of PTSD include, first of all, intrusions, i.e. involuntary, distressing memories of a traumatic event in the form of thoughts, images, dreams or so-called flashbacks, containing a component of derealization, where a person feels as if they found themselves in the threatening situation they experienced all over again. Another symptom is persistent avoidance, i.e. running away from emotions or thoughts related to the trauma as well as from people, activities or places that could remind the individual of the event. A person suffering from PTSD is also characterized

by negative changes in mood and cognitive processes, including i.a. dissociative amnesia (inability to remember the details of the event), self-blame and negative beliefs about oneself or alienation. Finally, PTSD also manifests itself in changes in the natural reactivity and arousal level of the individual, who may become hyper-vigilant, irritable and prone to outbursts or taking unnecessary risks. Symptoms often develop within a few months of the traumatic event and significantly impair individuals functioning in personal, social or professional areas of life (see e.g.: Jellestad, Vital, Malamud, Taeymans, Mueller-Pfeiffer, 2021).

Prevalence estimates of PTSD are quite varied. For example, Schein, Houle, Urganus, Cloutier, Patterson-Lomba et al. (2021) indicate the prevalence of the syndrome within a year of the event ranging from 2.3% to 9.1% in the general population of the United States. In specific populations the estimates may be higher, in the case of soldiers for example, who are more exposed to trauma due to their profession, they range from 6.7% to as much as 50.2% per year. In European countries the incidence of post-traumatic stress disorder is slightly lower, ranging from about 1.1% to 2.9% in the general population (Trautmann & Wittchen, 2018). The number of people struggling with post-traumatic stress disorder is therefore not negligible in the global perspective, nor is the impact of symptoms on the functioning of such individuals, even more so, as PTSD also co-occurs with higher levels of general anxiety, depression and psychological distress, where the correlation coefficients can reach as high as 0.70 (e.g. Unseld, Krammer, Lubowitzki, Jachs, Baumann, et al., 2019). Among the psychotherapeutic approaches cognitive-behavioral therapy seems to be effective in reducing PTSD symptoms as well as exposure therapy, including sessions conducted in virtual reality, and EMDR therapy (Eye Movement Desensitization and Reprocessing<sup>2</sup>; e.g. Eshuis, van Gelderen, van Zuiden, Nijdam, Vermetter, et al., 2021; Lewis, Roberts, Andrew, Starling, Bisson, 2020). Pharmacotherapy can also be helpful, often in combination with therapeutic interventions;

2 EMDR therapy involves reactivation of a traumatic or otherwise difficult memory with concurrent engagement in a simple sensory-motor task (usually eyeball movement in a specific pattern) in order to change the way it is being cognitively processed.

antidepressants such as fluoxetine or sertraline and antipsychotics such as quetiapine yield good results (e.g.: Hoskins, Bridges, Sinnerton, Nakamura, Underwood, et al., 2021; Mavranouzouli, Megnin-Viggars Daly, Dias, Welton, et al., 2020).

Despite the existence of a number of recognized methods of treatment and therapy, the management of PTSD poses various difficulties. For example, psychotherapy assumes the need to verbalize and recall a traumatic situation, which may result in retraumatization that strengthens the symptoms of PTSD, especially when such therapy is conducted very shortly after the traumatic event (e.g. Zohar, Juven-Wetzler, Sonnino, Cwikel-Hamzany, Balaban, et al., 2011). Similarly, the use of prescribed medications may be associated with experiencing side effects (e.g. Ehret, 2019). Some patients also show resistance to them (see e.g. Abdallah, Averill, Akiki, Raza, Averill, et al., 2019). Both psychotherapy and pharmacotherapy may also be unavailable to various groups of patients due to their costs or difficult access to health care, e.g. in certain geographical locations. Therefore, there is a constant need to introduce new forms of treatment or interventions aimed at alleviating PTSD symptoms that would be accessible and safe for patients and improve their daily functioning and quality of life. Attention is also drawn to the particular need for therapies focusing on reducing the number of intrusions, which seem to not only cause great distress to the sufferers, but can also lead to further consolidation of the traumatic memory through its involuntary, constant activation.

