



The impact of a sensory education on gustatory and olfactory perception in Austrian school children aged 11 to 14 – A consideration of long-term effects

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ABSTRACT

A sensory based education aims to stimulate sensory skills and enhance sensory perception through an experimental approach and is supposed to help making positive food experiences. As the first part of our study confirmed the hypothesis that a sensory education program has a short-term impact on gustatory and olfactory perception (within one month after a sensory intervention) in school children aged 11 to 14 years, we decided to evaluate long-term effects 6 months and 12 months after the sensory education was carried out. A statistically significant increase ($p < 0.05$) could be found in taste recognition (overall and individual taste qualities) for the education group but not for the control group. In both groups a statistically significant difference ($p < 0.05$) was observed for selected odorants. The results demonstrate a lasting effect of a sensory training over a longer period of time without further sensory stimulation. On the basis of these findings and the existing literature we recommend the implementation of a sensory based education in school in order to contribute to the nutrition literacy concept.

1. Introduction

It is a matter of fact that nutrition and food choice have a great impact on human health and on the environment. According to Willett et al. (2019) poor health and environmental degradation are inevitably linked to existing food systems and are the major health challenges of our time. On this account it is of the utmost importance to provide future generations with appropriate skills and find effective and feasible strategies in order to meet these challenges. However, in this context, nutrition literacy has to be considered as an essential element in the education system.

It appears from research that a simple but also effective tool of a contemporary nutrition and consumer education seems to be a sensory based education in children. The training of sensory skills can activate chemosensory awareness, as well as stimulate and enhance sensory perception. Furthermore, it helps to explore new and unfamiliar foods and create favorable food experiences.

A variety of positive effects of a sensory based education have been reported from different studies with children, such as a decrease of food neophobia (Mustonen & Tuorila, 2010; Reverdy, Chesnel, Schlich, Köster, & Lange, 2008), an increase of food acceptance (Reverdy,

Chesnel, Schlich, Köster, & Lange, 2008; Reverdy, Schlich, Köster, Ginon, & Lange, 2010), an increase of knowledge in nutrition and food (Battjes-Fries & Haveman-Nies, 2016) or an increase of sensory perception (Majchrzak & Altmann, 2013).

On that basis, we planned a study, which objective it was to find out whether a sensory based education has an impact on the function of chemical senses, especially on gustatory and olfactory perception in children at the age of 11 to 14 years. The hypothesis was that an implementation of a sensory program within the course of the Austrian school curriculum, integrated in the subject nutrition and household, can enhance taste and odor abilities and therefore contributes to a modern nutrition and consumer education. As the first part of the study (Wahl & Majchrzak, 2019) has shown a short-term effect (within 1 month after training) of a sensory education (significant differences between the education group with a sensory training and the control group without any intervention), it was interesting to continue the investigation to observe long-term effects. The results of these evaluations, 6 and 12 months after the sensory training, are presented in the current paper.

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2. Theory

The concept of a sensory based education implies a practical access to educate sensory skills and offers the possibility to learn through experience (Rigal et al, 2021). The hands-on approach and the interaction with food in various ways are highlighted in many studies (Højer et al., 2021). These aspects are considered to be a winning strategy as far as effective teaching methods are concerned. Moreover, it seems reasonable to assume that a sensory based education has the potential to meet the requirements of nutrition and consumer education and contributes to nutrition literacy.

Rigal et al. (2021) concludes that, even though there are differences in content and methodologies of the published literature, the effects of a sensory education seem to be positive in general. Although there is a number of studies which evaluated effects of a sensory education, there is still a lack of data regarding the lasting effects of a sensory training without further stimulation. Mustonen et al. (2009), for example, found an education effect of a sensory training in taste and smell perception, as well as in characterizing foods in 7–11-year-old school children. But the evaluated long-term effects were inconsistent over time. However, the overall improvement was rather small and appeared mainly for the younger pupils in the study. Within the same study population Food Neophobia scores were evaluated, which decreased after the sensory education (Mustonen & Tuorila, 2010). A lasting effect could be observed in the group with one wave of a sensory education. Especially in younger children the Food Neophobia score decreased after the training and stayed at the same level in the follow up evaluations, whereas in older children the score rose again in the end. Long-term effects in the group with two waves of sensory education were not evaluated and are unknown. Similar results were reported in a French study, where Food Neophobia decreased and the willingness to taste novel food increased after a sensory education, but effects did not remain 10 months afterwards (Reverdy, Chesnel, Schlich, Köster, & Lange, 2008). However, the authors did find a lasting effect after 10 months in the education group as far as the liking of products (with different arousal potential) are concerned (Reverdy, Schlich, Köster, Ginon, & Lange, 2010). Thus, it appears that long-term effects of a sensory education are visible, even though published results are very divers and further investigations are needed.

