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The Effects of Odor on Vocabulary Learning

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Abstract

Explicit vocabulary learning is a burden for most of the students. But vocabulary is the basis of each language, and not all words can be acquired incidentally through context or reading. Especially for content and language integrated learning in L2 it is important to offer lots of support for learning a large number of terms in order to avoid frustration and negative impact on motivation for the subject. This classroom study investigated the effects of odor on L2 vocabulary learning. The olfactory sense is connected with the limbic system and therefore associated with emotions and motivation. Young EFL Learners (n=158) were randomized to 7 different groups to compare the effects on retention of vocabulary, on motivation and concentration. A mix of essential oils that is proven to enhance concentration and vigilance was given as support. Major finding found as a result of the testing was the positive correlation with the time during a school day the odor was offered as support.

Keywords: *CLIL, Bilingual Biology Teaching, Vocabulary Learning, Olfactory Sense*

Introduction

Being multilingual can be of great advantage in a globalized world. Neuroscientists proved that early multilingualism shows positive effects on higher empathy, better impulse control, and better metalinguistic awareness (Mechelli et al. 2004; Della Rosa et al. 2013; Franceschini et al., 2003). Bilingual and multilingual children have advantages in learning new languages (Nitsch, 2007; Wattendorf et al., 2001). Speaking at least English as a second language (L2) on a high level supports students succeeding their academic and professional pursuits. More and more business meetings are conducted in English, and English became the universal language of science for example (Drubin & Kellogg, 2012).

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Considering the need of students to start using English as L2 as early as possible, the usual few hours a week of compulsory English lessons at school doesn´t seem to be sufficient. To increase the amount of exposure to the target languagemethodologies like CLIL (Content and Language Integrated Learning) could help. This European dual-focused educational approach, in which an additional language is used for the learning and teaching of content and language,has the objective of promoting both content and language mastery to pre-defined levels (Marsh & Frigols, 2010).

Studies on the effectiveness of CLIL show positive impact on L2 competences (Köller et al., 2012; Nold et al., 2008; Zydatiß, 2007) and on motivation for subject (Rumlich, 2014; Abendroth-Timmer, 2007). But a lack of language skill could alsohave a negative impact on subject expertise (Vockrodt-Scholz & Zydatiß, 2007; Bonnet, 2015; Marsh, 2002; Mearns, 2012) and on motivation for the subject (Yassin et al., 2009).

A number of studies focusing on problems students facing with language in CLIL projects, show lack of vocabulary and confusion with certain words (Hashimah, 2003), difficulty in understanding non-scientific terms in the scientific context (Saidi & Zurida,2004), or problems using the correct technical terms in L2 (Coetzee-Lachmann, 2007).

But a comprehension of the subject´s technical terms is crucial for developing concepts in the various disciplines. Even if some studies suggest to put an emphasis on learning those words exclusively from context and discouraging intentional learning tasks (Crow, 1986; Krashen, 1989; Oxford & Crookall, 1990), however, more and more vocabulary acquisition researcher support the combination of decontextualized tasks as well as contextualized tasks (Hunt & Beglar, 2005; Schmitt 2000, 2008; Webb 2007). Nation (2008) has argued that there should also be a place for learning vocabulary by word pairs because it can be a fast and efficient method of acquiring L2 vocabulary. This postulation seems to be contradictory to the view of the majority of language researchers that to really know a word means more than knowledge of form and meaning (Thornbury, 2002). But in a cumulative process (Nation, 2001), it is a start.

In the context of CLIL, vocabulary can be subject-specific, general academic or cross-curricular (Ball et al., 2015). Many terms can be learned through sensorimotor experience (Picard et al., 2010) or context, but not all of them, like memorizing the Latin names of bones and muscles in Biology or the period table in Chemistry.

For successful rote learning of word lists, repetition and spacingare important factors. Webb´s study showed that greater gains in knowledge of a word were found for each time of repetition (Webb, 2007). Spacing learning events apart proved to be more effective than massing them together (Kornell, 2009). Another strong influence on explicit vocabulary learning is contributed by the learners´ ability (Ahmed, 1989) and cognitive styles, like having high or low visual or verbal abilities (Zarei & Khazaie, 2011). Research showed for many years that the higher the personal involvement the deeper the processing (Laufer & Hulstijn, 2001; Kandel et al. 2000; Anderson, 2001), and the higher the chances that the new information will be retained.Successful vocabulary learning is proven to be dependent on the use of learning strategies, especially deep processing strategies, such as association, which is turning out to be more effective in vocabulary

retention than rote repetition strategies (Cohen & Aphek, 1981; Hulstijn, 1997; O´Malley & Chamot, 1990; Schmitt, 2000). On the path of gender difference research, the results of L2 studies reveal that women are usually more successful in learning vocabulary than men (Oxford, 2002) due to using strategies more frequently, according to Oxford (1990).