## **2. *Tetris* game as a „cognitive vaccine” against intrusions**

Holmes, James, Coode-Bate and Deeproose (2009) were the first to suggest the possibility of alleviating symptoms of post-traumatic stress disorder using a simple, commercial game. The research team focused their attention on the classic puzzle game *Tetris*, designed and published by Alexei Pajitnov in 1985. The game is played on a rectangular board (tetrion), where the player’s task is to form lines from blocks of various shapes (tetrominoes), fall-

ing down from upper part of the board, by moving and rotating them around. Once a line is formed, it disappears from the tetrion, creating more space for more tetrominoes. With lines being created and removed, the ever falling speed of subsequent blocks increases, inciting precise manipulation, and thus the game rendered more difficult. *Tetris* has undergone countless adaptations and expansions that change the parameters and modes of the gameplay (there are, among others, multiplayer or virtual reality versions) as well as conversions to various platforms (stationary and portable computers and consoles, smartphones and tablets). This makes the game flexible and customizable to the preferences and needs of a particular player, as well as easily accessible, thanks to which *Tetris* remains one of the most popular games of all time (Tyler, 2022).

*Tetris* raised a particular interest of Holmes team (2009) as it is believed to demand increased visuospatial processing. The game requires the player to imagine the shape of tetrominoe after turning it as well as to predict its fit into a specific place between the blocks already on the board. Therefore, it engages the processes of mental rotation and spatial visualization, loading visual working memory (see: Pilegard, Mayer, 2018). These speculations were confirmed in empirical research. For example, Lau-Zhu, E. Holmes, Butterfield and J. Holmes (2017) showed that the number of points obtained in a short game of *Tetris* correlated significantly with measures of visuospatial working memory efficiency. At the same time, the game score was related neither to intelligence of the participants nor the efficiency of their verbal working memory. This indicates that the game influences selected cognitive processes only. The conclusion was further supported by the results of Milani, Grumi and Di Blasio (2019) who verified the possibility of improving visuospatial functions using a 3-day game training (45 minutes a day). A positive, albeit small, impact of the game on the performance in tasks measuring selected components of working memory, such as the ability to perform mental rotations or spatial visualization, was observed. Interestingly, the size of the training effect for individual processes depended on the game variants of two-dimensional or three-dimensional

tetrominoes. The special involvement of visuospatial processes when playing *Tetris* was also confirmed by Angren, Hoppe, Singh, Holmes and Rosén (2023) using neuroimaging methods. Increased activation was observed, among others, in the inferior temporal cortex, the fusiform and angular gyri, the occipital cortex, the hippocampus, as well as the cerebellum and the premotor cortex. These structures are involved in identifying and classifying shapes, the perception of their location in space, as well as motor planning (activity resulting from the need to press keys while playing was controlled for during the experiment). What is important, as the authors themselves point out, studies focused on neurocorrelates of intrusive memories have found dysfunctions of brain areas similar to those activated by the *Tetris* game.

As part of their proposal, Holmes et al. (2009) indicate that in the case of PTSD one of the more troublesome symptoms are the aforementioned intrusions. They are visual in nature and a consequence of increased sensory processing at encoding stage of the traumatic event. As working memory has a limited capacity, the introduction of a second task with similar characteristics and cognitive requirements (i.e. the *Tetris* game) will cause both to compete for a limited pool of resources, and consequently, interference. As a result of redirecting some of the resources towards the gameplay, mental images related to the traumatic event are weakened, which translates into their less clear and incomplete encoding within the memory trace. This, in turn, should result in a reduced number of visual intrusions and flashbacks experienced. What's more, the authors postulate that this intervention can be effective not only right after the experienced trauma, but also when a few hours had passed (a 6-hour window was suggested). It is due to the duration of memory trace consolidation, a process prolonged in time, still ongoing even when the original stimulus or situation no longer affects the individual. This is not without practical significance; it is rarely possible to provide a person with psychological help right after a traumatizing event.