Therefore, we decided to expand our study and carried out a second part, in which evaluations 6 months (follow up 2) and 12 months (follow up 3) after the sensory education were performed in order to contribute to the state of research and gain information on the question how long the impact of a sensory education may last, which is a key element in planning an implementation in the school curriculum.

3. Material and methods

3.1. Participants

258 children at the age of 11 to 14 years from four secondary schools in Upper Austria participated in the current project. 234 pupils were included in the data analysis considering the long-term effects of a sensory education, as the data set was restricted to those pupils who were present in all 4 evaluations and were not older than 14 years at the time of the baseline measurement. The ethical committee of the province of Upper Austria, the Institutional Review Board at the University of Vienna, as well as the provincial education authority of Upper Austria, the principals of the schools and all the parents of the children were informed and provided their consent that the project could be carried out.

3.2. Study design

At the beginning of the study a baseline evaluation was conducted with all participating pupils, which consisted of a taste recognition test

according to DIN 10962 (1996) and ISO 3972 (1991) and an odor identification test using Sniffin'Sticks (Burghart GmbH, Germany). Following the first phase, one part of the study population (education group) took part in a sensory training over a period of 6 months. The sensory education program included 6 units (1 unit per month) and focused on the theory of the five senses and their practical applications, included different tastings and ended with a cooking class. The individual lessons lasted about 50 min, as they were integrated in the regular timetable of the children. Follow up evaluations (same conditions as at the baseline) within 1 month after completion of the training (follow up 1), as well as 6 months (follow up 2) and 12 months (follow up 3) afterwards were conducted with both groups.

The detailed information on material and methods is visible in the publication of Wahl and Majchrzak (2019), which described the short-term effect of a sensory education in the evaluated cohort.

3.3. Statistical data analysis

The analyzation of the data was carried out with Microsoft Excel 365 and RStudio Project for statistical Computing in version 3.5.1 (www.r-project.org). Correctly identified taste and smell stimuli were evaluated for each pupil as well as the mean numbers and standard deviations. For the normally distributed data the Shapiro-Wilk Test was used and to find differences on consecutive measurements between the investigated groups the Wilcoxon-Mann-Whitney Test was applied. The Exact Fisher Test with a 0.05 level of significance showed whether there is a significant difference between the two groups and the different evaluations for all smell and taste stimuli.

4. Results

4.1. Effect of training on gustatory and olfactory perception over the entire evaluation period

In the recognition of taste and odor qualities a difference between the control and education group could be observed in the mean values in all follow up evaluations. As reported in a previous publication (Wahl & Majchrzak, 2019) a short-term effect of a sensory education was visible within 1 month after the training. A statistically significant increase ($p < 0.001$) of gustatory perception could be found in the education group and a slight enhance in olfactory perception appeared in both groups. The present results also indicate a long-term effect of a sensory education, as there are still differences between the evaluated groups 6 months (follow up 2) and 12 months (follow up 3) after the sensory intervention (Fig. 1).

4.2. Taste recognition

Although a decrease of the mean values of the recognized taste qualities could be observed in the education group in the follow up 2 as well as in the follow up 3 evaluations in comparison to the follow up 1 (from 2.89 ± 1.51 in follow up 1 to 2.50 ± 1.54 in follow up 2 and to 2.38 ± 1.43 in follow up 3), the education effect was still present and statistically significant at both time points (follow up 2: $p < 0.01$; follow up 3: $p < 0.05$) compared to the baseline determination (1.79 ± 1.32), which indicates a lasting effect of the sensory training over the period of 6 and 12 months (Fig. 1). Fig. 1 also illustrates the course of changes in taste perception of the control group. The trend shows a decrease of the mean number of correctly identified taste qualities at the follow up 2 measurements (from 1.94 ± 1.46 in follow up 1 to 1.83 ± 1.32 in follow up 2) and afterwards an increase to 2.07 ± 1.40 at the follow up 3 time point. However, the differences were not statistically significant compared to the baseline evaluation, as well as between the follow ups (Table 1).

