MUSICIANS' PERSPECTIVES ON MUSIC THERAPY: EMOTIONAL, COGNITIVE, AND ETHICAL INSIGHTS

Poowaniy Diraksin[1], Premwit Jirasanyansakul[2], Wenxin Dong[3]*, Wei Shang[4], Tasnee Keawngam[5] and Rerkchai Ponsri[6]

[1,2,3,4,5,6] International College, Pathumthani University, Thailand

*Corresponding author e-mail: 270676141@qq.com

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Abstract

This study examines musicians' perspectives on the impact of music therapy, with a focus on their role in the emotional, cognitive, and neurological healing processes. While music therapy has been widely studied from the viewpoints of healthcare professionals and patients, limited attention has been given to the insights of musicians—those who create and perform the therapeutic medium. Using a qualitative research approach, data were collected through semi-structured interviews with professional musicians with experience in music therapy or who have worked closely with therapeutic settings. Inductive content analysis was employed to identify key themes, including the emotional influence of music, cognitive and neurological benefits, the role of musicians in therapy, challenges in integrating music into healthcare, and ethical considerations. Findings reveal that musicians perceive music as a powerful tool for emotional regulation, cognitive enhancement, and neuroplasticity. However, challenges such as limited formal training, lack of recognition in healthcare, and ethical concerns were also noted. The study highlights the importance of enhanced collaboration between musicians and certified therapists, as well as structured training programs and clear ethical guidelines, to optimize the integration of music into therapeutic practice. These insights contribute to the growing discourse on the role of music in healing and highlight avenues for future interdisciplinary research in music therapy.

Keywords: Music Therapy, Musicians' Perspectives, Emotional Regulation, Cognitive Enhancement, Interdisciplinary Collaboration

Introduction

Music therapy has long been recognized as a powerful tool for emotional, cognitive, and physical healing. Rooted in both ancient traditions and modern scientific research, it harnesses the therapeutic properties of music to address a wide range of psychological and physiological conditions, including stress reduction, pain management, and cognitive rehabilitation (Ansdell, 2014; Bradt & Dileo, 2010; Feng & Wang, 2025; Golden et al., 2025). Research has demonstrated that music therapy can improve mood, enhance memory recall, and even contribute to neuroplasticity, making it an effective intervention in clinical and rehabilitative settings (Koelsch, 2014; Leonardi et al., 2017; Siponkoski et al., 2020). While numerous studies have explored the benefits of music therapy from the perspectives of healthcare professionals, therapists, and patients, less attention has been given to the viewpoints of musicians—those who create and perform the very medium that facilitates healing (Barnett & Vasiu, 2024; Corriero et al., 2024; Rodríguez-Rodríguez et al., 2024).

According to Feng and Wang (2025), musicians, as both artists and facilitators of therapeutic experiences, possess unique insights into how music influences emotions, cognitive functions, and overall well-being. Their perspectives can provide a deeper understanding of the mechanisms through which music therapy promotes healing and personal growth. For instance, musicians may possess intuitive knowledge of how melody, rhythm, and harmony evoke emotional responses, as well as how various musical elements contribute to relaxation and mental clarity. Additionally, their lived experiences in performance, composition, and improvisation may illuminate the relationship between musical creativity and therapeutic outcomes. Given their deep engagement with music, musicians may also offer valuable insights into the ethical and emotional aspects of using music as a therapeutic tool (Gabrielsson & Lindström, 2010; Syarifani, 2024; Weng et al., 2024).

This study aims to investigate musicians' perspectives on the impact of music therapy, examining their perceptions of its effectiveness, their role in the therapeutic process, and how musical composition and performance contribute to healing experiences. Key questions include how musicians interpret the therapeutic potential of music, the challenges they face when integrating music into therapy, and the extent to which their artistic intentions align with the goals of music therapy practitioners. By focusing on musicians' perspectives, this research aims to bridge the gap between artistic expression and therapeutic application, providing valuable insights for practitioners, educators, and policymakers.

Understanding how musicians perceive and engage with music therapy can enhance the development of more effective therapeutic approaches and strengthen collaborations between musicians and healthcare professionals. Furthermore, as music therapy continues to evolve with advancements in neuroscience and digital technology, musicians' insights may contribute to innovative therapeutic techniques, including the use of artificial intelligence-generated music, personalized soundscapes, and virtual reality-assisted music therapy. By

integrating musicians' perspectives, this study aims to foster a more comprehensive understanding of music's role in promoting healing and well-being.

