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Review of the Ph.D. Dissertation by Michał Pieniak

"*Sensory, emotional, and cognitive effects of olfactory training in children and adolescents*"

(„*Wpływ treningu węchowego na funkcjonowanie sensoryczne, emocjonalne i poznawcze dzieci i adolescentów*")

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Michał Pieniak's dissertation is located in the domain of psychology of olfaction. The topic chosen is very timely, interesting and important. For many decades human olfaction had been on the margin of psychologists' interest. Yet, with the COVID-19 pandemic, the situation changed, as the infections very often caused olfaction deteriorations. By the same token, effective methods of rehabilitation became badly needed. The dissertation addresses that need and has a clear application aspect. The research conducted by the Candidate has also theoretical value as it helps in a better understanding of mechanisms of olfaction and their ontogenetic development. It must be stressed that the research has a path-breaking character in psychology and is challenging as so far only a handful of standardized methods measuring olfactory sensitivity and odor identification in children have been available.

The dissertation is divided into following parts: the short abstracts in English and Polish, the list of publications, the introduction, the presentation of the content of five published papers, the general discussion, and the five papers in English, published in leading academic journals. The Candidate is the co-author of all papers,. Two of the said papers are *brief reports*. Co-authors statements concerning their substantive contribution and percentage share in the reports' development are missing (which is concerning as such information is especially important in doctoral dissertation reviews). The Candidate included only the information about his own contribution to each publication. In the case of one paper, the information is also present in that very paper.

The analysis of the submitted material allows me to conclude that, with respect to every paper submitted for my evaluation, the Candidate was responsible for their writing, reviewing and editing; in three papers he was responsible for problem conceptualization, methodology development, investigation and data analysis; in one paper, he contributed to by literature review. Consequentially, I can assume that the presented papers constitute to a great extent his individual contribution to science.

The list of publications presented as the doctoral dissertation contains the following contributions:

1. Pieniak. M., Oleszkiewicz, A., Avaro, V., & Hummel, T. (2022). Olfactory training – Thirteen years of research reviewed. *Neuroscience & Biobehavioral Reviews, 141*, 104853. https://doi.org/10.1016/J.NEUBIOREV.2022.104853
2. Mahmut, M.K., Pieniak, M., Resler, K., Schriever, V.A., Haehner, A., & Oleszkiewicz, A. (2021). Olfactory training in 8-year-olds increases odour identification ability: a preliminary study. *European Journal of Pediatrics, 180,* 2049-2053. https://doi.org/10.1007/s00431-021-03970-y
3. Pieniak, M., Seidel, K., Oleszkiewicz, A., Gellrich, J., Karpinski, C., Fitze, G., & Schreiver, V.A. (2023). Olfactory training effects in children after mild traumatic brain injury. *Brain Injury, 37* (11), 1272-1284. https://doi.org/10.1080/02699052.2023.2237889
4. Pieniak, M., Rokosz, M., Nawrocka, P., Reichert, A., Żyżelewicz, B., Mahmut, M.K., & Oleszkiewicz, A. (2024). Null cross-modal effects of olfactory training on visual, auditory or olfactory working memory in 6-to 9-year-old children. *Neuropsychological Rehabilitation*, 1-22. https://doi.org/10.1080/09602011.2024.2343484
5. Pieniak, M., Rokosz, M., Ivcevic, Z., Reichert, A., Żyżelewicz, B., Nawrocka, P., Lebuda, I., & Oleszkiewicz, A. (2024). Olfactory training improves emotion matching ability in 6–9 years old children—preliminary evidence. *Journal of Sensory Studies, 39* (2), e12912. https://doi.org/10.1111/joss.12912

The starting point of the Candidate's investigation was an assumptions concerning the specificity of olfaction, i. e. its flexibility, ability to regenerate and unique neuroanatomical architecture. Olfactory stimuli activate the limbic system which is of particular interest, as - as

a result - they are processed in an emotional way and that can influence memory processes. In this context, the Candidate formulated the hypothesis that olfactory training (OT) can impact not only olfactory functions, but also emotional and cognitive ones. In the psychological literature, one can find data originating from research in adults corroborating this hypothesis. Yet, there are no analogical data from any research involving younger participants. The dissertation fills in the gap in psychological knowledge in the form of one review article and three pieces of research described in four articles.

The first publication (Pieniak, Oleszkiewicz, Avaro, & Hummel, 2022) is a review of empirical data concerning effectiveness of OT. They present results of clinical research of rehabilitation of olfaction after damages; they also discuss often postulated training influence mechanisms and challenges very often presented in relevant studies. The review showed that OT was effective in adults and that evidence from research with children was missing. I value highly that paper as it is very well elaborated and included numerous data and a critical analysis. It represents a good theoretical grounding for the Candidate research, described in his later papers. It will certainly help other researchers plan their own studies.