The analysis of the individual taste qualities underlines the different development in the taste perception between the two investigated

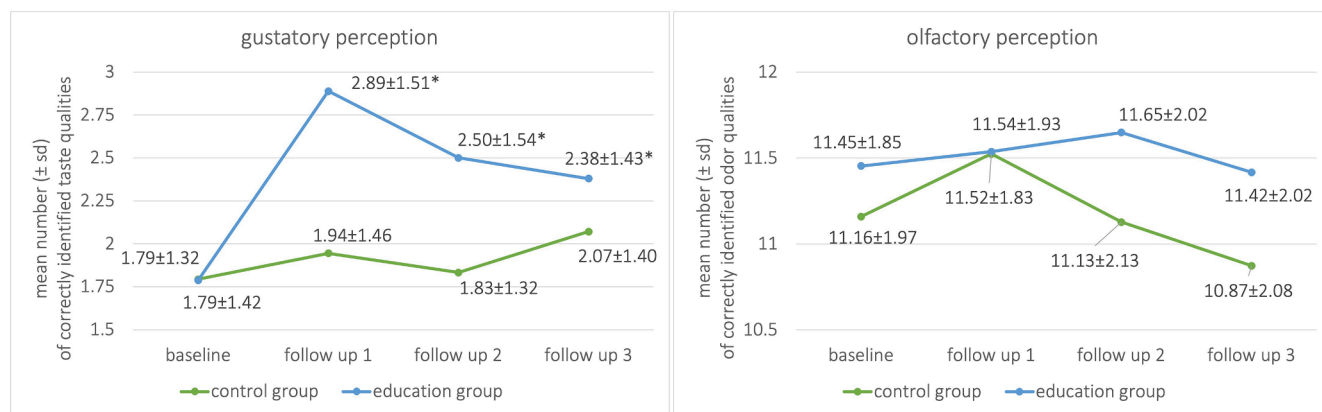


Fig. 1. Trends in the overall recognition of taste and odor qualities during the entire evaluation period (baseline, follow up 1, follow up 2, follow up 3) in control and education group (*significant change to baseline, $p < 0.05$).

Table 1

Comparison of the p-values in gustatory perception over the evaluation period (*significant change between evaluations, $p < 0.05$).

Evaluations	p-values control group	p-values education group
baseline – follow up 1	0.8286	0.0000*
baseline – follow up 2	0.9960	0.0019*
baseline – follow up 3	0.3954	0.0150*
follow up 1 – follow up 2	0.9227	0.2012
follow up 1 – follow up 3	0.8896	0.0500
follow up 2 – follow up 3	0.5329	0.9290

groups. The statistically significant ($p < 0.05$) improvement in the recognition of four basic taste qualities (umami, sourness, saltiness and bitterness) after the sensory education, which was visible at the follow up 1 evaluation (Wahl & Majchrzak, 2019) was still observed 6 months (follow up 2) and 12 months after training (follow up 3) (Fig. 2). The

present results also show a statistically significant ($p < 0.05$) improvement of recognition in four out of the five basic taste qualities in comparison to the baseline evaluation. The identification of the bitter taste remained at a similar level in both evaluations (follow up 2: $p < 0.05$ and follow up 3: $p < 0.01$) and decreased for the taste quality umami in follow up 2 and 3, but the change compared to the baseline level was still significant ($p < 0.001$). The alteration in the recognition of sourness was still significant in the follow up 2 ($p < 0.001$) but decreased on a not significant level in the follow up 3 evaluation. The significant increase ($p < 0.01$) for salty was visible right after the training and disappeared after 6 months. However, the percentage of the correct identification increased again on a significant level ($p < 0.05$) after 12 months. Although the level of recognition was highest in sweet, the differences were not significant at all 3 follow up time points but rather constant.