Research Objective

This study aims to explore musicians' perspectives on the therapeutic impact of music therapy and their role in the healing process. This study may contribute to a deeper understanding of the role musicians play in music therapy, offering insights into how their artistic practices influence therapeutic outcomes.

Methodology

Research Design

This study employed a qualitative research design to explore musicians' perspectives on the therapeutic impact of music therapy and their role in the healing process. Qualitative research explores the underlying reasons for a phenomenon by examining the contextual factors that influence individuals' or groups' decisions and behaviors. Hence, this approach is appropriate because it enables an in-depth examination of participants' experiences, views, and insights (Asanprakit & Limna, 2023; Ugwu & Eze, 2023). The study employed a descriptive, exploratory research design to capture the nuances of musicians' experiences and uncover emerging themes related to music's healing potential.

Data Collection

The data was collected through semi-structured interviews with professional musicians who have experience in music therapy or have worked closely with therapeutic settings. The interviews were conducted in January 2025, either in person or via online platforms (such as Zoom and Line), depending on participant availability and location. The interview questions were designed to explore musicians' perceptions of the therapeutic potential of music, their role in the music therapy process, and the emotional, cognitive, and physical effects they believe music can have on individuals. In addition to the interviews, relevant textual data, such as articles, books, and other writings by musicians about their experiences or beliefs regarding music therapy, were included as supplementary sources to enrich the analysis. The study adhered to ethical standards to ensure the rights and confidentiality of all participants. Informed consent was obtained before conducting the interviews, outlining the study's purpose, procedures, and participants' right to withdraw at any time without penalty. The data was stored securely, and pseudonyms were used to protect participants' identities. Audio recordings were kept confidential and deleted after transcription.

Sample and Sampling

The sample for this study consisted of professional musicians, music educators, and music therapists with experience in music therapy or knowledge about its application. The selection of participants was guided by purposive sampling, a non-probability sampling

technique that ensures participants have specific characteristics relevant to the research questions (Campbell et al., 2020). Purposive sampling enables researchers to target individuals with relevant expertise and experience in music therapy. This study included 12 participants. The sample was selected based on the following criteria: a) musicians who have either formal education or significant professional experience in music; b) musicians who have experience with or knowledge of music therapy practices; and c) music educators or therapists who incorporate music therapy into their teaching or therapeutic practices.

Data Analysis

The data from the semi-structured interviews were analyzed using inductive content analysis. This qualitative method systematically and objectively describes and quantifies specific phenomena by making valid inferences from verbal, visual, or written data. This method is particularly effective for identifying patterns and themes within qualitative data. It involves organizing data into categories or themes, enabling researchers to draw meaningful inferences through inductive reasoning. Through careful examination and comparison of the data, themes emerge naturally, allowing the researcher to derive insights directly from the content without relying on predefined categories or frameworks. This makes inductive content analysis an ideal approach for exploratory research (Bengtsson, 2016; Limna et al., 2022; Rafiyya et al., 2024).

Results

Through an in-depth analysis of the interview data, several themes emerged regarding musicians' perspectives on the impact of music therapy. These themes encompass the emotional impact of music, cognitive and neurological benefits, the role of musicians in therapy, challenges in integrating music into therapeutic settings, and the ethical considerations of music therapy.

Emotional Influence of Music

A predominant theme that emerged from the interviews was the emotional influence of music in therapeutic settings. Musicians emphasized that music has a unique capacity to evoke, regulate, and transform emotions, playing a crucial role in facilitating emotional release, relaxation, and catharsis. Moreover, participants highlighted that elements such as melody, harmony, rhythm, and tempo have a direct impact on emotional responses, often shaping an individual’s mood and mental state. One musician explained how different musical elements can elicit varied emotional reactions:

> *"Music has an unparalleled power to deeply touch emotions, whether it brings joy or provides comfort in times of distress. This emotional connection is what makes music therapy so impactful"* (A respondent, personal communication).