Focusing on the noticing phase (Nation, 2001) as the important first stage of explicit vocabulary learning (Barcroft, 2008; Gass, 1997), is revealing some possibilities for its support. This phase can be more effective by increasing the attention (Nation, 2001), defined as alertness,the concentration (Reynoldset al., 2015), meaning maintaining of attention over a long period of time with intention (Schmidt-Atzert et al., 2008), and motivation (Robbins & Everitt, 2003; Lamb, 2017), especially when learning difficult words (Crookes & Schmidt, 1991; Eysenck & Eysenck, 1980). Another important way to increase the effectiveness of explicit vocabulary learning is through multimodal input, which means students being exposed to visual, reading, written or aural modes (Bisson et al., 2014; Shams & Seitz, 2008; Zarei & Khazaie, 2011), being implemented through captioning videos (Sydorenko, 2010, Winke et al., 2010), or matching iconic gestures (Macedonia et al., 2011) for example.

Given that vocabulary plays a key role in language learning, explicit word learning is a necessity in some cases and has to be supported, which can be done effectively by multimodal input, this study investigates the effects of the oldest sense human have.

Literature Review on Main Research Interest: Olfactory Sense and Learning

The sense of smell is characterized by its vicinity to the limbic system, with so called amygdala, responsible for emotions and motivation (Wright, 1997), due to a shared neural network (Gottfried, 2010). Therefore, the olfactory sense is called an emotional system (Lundström et al., 2010). Studies showed that odor cued memories were related to stronger activations in the amygdala than picture cued recollections (Herz et al., 2004; Arshamian et al., 2013; Morgane et al. 2005). The bulk of research on autobiographical memories (AMs) (Conway & Pleydell-Pearce, 2000), cued by the sense of smell (e.g. Chu & Downes, 2000; Larsson &Willander, 2006; Zucco et al., 2012), indicates that olfactory evoked AM differ from memories evoked by sight, and hearing by being limbic, older, vivid, more emotional, and relatively rare – therefore the acronym LOVER.

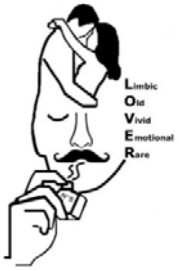

Figure1. lllustration of the acronym olfactory LOVER covering the core features of an autobiographical memory evoked by olfactory information (Arshamian in Larsson et al., 2014)

Associative odor learning begins very early in life, with events and experiences that may become accessible in old age through exposure to event-congruent olfactory information (Yeshurun et al., 2009). A recent study (Arshamian et al., 2013) showed that an olfactory cued retrieval resulted in more activity in the temporal poles that have been associated with positive memory processing (Piefke et al., 2003).

Studies on rodents showed the great potential of odor to support retrieval of declarative memory (Igarashi et al., 2014). Also, with humans the efficacy of odors as memory cues has been confirmed in experimental studies (Smith et al., 1992; Schab, 1990). When stimuli have been learned in the presence of a contextual odor, retrieval of the stimuli was improved when the olfactory stimulus was also present during retrieval testing (Rihm et al. 2014). Studies on humans proved further the impact of the olfactory sense on memorization during sleep (Shanahan et al., 2018, Rasch et al., 2007; Diekelmann et al., 2011). With those studies an odor was presented during sleep that had been presented as context during prior learning (Cann & Ross, 1989). But for the use of odor as support for learning, the coupling of odor and words would demand the use of the same odor to reactivate vocabulary. But even if the effect of an odor on an individual is dependent on a variety of factors, including previous associations you might have had with an odor, the inability to smell, the quantity of the odor…, some essential oils show repeatedly the same effects on body and mind like relieving of strain,enhancingof mood, increasing of concentration (Sugano, 1989; Buchbauer et al., 1991). Lavender oil for example can cause a depression of the central nervous system, increasing α and β brain waves (Diego et al., 1989), which are typical for a relaxed mood. This way Lavender oil can suppress anxiety (Halder et al., 2018) and help to activate the vigilance for long-term tasks (Shimizu et al., 2008). This is due to containing linalool showing sedative effects and linalyl acetate causing narcotic actions. Rosemaryoil with camphor as the main characteristic component (Zaouali et al., 2010), can help to increase concentration (Schandry, 2008). Participants of a study were able to solve mathematical tasks with less mistakes when sniffling rosemary (Diego et al., 1998). The same effect on concentration can have lemon oil and coriander/cilantro oil (Steflitsch et al., 2013).