For the control group, no statistically significant changes could be found in the analysis of the individual taste qualities in all follow up evaluations. A moderate, but insignificant improvement of recognition

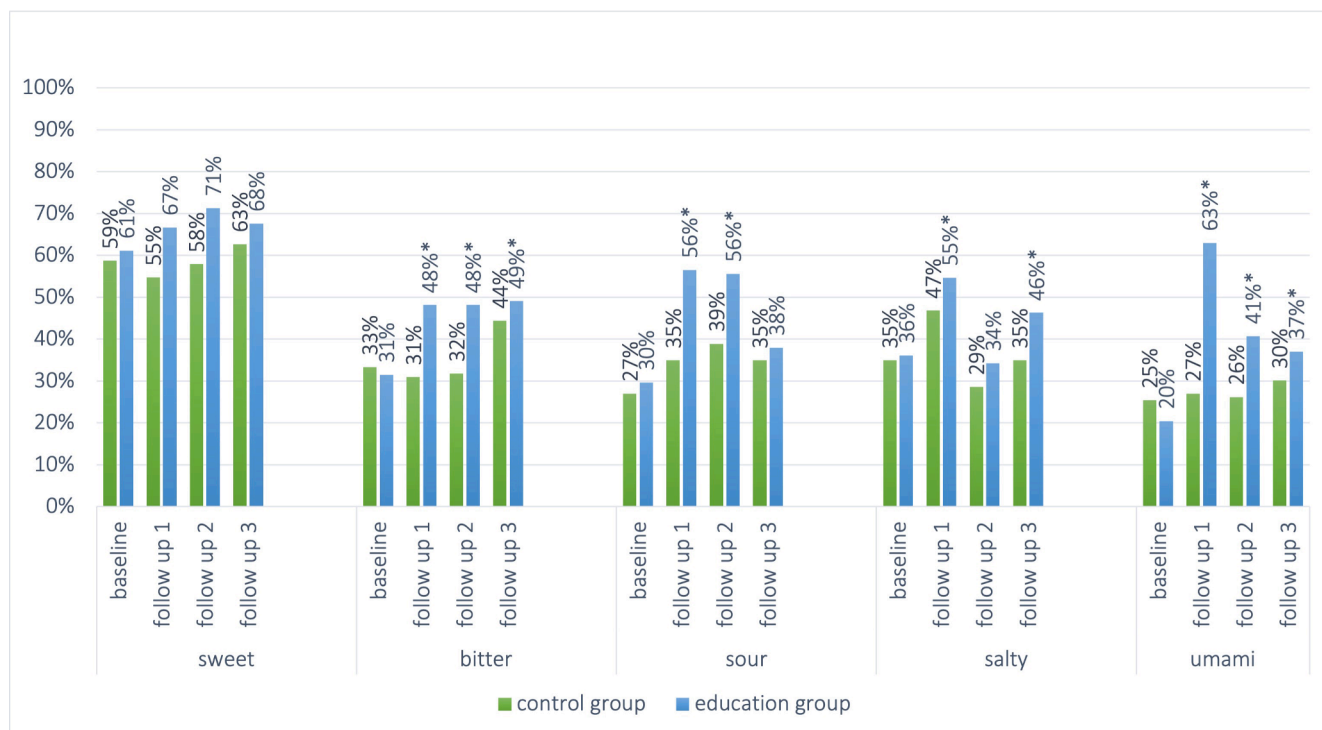


Fig. 2. Percentage of correctly identified taste qualities by children per session (baseline, follow up 1, follow up 2, follow up 3) in control and education group (* significant change to baseline, $p < 0.05$).

could be found in sour and umami for all follow up evaluations, in salty for the first follow up and in bitter and sweet for the third follow up.

4.3. Odor identification

Although the differences in the number of correctly identified odor qualities are neither significant nor very distinctive between the two investigated groups, the gap increased 6 months as well as 12 months after the sensory education (Fig. 1). For the education group a further enhance of the mean values was visible in the follow up 2 evaluation (11.65 ± 2.0), which decreased on a lower level similar to the baseline (11.42 ± 2.15) in the follow up 3 measurement after 12 months. In the control group the mean number of the correctly identified odors declined below baseline level to 11.13 ± 2.13 in follow up 2 and to 10.87 ± 2.08 in follow up 3 (Fig. 1) determinations.