Another respondent emphasized music's ability to foster connections and enhance communication, particularly in therapeutic settings where verbal expression may be challenging. For individuals experiencing anxiety, depression, or trauma, music provides a non-verbal outlet for expressing emotions that might otherwise remain unspoken. Additionally, participants noted that certain genres or personalized compositions could be tailored to match an individual's emotional needs, making therapy more effective. Furthermore, several musicians also discussed the psychological and physiological effects of music, noting that calming melodies and slow rhythms can lower stress levels, reduce heart rates, and create a sense of safety, while upbeat tempos can energize and uplift individuals. This ability to modulate emotions and physiological states reinforces music's role as a powerful therapeutic tool, particularly for individuals experiencing emotional distress or communication barriers.

Cognitive and Neurological Benefits

Musicians in the study also highlighted the cognitive and neurological benefits of music therapy, emphasizing its ability to enhance memory recall, focus, and cognitive processing. Many participants shared experiences in which structured musical activities supported neuroplasticity and cognitive rehabilitation, particularly among individuals with cognitive impairments or neurological conditions. One musician with experience in therapeutic music programs noted:

> *"Music engages multiple areas of the brain simultaneously, making it a powerful tool for enhancing memory and concentration. I have seen patients with memory loss react positively to familiar songs, sometimes even recalling forgotten moments"* (A respondent, personal communication).

Participants further explained that rhythmic patterns and repetitive melodies help strengthen neural connections, reinforcing learning and aiding individuals with conditions such as dementia, stroke recovery, and traumatic brain injuries. Some musicians reported that playing or listening to music improved mental clarity and cognitive resilience, particularly among older adults and individuals undergoing rehabilitation. These findings indicate that music therapy contributes to cognitive enhancement and neurorehabilitation by stimulating brain activity, fostering emotional engagement, and improving overall cognitive function.

Musicians' Role in Therapy

Participants also reflected on their perceived role in the music therapy process. While not all musicians considered themselves therapists, they acknowledged their ability to facilitate healing through musical performance and composition. Many recognized the emotional and psychological impact of their work and expressed an interest in deepening their understanding of therapeutic applications. Several musicians emphasized the need for structured collaboration between professional musicians and certified music therapists to enhance therapeutic outcomes. One participant shared:

> *"Musicians create and deliver the music, but working alongside therapists could help bridge the gap between artistic expression and clinical application"* (A respondent, personal communication).

Another musician underscored the importance of understanding the therapeutic intent behind music selection and composition, noting that different musical elements can evoke specific emotional and cognitive responses. This perspective highlighted the value of formal training in music therapy principles, enabling musicians to tailor their compositions and performances to align with therapeutic goals. Overall, participants expressed a desire for greater interdisciplinary engagement between musicians and therapists, advocating for education, workshops, and collaborative frameworks to strengthen the effectiveness of music therapy interventions.

Challenges in Integrating Music into Therapy

Despite the positive perceptions, musicians identified several challenges in integrating music into therapeutic settings. Key concerns included a lack of formal training in therapy-related practices, insufficient recognition of musicians' contributions in healthcare settings, and logistical challenges in implementing live music therapy sessions. One respondent highlighted the complexities involved in using music therapeutically:

> *"There's a misconception that any music can be therapeutic. In reality, it requires careful consideration of individual needs, preferences, and contexts"* (A respondent, personal communication).

Additionally, participants emphasized the need for more accessible music therapy programs that actively involve professional musicians as key contributors. Many advocated for greater collaboration between musicians and certified therapists, as well as increased opportunities for training in therapeutic techniques. Addressing these challenges could enhance the effectiveness of music therapy and expand its reach within healthcare and community settings.

Ethical Considerations in Music Therapy

Ethical concerns also emerged as a significant theme, with musicians raising important questions about the appropriate use of music in therapy, notably regarding consent, emotional vulnerability, and cultural sensitivity. They emphasized the need for ethical awareness in the selection and delivery of music in therapeutic settings. One musician highlighted the potential risks of unintended emotional triggers:

> *Music can be compelling, but it is essential to ensure that it has used ethically. Some songs may trigger distressing memories for individuals, so therapists and musicians need to be mindful of this*.