Holmes et al. (2009) tested the effectiveness of the proposal in experimental setting, using the so-called trauma movie paradigm. Participants were shown a 12-minute video compilation of real-life

traumatizing scenes depicting mutilation and accidents, including fatalities. It is assumed that such a stimulus is an approximation of a true traumatic event so the content of the film is subjected to similar memory processing rules and may result in intrusions (see, e.g.: Asselbergs, van Bentum, Riper, Cuijpers, Holmes, et al., 2023; James, Lau-Zhu, Clark, Visser, Hageraars, et al., 2016a). After watching the film and a 30-minute break, the participants in the experimental group played *Tetris* for 10 minutes or had no activity in the control group. Over the next 7 days, participants from both groups recorded the number of visual intrusions they experienced each day concerning the videos they watched. Based on the results, the effectiveness of the intervention using the game was confirmed, the participants experienced on average 3 times less intrusions than those in the control group. Interestingly, both groups remembered a similar number of details about the movies they watched after a week. This result shows that the introduction of a visuospatial game during memory encoding disturbs the memorization of the visual aspect of the event only, not its general memory. Based on the obtained results, the authors propose the use of *Tetris* gameplay as a "cognitive vaccine" against intrusions and flashbacks after experiencing trauma. It is a proposition worth considering as patients engagement in such intervention does not require experience with computer games, specialized equipment or involving high costs.

The above results were replicated in subsequent studies (e.g.: Hageraars, Holmes, Klassen, Elzinga, 2017; Holmes, James, Kilford, Deepröse, 2010; James, Bonsall, Hoppitt, Tunbridge, Geddes, et al., 2015; James, Lau-Zhu, Tickle, Horsch, Holmes, 2016b; Lau-Zhu, Henson, Holmes, 2019), while also deepening understanding of the effects *Tetris* may have on PTSD symptomatology. For example, the possibility that the game offers a mere distraction after experiencing trauma, interfering with memory encoding, was excluded. The use of a verbal game, devoid of the visuospatial component, did not lead to the reduction of intrusions after watching traumatizing films. Similarly, engaging in the game before experiencing negative events was also not effective, suggesting retroactive interference mechanism, not

a proactive one (which is at odds with the idea of a “vaccine”). It was also confirmed that the window of effectiveness of the intervention is wider than originally thought, as *Tetris* successfully reduced the number of intrusions even when administered 24 hours after the trauma. Despite some criticism (see e.g.: Cristea, Naudet, Shanks, Hardwicke, 2017) and clear need for further research, there are many indications that the proposed intervention may actually be effective.

### **3. Verification of intervention effectiveness in clinical setting**

All previously cited publications tested the usefulness of the proposed intervention in laboratory setting only, where traumatic memories were artificially evoked using specially prepared visual materials. It is obvious that this is only an approximation of traumatic events experienced by participants and witnesses in real life. To conclude on the protective effect of playing *Tetris* in the context of PTSD formation, it was necessary to test its effectiveness in studies with higher ecological validity, involving clinical groups and people with real trauma experience. These studies also provided additional data on the well-being and mental health of people who underwent the described intervention.

Horsch, Vial, Favrod, Harari, Blackwell and colleagues (2017) were among the first to verify the usefulness of *Tetris* against intrusions and the intensity of PTSD symptoms. The study was conducted in a hospital neonatology ward with women who had experienced an emergency caesarean section. The procedure was necessary due to a life-threatening condition of the mother or child, thus qualifying as a traumatizing event. Within 6 hours of the c-section, participants had played *Tetris* for a minimum of 15 minutes; the control group consisted of women with a similar experience who were not offered any type of intervention. Symptom diaries kept for a subsequent week showed a significant difference in the number of intrusions, which was almost 50% lower in the intervention group compared to the control group. Lower indicators of post-traumatic

stress symptoms intensity were also found, primarily concerning re-experiencing of the traumatizing event, which confirms the effectiveness of the intervention, although the authors admit that the stability of this effect for periods longer than one week was unknown. It is also important to note that the vast majority of patients considered engaging in a computer game to be an acceptable form of intervention during that difficult time.