Even though using odor as a stimulant for learning has been practiced by a lot of teachers for a long time there are no studies on the impact of using odors for explicit vocabulary learning in a classroom with no object odor coupling. This lack of studies is due to methodological problems when working with odor, like controlling the intensity and the constancy of the stimulus (Raab, 2001) and regarding possible individual negative associations with certain odors. Assuming that concentration has a positive impact on successful noticing and therefore retrieval phase of vocabulary learning, and some odors have proven effects on enhancing concentration, it would be interesting to reveal those correlations, especially taking the different phases of concentration in consideration, a kid passes throughout the school day.

Current Study

To summarize, explicit vocabulary learning can be supported by multimodal input, but the olfactory sense as an important modal with influence on concentration, motivation and memorization, was not tested in classrooms so far. The main goal of the present study was to examine the potential of odor as an additional support for explicit learning of vocabulary.

Research Questions

RQ 1: Does odor improve the explicit learning of vocabulary?
RQ 2: Does odor improve the motivation while learning vocabulary explicitly?
RQ 3: Does odor improve the concentration while learning vocabulary explicitly?
RQ 4: Does effects of odor correlate to time of school day?

Operationalization of Concept

An overview of the most important factors that could have an impact on explicit vocabulary learning,helps to filter out covariation factors to be followed up.

Explicit vocabulary learningat the lowest level:

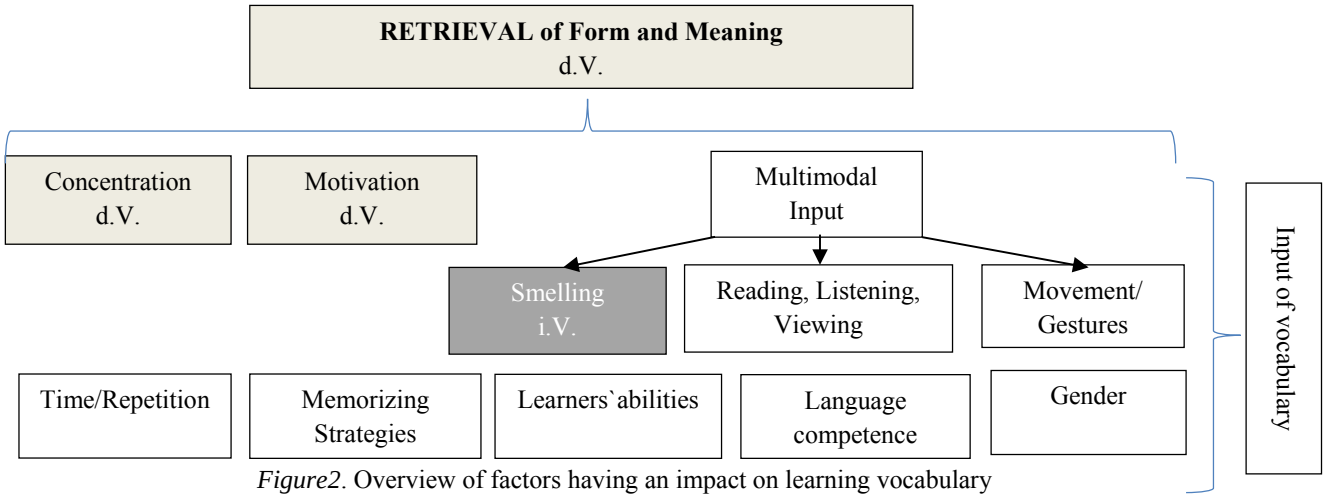

Figure2. Overview of factors having an impact on learning vocabulary

Retrieval of the words is a way to test the effectiveness of the input/noticing phase and should be the main dependent variable. Odor should be tested as independent variable (i.V.), motivation and concentration as further dependent variables with concentration not as a basic condition of the individual, but the current state, as being assessed by each subject.

Provided time for learning the new vocabulary has to be set as a stable variable by presenting the new words at a given time and a set number of repetitions.