Equally to the reported results of the follow up 1 evaluation (Wahl & Majchrzak, 2019) a statistically significant difference ($p < 0.05$) in both groups appeared in specific odorants in all further follow up evaluations. Although orange was one of the most frequently recognized odor qualities at the baseline in both investigated groups, a significant decrease in the identification could be found within 1 month (follow up 1) after the sensory training ($p < 0.05$), as well as 6 ($p < 0.05$) and 12 months ($p < 0.001$) afterwards for the education group and for the control group in the follow up 2 and 3 evaluation ($p < 0.01$). A significant decrease ($p < 0.01$) could also be found for the odor quality lemon for both groups at all measurement time points (Fig. 3). Additionally, a decrease of identification for odorant pineapple was observed in the control group in all follow up evaluations, which was significant for follow up 2 ($p < 0.05$) and follow up 3 ($p < 0.01$). A consistent increase of identification could be found for the odor quality banana in both investigated groups, which was statistically significant ($p < 0.05$) in follow up 2 for the education group and in follow up 2 and 3 evaluations in the control group (Fig. 4). Additionally, a continuous increase appeared for the odorant shoe-leather in the education group (follow up 3, $p < 0.05$) and anise in the

control group (follow up 2 and 3, $p < 0.05$). Fig. 4 shows selected odorants (peppermint, fish, licorice, rose and apple in both groups; coffee and cinnamon in the education group and clove and anise in control group), which identification increased moderately or stayed at a similar level compared to the baseline measurement both in the education group, as well as the control group at all evaluation time points.

5. Discussion

The results of the present study clearly support our hypothesis, that a sensory based education implemented in the regular lessons of the subject nutrition and household has an impact on gustatory and olfactory perception of children at the age of 11 to 14 years, which is demonstrated in the increase of taste and odor recognition. Moreover, we also found a lasting effect of a sensory education over a longer period of time without any further sensory stimulation.

The data revealed differences between the two investigated groups (education and control group) 6 months, as well as 12 months after the sensory training. A statistically significant increase ($p < 0.05$) could be found in the taste recognition for the mean values of five basic tastes and for the individual taste qualities sour, bitter, salty and umami for the education group but not for the control group.

In the odor identification a slight enhance in the mean number of correctly recognized samples was visible in both evaluated groups. A statistically significant difference ($p < 0.05$) was observed for selected odorants, such as lemon, orange and banana, in the education and the control group. The found decrease of identification in orange and lemon might be due to a mix up with other possible choices or odors within the citrus fruit family. A possible explanation for the high identification rate and the additional increase in banana could be the exposure since early childhood and the repeated confrontation at the evaluation time points in both groups. A rather high baseline level could also be observed for most of the odorants with a stable identification rate in the follow up sessions, except from anise and apple. In the case of anise, the lower