These results were replicated and extended by Deforges, Fort, Stujifzand, Holmes, and Horsch (2022) who examined a group of women who had experienced a traumatic birth between 7 months and as many as 7 years earlier and reported ongoing intrusions related to that event. In order to reactivate memories, before playing the game, women recalled the course of their traumatic childbirth, and the study itself was carried out in the same hospital where they previously gave birth (contextual clues). The participants then engaged in a 20-minute game of *Tetris*, after which they tracked the occurrence of intrusion for a month. A significant decrease in the number of intrusions, the overall intensity of PTSD as well as its individual components, re-experiencing trauma, persistent avoidance, increased arousal and reactivity, negative thoughts and feelings were observed, compared to the period before the intervention, improving the functioning of the women. The decrease reached as much as 80%, remaining at the same level after a month for the majority of the participants. The study proved, in addition to replicating Horsch et al.'s (2017) results, that the intervention can target already consolidated traumatic memories. However, it is assumed that they must be reactivated, recalling and re-experiencing a traumatic event makes memory trace susceptible to changes owing to reconsolidation mechanism (memory re-coding). Secondly, the stability of therapeutic effects in a longer time duration than the originally studied week was also clear. Finally, here again the intervention was highly acceptable to the participants.

In a study by Iyadurai, Blackwell, Meiser-Stedman, Watson, Bonsall and colleagues (2018), the effectiveness of *Tetris* interventions was tested in a group of people who had experienced a different type of traumatic event. The research was conducted

in the emergency department of one of the hospitals, where participation was offered to people who had been involved in car accidents up to 3 hours earlier. After reactivating the memory and describing subsequent actions taken since the event, the subjects played *Tetris* for 20 minutes, while the control group was not given any activity. After a week during which participants tracked event-related intrusions, there were statistically significant differences between the groups. The number of intrusions related to the traumatic event was almost 3 times lower in the intervention group compared to the passive control group. This also manifested in the results of the appropriate subscale of the tool measuring the intensity of PTSD symptoms. The differences between the groups, however, disappeared after 1 month. Nevertheless, respondents reported that the gaming intervention was helpful without being burdensome.

A similar group was also studied by Kanstrup, Singh, Göransson, Widoff, Taylor et al. (2021a). People who found themselves in the emergency department were asked to play a 20-minute game of *Tetris* within 72 hours of the traumatic event they participated in. The control group, in turn, was asked to listen to a podcast of similar duration. In both groups, reactivation of memories was used, similarly to previously cited studies, making them sensitive to change in the process of reconsolidation. However, unlike Iyadurai et al. (2018), possible changes in well-being and general functioning of the participants were tracked for as long as 6 consecutive months. The obtained results confirmed the effectiveness of the intervention, the gaming group recorded statistically fewer intrusions related to the traumatic event than the active control group. The effect was evident to both a week and a month after the intervention. It was also visible when PTSD questionnaire scores were taken into consideration. Differences were shown for the intrusion and persistent avoidance subscales, in favor of the intervention group, which were still visible after 3 and 6 months, proving the stability of the therapeutic effect over time. What is more, the study also used other measures of psychological well-being. The *Tetris*-playing group reported significantly lower levels of anxiety and depression symptoms than the control group, and rated their

sleep quality and health higher, an effect that was observed throughout the whole six-month period. These results clearly indicate that a brief intervention using a visuospatial game can have a wide range of benefits for mental health.

The *Tetris* game intervention has also been used successfully in research involving groups of war refugees. In Holmes, Ghaderi, Eriksson, Olofsdotter Lauri, Kukacka and colleagues (2017) study, young Syrians and Iraqis residing in Sweden were asked to participate. The aim of the week-long project was to assess the feasibility of *Tetris* intervention to reduce the number of intrusions they experienced. The second goal was to improve cognitive functioning of participants who reported having difficulty concentrating due to intrusions. The participants were to play *Tetris* on their own smartphones for up to 20 minutes each day after reactivating memories of traumatic events, as well as track intrusions and attention deficits using a diary. It was observed that the number of reported intrusions was strongly correlated with the intensity of attentional difficulties (0.64) and a single intrusion occupied the participants' attention for several minutes after its occurrence. In the opinion of the respondents, everyday involvement in the game was effective against intrusions and ruminations related to traumatic events, and the game itself was a relaxing and acceptable activity. This result is important because the intervention using *Tetris* is linguistically and culturally neutral, which is important when working with groups of people who do not speak the language of mental health professionals fluently. What is more, the relationship between the number of intrusions and attentional parameters suggests that along with intrusions alleviation the subjects should also observe an improvement in cognitive functioning. This may, in turn, make it easier to learn a new language, which is one of the key factors for successful adaptation to a new environment.