To avoid the participants using memorizing strategies like chunking or using graphic organizers, the words should be presented one after the other and writing, drawing, movements, and gestures should not be allowed, all participants being instructed to only reading the words. To detect possible covariation factors, the individual inventory of memorizing strategies should

be pre-tested and hints on the participants´ general learning ability could be given by their grades in the main subjects. Influence of general language knowledge could be determined by taking the participants grades in English and their multilingual background into consideration. Specific language knowledge for the test should be ruled out by either using non existing words or words from a language that is not spoken by the test participants. Influence of gender has to be tested as well.

Pilot Study

As a first step,two different set mixtures of essential oils being available in stores (one containing lavender and citrus, the other one lemon, grapefruit and orange) were tested on a population of 60 children, aged 11, to check which mixture the majority preferred. Using the mostly preferred first mixture afirst study was then conducted with 30 young EFL learners (aged 11) divided in three experimental groups (smell perceived consciously, unconsciously and no smell) in anone to one intervention and all at the same time of day. Task was to memorize 20 unknown nouns. Independent variables memorization, concentration and motivation were tested at T1 (immediately after), T2 after one week and T3 after 3 months. The essential oils have been applied either directly on the word cards or hidden via a dispenser. Results showed no difference between subconsciously inhaled odor and no odor, and no significant difference in motivation, concentration and memorization, but some hints that it could work. As a result of the feasibility study, a main study was designed with much bigger population, change of order and number of presented words and different experimental settings.

Design of the Main Study

The main study was conducted as a classroom intervention, based on a mixed control group design (pre-, posttest) with 7 different groups and using smell as intervention. Participants (aged 10) should state their gender, their grades in their main subjects (German and math, as English is not graded at that age in Germany), and their multilingual background. First 8 words should be presented on flashcards via projector with (or without) participants sniffling a mixture of essential oils composed for enhancing alertness and activating vigilance for long term tasks, being applied on small paper strips. Next set of 8 words should be shown accordingly without (with) using an odor to support learning. A control group should have the words being presented without using odor. After each 8 words the retentionof all 16 words (sample rate 100%) should be tested with a vocabulary test, given the German equivalent. After each set of words, participants should assess their concentration and motivation on a 10-point numeric scale ranging from 1 (very high) to 10 (very low) according to the school grades the German participants are used to.

The order of the set of 8 words should be changed with every group, to eliminate effects of word difficulties.Testing the effect of odor given to different time during a school day the order of the groups being tested would be: group 1, group 2, control, group 3, group 4, control 2, and group 5.

By changing the order of the set of words, following groups are formed:

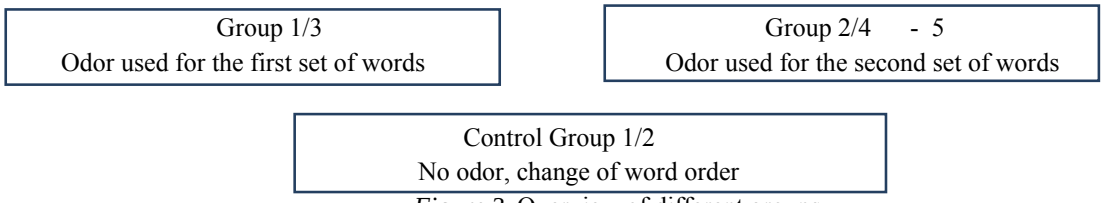

Figure 3. Overview of different groups

Subjects

The data analyzed in the current study were drawn from a sample of 152 participants, distributed almost equally to male (79) and female (71). The EFL learners for 2 years averaged 9.62 years (SD=0,62) and were randomly divided into the 7 different groups mentioned above.

Vocabulary

The targets were 16 Indonesian concrete nouns. One Indonesian girl was ruled out of the test. The others didn´t know Indonesian, so no participant knew a word. To make sure the words were understood semantically, only high-frequency words i.d. 40-60 occurrences per million (Kučera & Francis, 1967) were chosen and pretested in the pilot study. In addition to that, each word was presented with the German meaning and an easy and clear iconic picture.

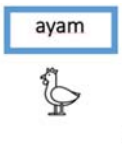

Figure 4. Example of flash card to present the unknown words (via projector).