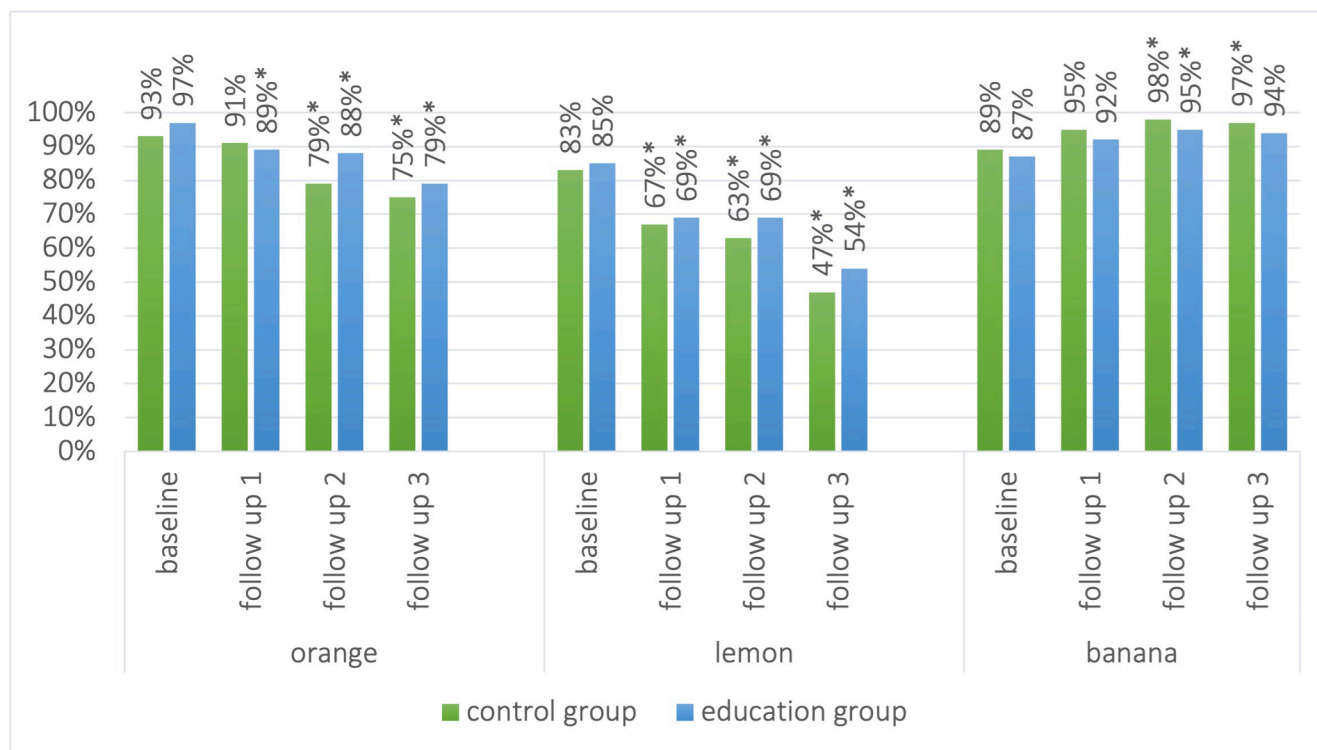


Fig. 3. Changes of correctly identified odor qualities orange, lemon and banana by children per session (baseline, follow up 1, follow up 2, follow up 3) in control and education group (* significant change to baseline, $p < 0.05$). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