These insights underscore the necessity of clear ethical guidelines and specialized training for both musicians and therapists. Participants suggested that incorporating ethical

considerations into music therapy education could help practitioners navigate sensitive situations and ensure that music is used in ways that respect individual well-being and cultural contexts.

The findings of this study highlight musicians' unique perspectives on the impact of music therapy. Their insights highlight the emotional and cognitive benefits of music, the role of musicians in therapy, the challenges of integrating music into therapeutic contexts, and the ethical considerations surrounding its application. These perspectives provide valuable insights to inform the development of more effective music therapy programs and to foster stronger collaborations between musicians and healthcare professionals.

Discussion and Conclusion

The findings of this study highlight the significant role of musicians in music therapy, particularly in influencing emotional, cognitive, and neurological responses to music. Participants affirmed that music therapy serves as a powerful tool for emotional regulation, stress reduction, and cognitive enhancement, reinforcing prior research on its therapeutic benefits. Musicians described how elements such as melody, rhythm, and harmony can elicit profound emotional reactions, aid memory recall, and facilitate neuroplasticity. Their experiences illustrate the transformative impact of music on mental and emotional well-being, particularly in populations facing psychological distress, neurodegenerative conditions, or cognitive impairments.

However, the study also highlights key challenges and barriers to the effective integration of music therapy. A primary concern is the lack of formal training in therapeutic techniques, which may limit musicians' ability to tailor their work to clinical needs. Additionally, insufficient recognition of musicians' contributions within healthcare settings was frequently mentioned, suggesting a need for clearer professional pathways and institutional support for musicians in therapeutic roles. These findings suggest that fostering collaborations between musicians and certified therapists could significantly enhance the effectiveness of music therapy interventions, ensuring that artistic expression aligns with clinical and therapeutic objectives (Jun, 2023; Ng, 2022; Permsiriniwas et al., 2025).

Furthermore, this study highlights the complexity of utilizing music as a therapeutic tool. Musicians' perspectives reveal that the effectiveness of music therapy depends on multiple factors, including the selection of music, the listener’s emotional and psychological state, cultural background, and the therapeutic setting. Personalised approaches that tailor music interventions to the specific needs of individuals are crucial for maximising therapeutic benefits (Lai-Tan et al., 2023; Ramirez-Melendez, 2023). Participants also emphasized the importance of ongoing education and interdisciplinary collaboration in refining therapeutic strategies and tailoring interventions to diverse populations. Furthermore, ethical considerations emerged as an essential theme. Musicians emphasised concerns related to

informed consent, emotional vulnerability, and cultural sensitivity, mainly when working with individuals with trauma histories or neurological conditions. Without proper ethical guidelines, music therapy risks triggering unintended distress rather than offering relief. As such, this study reinforces the need for comprehensive ethical training and the development of standardised guidelines to ensure that music therapy is conducted in a responsible, culturally competent, and patient-centered manner (Valkanas, 2020; Wilhelm, 2020).

This study offers valuable insights into musicians' perspectives on music therapy, highlighting their distinctive role as facilitators of emotional and cognitive well-being. While the therapeutic benefits of music are well established, this research introduces a new dimension by focusing on the lived experiences of musicians who create and deliver therapeutic music. By addressing challenges related to training, professional recognition, interdisciplinary collaboration, and ethical considerations, this study highlights key areas for improvement that could help bridge the gap between artistic expression and clinical application. Strengthening these areas will ultimately enhance the impact, accessibility, and effectiveness of music therapy across diverse settings, benefiting both practitioners and patients alike.

Practical and Academic Implications

From a practical standpoint, this study suggests the need for structured training programs that equip musicians with knowledge of therapeutic practices, enabling them to utilize their musical expertise in clinical settings effectively. Establishing interdisciplinary partnerships between musicians, therapists, and healthcare providers can lead to more impactful music therapy interventions. Additionally, healthcare institutions should recognize and integrate professional musicians into therapy programs, leveraging their expertise to enhance patient outcomes. Academically, this study adds to the growing body of literature on music therapy by providing a musician-centric perspective. This highlights the need for further research on integrating music therapy across diverse cultural and clinical contexts. Future studies could explore how technological advancements, such as AI-generated music and virtual reality-assisted therapy, can further enhance the therapeutic applications of music. By expanding the discourse on music therapy through both practical and academic lenses, this research paves the way for a more comprehensive understanding of music’s role in healing and well-being.