All nouns were equally difficult concerning the number of syllables. Attention was paid not to choose words that would evoke associations with German words in terms of form and meaning. For the order of the presented words it was considered to avoid similar sounding nouns and nouns deriving from the same context (e.g. doctor, hospital) following each other. This way inhibitions and priming effects could be prevented. The first study showed that offering 20 new words was too much for the students so for the main study only 16 new words were presented with each word for 1 minute with one repetition for 0,5 minutes. To avoid the students using strategies for categorization the words were shown one after the other. Productive knowledge of meaning and form was measured by means of a translation test; the learners were given the L1 meanings and asked to write the words that the meanings had been paired with in the treatment. The aim of this test was to determine whether the learners could link the L2 form of the target words with their L1 meanings.Each correct word scored 2 points, if it was still recognizable it scored 1 point.

Major Findings

Taking a look at the total score for each word remembered, independently of the intervention, it shows that the two set of vocabulary were arranged almost equally regarding the difficulty.

Table 1.
Vocabulary and sum of total score

Kumgang	170	Ayam	257
Sapi	237	Rumah	149
Ganung	169	Gadis	206
Tangan	81	Rumput	127
Mata	199	Atap	111
Hutan	64	Danau	230
Madu	121	Dapur	52
Bintang	96	Pohon	156
1137		1288	

In order to answer the research question 1-3, mean scores for change of motivation, concentration and total score of remembered vocabulary were compared between the groups with odor and without. No significant differences opened up.

Table 2.
Comparison of mean scores

	odor	no odor
Motivation	3,81	4,03
Concentration	3,72	4,00
Score	8,10	8,12

But comparing the time of school-day (RQ 4) the odor was presented, some interesting findings were revealed:

Table 3.
Correlations between mean scores with odor and school lesson

		School Lesson	*MeanScoresWithOdor*	*MeanScoresWithoutOdor*
School Lesson	*Pearson Correlation*	*1*	*.824*	*-.264*
	Sig. (2-tailed)		*.086*	*.667*
	N	*5*	*5*	*5*
MeanScoresWithOdor	*Pearson Correlation*	*.824*	*1*	*.328*
	Sig. (2-tailed)	*.086*		*.590*
	N	*5*	*5*	*5*
MeanScoresWithoutOdor	*Pearson Correlation*	*-.264*	*.328*	*1*
	Sig. (2-tailed)	*.667*	*.590*	
	N	*5*	*5*	*5*

Students using odor in the first 3 lessons of the day achieved lower scores with odor than without. A different picture showed for the last 2 lessons of the day. Here, the students achieved a higher score using odor compared to them not using odor. For each group the sequence of presenting odor for the first 8 words or the second set of 8 words changed with each group.

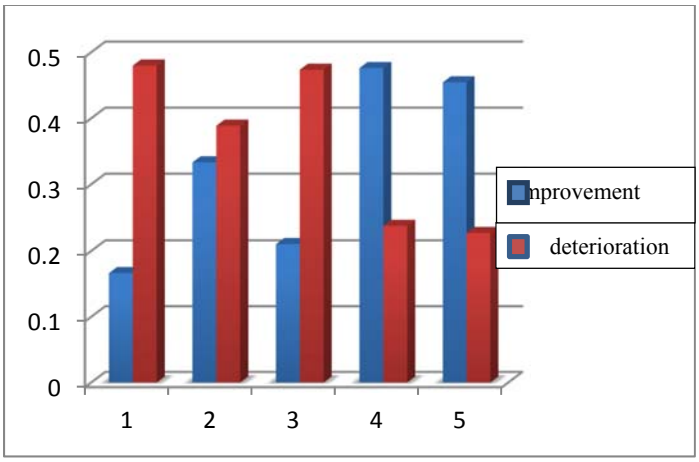

Figure 5. Ratio of students showingsignificantimprovement vs. deterioration ofretention rate with odor for each school lesson

Contradictory to the results of the retention rate, concentration and motivation was not changing accordingly.