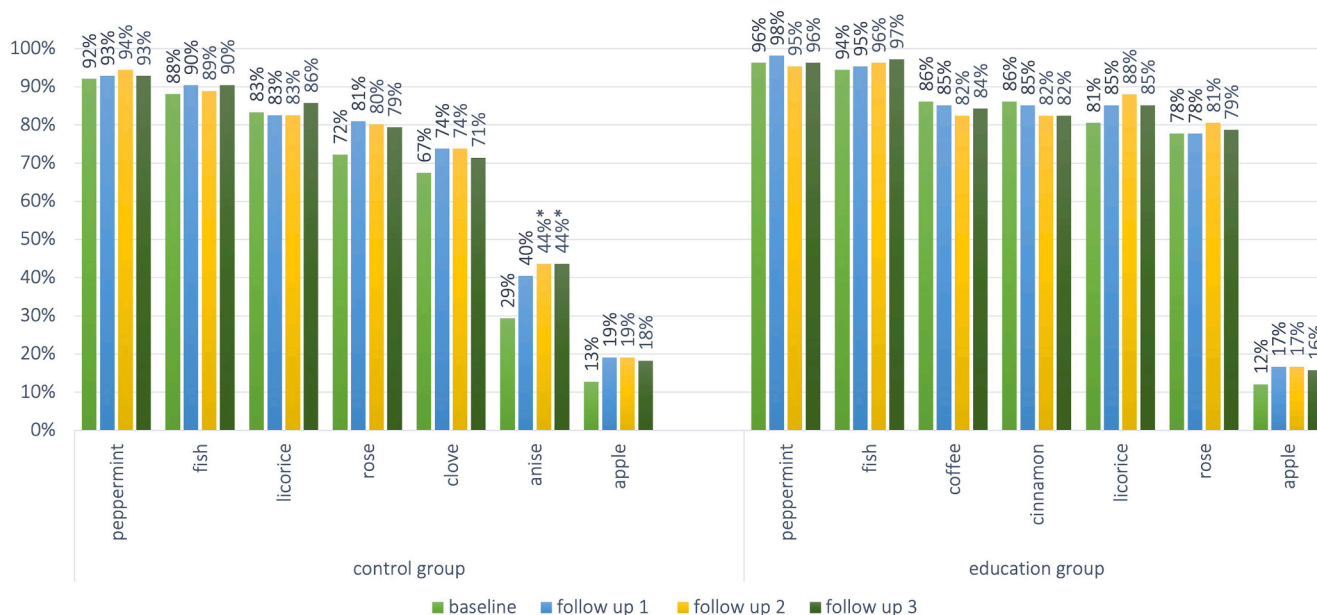


Fig. 4. Identification of odors remained stable in all follow up sessions (baseline, follow up 1, follow up 2, follow up 3) compared to baseline or at baseline level in control and education group (* significant change to baseline, $p < 0.05$).

identification rate might be the result that the odorant is not very well known within this age group. However, this does not apply for the odorant apple. The low recognition of apple is very likely due to the synthetic version of the apple odor in the SniffinStick, as similar results were observed in other studies (Dürschmid et al., 2008; Majchrzak & Altmann, 2013).

The availability on data regarding the long-term effects of a sensory based education on gustatory and olfactory perception is very limited. Only a few studies have investigated this issue and although lasting effects occurred in two of the investigations (Mustonen & Tuorila, 2010; Reverdy, Schlich, Köster, Ginon, & Lange, 2010), others reported either inconsistent results over the evaluated period (Mustonen et al., 2009) or disappearing effects after a while (Reverdy, Chesnel, Schlich, Köster, & Lange, 2008). Additionally, the various methods, differences in the duration time of the programs and differences in the evaluated parameters make it difficult to compare the existing data with one each other.

Nevertheless, an interesting aspect to look at is the structure of the sensory education program of the cited studies. The study of Reverdy, Chesnel, Schlich, Köster, & Lange (2008) consisted of 12 lessons over 4 months and contained theoretical background on the five senses and their interactions, a cooking workshop, a restaurant visit and tastings of unfamiliar foods and regional specialties. Mustonen et al. (2009) started with 9 sensory lessons over 3 months that included theory, discussions and practical inputs on the 5 senses as well as on regional and ethnic foods and a restaurant visit. Within the mentioned study a second wave of 5 lessons on specific food categories (theory, preparations and tastings) was carried out one year afterwards. The comparison illustrates, that this aspect might play a minor role as far as the effects of a sensory education are concerned, as both studies exhibit a higher amount of lessons and a broader content compared to the present evaluation. Although the sensory training in our investigation shows a similar content (theory of five senses and their practical applications, tastings, cooking workshop) and was carried out during a period of 6 months, we only held 6 units with 50 min each, and the lasting effects were more significant and stayed on longer time. A possible explanation could be that the sensory training was best possible integrated in the timetable of the school subject nutrition and household and was therefore linked to other content.

Generally, a positive impact of a sensory based education, independently of its design, is reported by different studies in this field and a

broad agreement on its advantages does exist.

6. Conclusion and perspectives

Although there is increasing evidence for the effectiveness of a sensory based education, too little attention is given to the stimulation and training of sensory skills in children as an important element of a modern nutrition and consumer education. On this account the present study was conducted in order to provide a basis for the integration of a sensory based education in the course of the Austrian school curriculum.

The findings of the current study show a significant impact of a sensory education on gustatory and olfactory perception in school children at the age of 11 to 14 years, which also lasts one year after the intervention took place. Furthermore, they underline the outcome of previous research, close an existing research gap regarding the effectiveness and realization of a sensory education program.

The arguments given above as well as our results lead to the conclusion that any sensory stimulation, independent on content and duration, can have positive effects for the children in various age groups. This aspect also allows a great degree of flexibility as far as the practical application of a sensory education program is concerned, which is an important criterion in order to implement a sensory based education in the school environment.

In summary, we definitely recommend and support the introduction of a sensory education in school, as it is a simple but effective approach in children's nutrition and consumer education.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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