Limitations and Recommendations for Future Research

This study provides valuable insights into musicians' perspectives on music therapy; however, several limitations should be acknowledged. First, the study relies on qualitative data from a relatively small sample, which may not fully represent the diverse experiences of musicians involved in therapeutic settings. A larger, more diverse participant pool, including

musicians from different cultural and musical backgrounds, could offer a broader understanding of the topic. Second, the study primarily explores musicians' perceptions, rather than incorporating the views of certified music therapists, healthcare professionals, or patients who receive music therapy. Future research should adopt a multi-perspective approach, integrating insights from these key stakeholders to provide a more comprehensive evaluation of music therapy's impact. Additionally, this study focuses on semi-structured interviews, which, while effective in capturing in-depth perspectives, may benefit from being supplemented with longitudinal studies or observational research to assess how musicians' involvement in therapy evolves. For future research, it is recommended that the effectiveness of collaborative models between musicians and certified therapists be explored, with particular attention to how structured partnerships influence therapeutic outcomes. Investigating the impact of formal training programs for musicians in therapy-related practices could also provide insights into bridging the gap between artistic expression and clinical application. Furthermore, given the ethical concerns raised in this study, future studies should focus on developing standardized ethical guidelines for musicians engaged in therapeutic work, ensuring responsible, culturally sensitive practices. Lastly, as digital and AI-assisted music therapy continues to grow, future research could explore the role of technology in expanding access to music therapy and how musicians can adapt to these evolving therapeutic landscapes.

References

Ansdell, G. (2014). *How music helps in music therapy and everyday life* (1st ed.). Routledge. https://doi.org/10.4324/9781315587172

Asanprakit, S., & Limna, P. (2023). Understanding the role of social influence in consumers' intention to use social commerce. *Rom Yoong Thong Journal, 1*(2), 103-121. https://so08.tci-thaijo.org/index.php/romyoongthong/article/view/2188

Barnett, K. S., & Vasiu, F. (2024). How the arts heal: a review of the neural mechanisms behind the therapeutic effects of creative arts on mental and physical health. *Frontiers in Behavioral Neuroscience, 18*, 1422361. https://doi.org/10.3389/fnbeh.2024.1422361

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open, 2*, 8-14. https://doi.org/10.1016/j.npls.2016.01.001

Bradt, J., & Dileo, C. (2010). Music therapy for end-of-life care. *The Cochrane Database of Systematic Reviews, 20*(1), CD007169. https://doi.org/10.1002/14651858.CD007169.pub2

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K.

(2020). Purposive sampling: Complex or simple? Research case examples. *Journal of Research in Nursing, 25*(8), 652-661. https://doi.org/10.1177/1744987120927206

Corriero, A., Giglio, M., Soloperto, R., Varrassi, G., & Puntillo, F. (2024). Harnessing the healing power of creativity: Exploring the role of art in healthcare through art, dance, and music therapy. *Advancements in Health Research, 1*(17), 42-46. https://doi.org/10.4081/ahr.2024.17

Feng, Y., & Wang, M. (2025). Effect of music therapy on emotional resilience, well-being, and employability: A quantitative investigation of mediation and moderation. *BMC Psychology, 13*, 47. https://doi.org/10.1186/s40359-024-02336-x

Gabrielsson, A., & Lindström, E. (2010). The role of structure in the musical expression of emotions. In P. N.

Juslin & J. A. Sloboda (Eds.), *Handbook of Music and Emotion: Theory, Research, Applications* (pp. 367-400). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199230143.003.0014

Golden, T. L., Sandu, C. C., Edwards, E. E. (2025). Live music for mental health: A pilot study of how concerts influence mental health stigma, empathy, and resource utilization. *Health Promotion Practice*. https://doi.org/10.1177/15248399241311286

Jun, H. P. (2023). *An exploration into art therapists' experiences of collaboration with music therapists to treat people with autistic spectrum disorder* (Master's thesis). Molloy University. https://digitalcommons.molloy.edu/etd/150/

Koelsch S. (2014). Brain correlates of music-evoked emotions. *Nature Reviews Neuroscience, 15*(3), 170-180. https://doi.org/10.1038/nrn3666