An extension of the above project is Kanstrup, Kontio, Geranmayeh, Olofsdotter Lauri, Molds and colleagues (2021b) study with a small group of refugees from Afghanistan and Iran experiencing intrusions related to warfare, violence and fleeing the country. Similarly to previously cited studies, the participants had to reactivate the memory of

a difficult experience and then play a 20-minute game of *Tetris* on their smartphone. The number of intrusions and other indicators of mental health were tracked using diaries. A significant decrease in the number of intrusions was observed during the intervention compared to one-week period preceding it. Their smaller number, in turn, translated into an improved functioning in various areas increasing, among others, the sense of control, the ability to regulate emotions or the degree of attentional focus. The study also showed that the intervention did not require supervision by a mental health professional, self-administered sessions were as effective as sessions led by a psychologist or psychiatrist. Moreover, the results of the study indicate that during reactivation of memories it is possible to use the so-called hotspots, requiring focusing on one specific aspect of the traumatic situation (e.g. the image of a boat or tank) in order to recall it, instead of the mental image of the full event. Working with hotspots proved to be as effective as eliciting a complete memory, while reducing the risk of retraumatization and causing participants less concern about their reactions when the memory is successfully reactivated.

Finally, it is worth mentioning the study by Butler, Herr, Willmund, Gallinat, Kühn and colleagues (2020), which is unique as it also tracked structural and functional changes in the brains of people undergoing the *Tetris* intervention. The project involved war veterans suffering from PTSD who were subjected to a 6-week EMDR therapy. As part of the intervention, they were asked to play for a total of 60 minutes a day; the control group received no additional task. After the basic treatment, the intensity of PTSD, anxiety and depression symptoms was assessed in both groups. Both the intervention group and the control group showed a decrease in PTSD symptoms, also maintained at the follow-up examination 6 months later. Similarly, just after the end of treatment both groups reported a decrease in the intensity of anxiety, but only in the *Tetris* group it progressed over the next months, being cumulatively greater. The fMRI study additionally showed that the volume of the hippocampus increased only in those who played visuospatial game. This is important because in people suffering from PTSD

this volume decreases, correlating with the severity of the syndrome. The greater the increase in volume observed, the greater the reported improvement in functioning after 6 months. This study is important for two reasons. Firstly, it indicates that the intervention using the *Tetris* game not only does not reduce the effectiveness of other therapeutic interventions, but also seems to work synergistically with them. Second, the intervention appears to have specific brain correlates and a specific, identifiable mechanism of action.

## **Concluding remarks**

In all of the clinical group studies cited in this article, the intervention involving playing *Tetris* was found to be effective. It is impossible not to notice many benefits associated with the use of the discussed intervention. Firstly, research confirms its universal effectiveness, regardless of the type of trauma or the time that has passed since the event. Moreover, it seems that the introduction of a short game in the period immediately after a traumatic event does not lead to retraumatization. Secondly, intervention using *Tetris* does not seem to interfere with other forms of therapy, on the contrary, it may enhance their effects. Thirdly, the game is non-verbal, so it is culturally and linguistically neutral and can be used in groups with poor language comprehension. Fourthly, the intervention seems to be flexible – despite the lack of a uniform protocol regarding, among others, duration, both of its entirety and a single session or gameplay parameters (e.g. difficulty, graphics and sound settings of the game), its positive impact on the well-being and functioning of patients is reported. The fact that this type of intervention is highly accessible to almost every person, requires virtually no costs as many of the available variants of the *Tetris* game are available for free, and can also be administered by the person themselves, without the supervision of specialists, is also worth noting. Finally, in virtually all of the cited studies, gaming was an accepted, easy-to-learn form of activity that did not burden patients and brought pleasure, which is important for compliance with therapeutic recommendations.

Of course, further research is necessary, including both experimental and laboratory studies, aimed at gaining a deeper understanding of the mechanism in which the visuospatial game affects the symptomatology of post-traumatic stress disorder, as well as determining the universality of this effect in relation to the game itself. It is also unreasonable to expect that making such a game the central part of therapeutic efforts would resolve PTSD and its

symptoms. It seems, however, worth considering to introduce such an activity into therapeutic programs as an auxiliary or supporting the primary forms of treatment. The research results indicate the safety of its use and, at the same time, the possibility of contributing to a greater or faster reduction of the symptoms of post-traumatic stress disorder, especially intrusion, leading to functional improvements and greater well-being.

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