The second paper submitted for the review (Mahmut, Pieniak, Resler, Schriever, Haehner, & Oleszkiewicz, 2021) contains the report from a study aimed at verification of whether OT in 8-years old conducted in school settings results in a better olfactory sensitivity and odor identification. No changes in the olfactory threshold were found, but odor identification appeared to be better and that effect was present also in a longer run. It is an interesting result that can be interpreted as an evidence of higher odor awareness and better odor processing even after the end of OT.

The third paper (Pieniak, Seidel, Oleszkiewicz, Gellrich, Karpinski, Fitze, & Schreiver, 2023) presents a study examining OT results for both olfactory and cognitive functioning in a group of children and adolescents (aged 6 to 16) after mild traumatic brain injuries contrasted with a group of their healthy peers. Two OT variants were used: one with high and another with low odor concentration. The research showed that OT with low-concentration odors was beneficial for olfactory sensitivity in participants after mild traumatic brain injuries. In both groups the indices of fluid intelligence were higher. But no effects were observed as far as working memory was concerned. A stronger impact of low-concentration odors is an unexpected and interesting finding. Thus, this research should be replicated in more studies.

The fourth research is presented in two papers (Pieniak, Rokosz, Nawrocka, Reichert, Żyżelewicz, Mahmut, & Oleszkiewicz, 2024; Pieniak, Rokosz, Ivcevic, Reichert, Żyżelewicz, Nawrocka, Lebuda, & Oleszkiewicz, 2024). Its main goal was to verify whether OT can improve working memory indices in three modalities (vision, audition, olfaction), and enhance ability to match emotional face expressions in 6 to 9 year olds. The research showed that indices of working memory did not change, but the ability to match emotional face expressions improved. Such results call for more research confirming OT influence in emotional assessment tasks. I evaluate positively the four empirical papers as they were well prepared and include new and interesting data.

The most important criterion of scientific work assessment is its contribution to knowledge, being an original solution of a scientific problem. The dissertation meets that criterion. Firstly, the obtained results demonstrated OT beneficial influence in children and adolescents with olfactory dysfunctions and healthy ones enjoying better odor identification and sensitivity. It must be stressed that positive outcomes were present even after the end of training. Secondly, the results demonstrate some impact of OT on cognitive and emotional functioning. Still many issues remain open. Namely, more research is needed, with application of different methods, to make it possible to unequivocally define potential OT benefits. The Candidate rightly noted that more neuroimaging research had to be performed, helping better describe and explain OT mechanisms at the brain level.

The dissertation represents a consistent set of theoretical analyses and research. The obtained results significantly contribute to knowledge about olfactory functioning, and possibility of its improvement in children and adolescents. By the same token, they fill in a gap in the existing knowledge.

The research and its results prompt some interesting questions. Firstly, will different odors also give positive effects? Secondly, are OT effects stronger and more durable in children and adolescents as compared to adults? Thirdly, do OT effects differ, and if yes how, in healthy people as contrasted with those suffering from olfactory dysfunctions of varied etiology? Also interesting is the question to what extent the revealed effects are universal or depend on the environment one lives in? As we know, environmental conditions influence olfactory functioning. Should we expect that in people with higher olfactory functioning OT effects would be weaker? And lastly: which other methods for measuring cognitive and

emotional functioning could be used to augment the probability of showing OT positive outcomes?

The assessment of the methodological side of the dissertation calls allows me to acknowledge the Candidate's high competence in launching and implementing empirical research. He performed a critical analysis of the existing research and their procedures, modified them according to his needs and used the resulting research design adequately for the hypotheses; he also chose adequate sophisticated statistical methods for the analyses. I feel urged to stress the following aspects: (1) careful selection of participants, and their number relatively high as the procedure is concerned; (2) utilization of earlier results of own research in planning next ones; (3) employment of verified methods for measuring working memory and fluid intelligence, as well as modifications of methods employed in earlier research; (4) caution in formulating conclusions on the basis of the obtained results; (5) the awareness of the limitations of the research and propositions of future one giving the possibility to a further knowledge widening.

From the editorial, formal, point of view, the dissertation fulfills all the requirements of scientific psychological publications. The papers are published in renowned journals caring about highest content and editorial standards. The Candidate carefully prepared the papers and all the materials presented as the doctoral dissertation.

In conclusion I state that the dissertation „*Wpływ treningu węchowego na funkcjonowanie sensoryczne, emocjonalne i poznawcze dzieci i adolescentów*" ("*Sensory, emotional, and cognitive effects of olfactory training in children and adolescents*") meets the requirements of the Polish law, i .e. Art. 187 ust. 3 of Law of 20 July 2018 – Law on higher education and science (Official Journal 2023. item 742 with further amendments). Thus, I recommend to admit Michał Pieniak to further steps of the doctoral procedure.