Lai-Tan, N., Philiastides, M. G., Kawsar, F., & Deligianni, F. (2023). Toward personalized music-therapy: A neurocomputational modeling perspective. *IEEE Pervasive Computing, 22*(3), 27-37. https://doi.org/10.1109/MPRV.2023.3285087

Leonardi, S., Cacciola, A., De Luca, R., Aragona, B., Andronaco, V., Milardi, D., ... Calabrò, R. S. (2017). The role of music therapy in rehabilitation: Improving aphasia and beyond. *International Journal of Neuroscience, 128*(1), 90-99. https://doi.org/10.1080/00207454.2017.1353981

Limna, P., Sitthipon, T., Siripipattanakul, S., Jaipong, P., & Auttawechasakoon, P. (2022). The health belief model explaining behavioural changes among Thai people: A qualitative case study of Khlong Phon Subdistrict Municipality, Krabi in Thailand. *Review of Advanced Multidisciplinary Sciences, Engineering & Innovation, 1*(1), 1-15. https://www.researchgate.net/publication/359970451

Ng, E. L. E. (2022). *The collaborative roles of music therapists and teachers in working with children and adolescents with autism spectrum disorder: An integrative review of the literature* (Master's thesis). Chulalongkorn University. https://digital.car.chula.ac.th/chulaetd/8116

Permsiriniwas, P., Kaenampornpan, P., & Vatanasapt, P. (2025). Therapeutic songwriting: Technique in music therapy. *Srinagarind Medical Journal, 40*(1), 115-125. https://li01.tci-thaijo.org/index.php/SRIMEDJ/article/view/265340

Rafiyya, A., Kraiwanit, T., Limna, P., Sonsuphap, R., Kasrisom, A., & Snongtaweeporn, T. (2024). Early childhood social-emotional development: An impact on a developing country. *International Journal of Evaluation and Research in Education, 13*(5), 3081-3089. https://doi.org/10.11591/ijere.v13i5.29462

Ramirez-Melendez, R. (2023). Personalizing music interventions. In *Neurocognitive Music Therapy: Intersecting Music, Medicine and Technology for Health and Well-Being* (pp. 83-89). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-48635-7_7

Rodríguez-Rodríguez, R. C., Noreña-Peña, A., Cháfer-Bixquert, T., de Dios, J. G., & Ruiz, C. S. (2024). The perception of healthcare professionals, through their own personal experiences, of the use of music therapy in hospitalised children and adolescents. *Journal of Pediatric Nursing, 77*, 63-73. https://doi.org/10.1016/j.pedn.2024.02.030

Siponkoski, S. T., Martínez-Molina, N., Kuusela, L., Laitinen, S., Holma, M., Ahlfors, M., ... & Särkämö, T. (2020). Music therapy enhances executive functions and prefrontal structural neuroplasticity after traumatic brain injury: Evidence from a randomized controlled trial. *Journal of Neurotrauma, 37*(4), 618-634. https://doi.org/10.1089/neu.2019.6413

Syarifani, N. (2024). Implications of music therapy as a form of catharsis and emotional relaxation. *Happiness: Journal of Psychology and Islamic Science, 8*(1), 1-11. https://doi.org/10.30762/happiness.v8i1.2136

Ugwu, C. N. & Eze, V. H. U. (2023). Qualitative research. *Idosr Journal of Computer and Applied Sciences, 8*(1), 20-35. https://www.idosr.org/wp-content/uploads/2023/01/IDOSR-JCAS-8120-35-2023.docx.pdf

Valkanas, K. (2020). Ethical issues in art therapy (4th edition) (Enjeux éthiques en art-thérapie) by Bruce L. Moon and Emily Goldstein Nolan. *Canadian Journal of Art Therapy, 33*(2), 91-92. https://doi.org/10.1080/26907240.2020.1844467

Weng, Q., Liu, Y., & Zhang, J. (2024). The impact of music therapy on individuals with autism. *MedScien, 1*(10), 1-5. https://doi.org/10.61173/ccghjj65

Wilhelm, K. (2020). Ethical considerations in music therapy private practice: A review of the literature. *Music Therapy Perspectives, 38*(1), 25-33. https://doi.org/10.1093/mtp/miz028