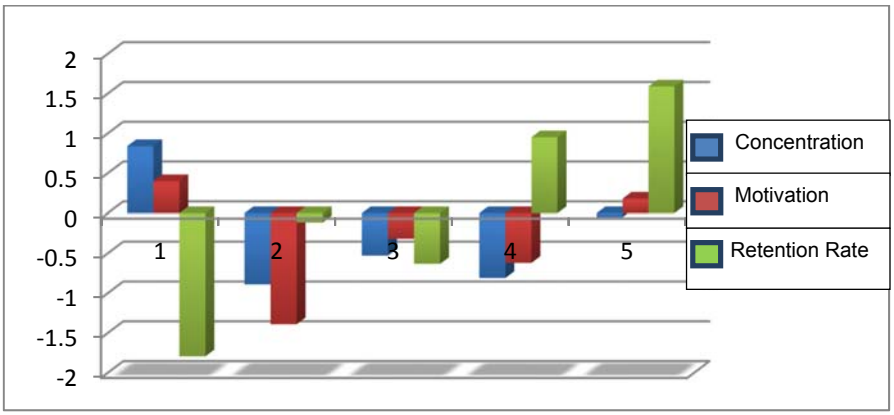

Figure 6. Ratio of students showing significantimprovement or deteriorationof concentration/motivation/retention rate with odor for each school lesson

According to correlation of school grade, retention rate and odor, students with the best grades in German and math did not really do better with support of odor, whereas students with medium grades in German and math improved their retention rate with odor support. Comparing mono-, vs. bilingual students this finding is more significant among bilingual students, especially for low grades in math.

Table 4.
Correlation of mono-, bilingualism vs. school marks and retention rate with support of odor

Grade in math	Mean value of improvement of score with support of odor		Grade in German
Mono-linguals	0,015873016		
1 (highest grade)	- 0,142857143	-0,454545455	1 (highest grade)
2	0,0625	0,238095238	2
3	0,111111111	-0,25	3
4	1	-1	4
Bilinguals	0,375		
1 (highest grade)	-0,333333333	-0,5	1 (highest grade)
2	0,35	0,333333333	2
3	0,666666667	0,785714286	3
4	0,8	0	4

Taking a look at correlation of using memorizing strategies, retention rate and odor, those students with no strategies improved most through the support of odor.

Table 5.
Correlation of number of memorizing strategies and mean values of improvement of score with odor

Number of memorizing strategies	Mean value of improvement of score with support of odor
0	**0,5**
1	0,285714286
2	0,148148148
3	0,238095238
4	-0,466666667
5	-2

Some would expect that those who liked the provided smell, got higher scores with support of odor. But even the ones who settled their preference in the middle, still scored well with odor. But if they stated their dislike, the scores were low as well.

Table 6.
Correlation of preference of odor, retention rate with support of odor

Preference of odor	Mean value of improvement of score with support of odor
1 (very much liked)	**0,416666667**
2	0,1
3	1
4	0
5	**0,428571429**
6	0,222222222
7	-0,5
8	0,5
9	-0,5
10 (very much disliked)	-0,8

Taking a closer look on sex differences if it comes to effectiveness of odor for learning, it seemed to be more helpful for girls than it was for boys.

Table 7.
Correlationof sex and retention rate with support of odor

Sex	Mean value of improvement of score with support of odor
Male	0,035087719
Female	**0,255319149**

Discussion and Conclusions

The main goal of the present study was to examine the potential of odor as an additional support for explicit learning of vocabulary.Assuming that concentration and motivation have a positive impact on successful noticing and therefore on the retrieval phase of vocabulary learning, both were tested together with successful vocabulary learning shown by the retention rate. As concentration usually decreases during a school day, the point of time the experiment was conducted was added as another variable to be tested as well. All possible factors influencing vocabulary learning were kept stable whenever possible. Time of exposure and number of repetition to the new words was all set at the same time. To avoid using memorization strategies the words were shown one after the other and no other strategies were allowed. Conclusions about learning abilities were drawn through the grades which showed some interesting findings. The language abilities of the students didn´t turn out to be a suitable influencing factor for vocabulary learning for this study as this information was gathered through stated bi- or multilingualism and it revealed that this usually correlated with low grades in math and German. The factor gender showed interesting results as well.

For the treatment a mixture of essential oils containing compounds that have proven effects on increasing concentration and reducing anxiety were chosen. It would have made it easier to backtrack the shown results to one essential oil only but for repetition of the same experiment and implementation to practice a set mixture that can be purchased makes it easier. To make sure that the students were actually capable of sniffling they had to indicateif that would not be the case. Those with smelling problems were excluded from the evaluation.

The decision to use Indonesian nouns to test the effects turned out to be the right one. For almost everybody the words were unkown. Only one Indonesian girl couldn´t take part in the study. And yet,compared to the use of phantasy words, even if nobody knew the words they all were motivated to learn vocabulary of a real language they might be able to use one day. The conductment of the study went as planned. It occurred that some student complaint about the intensity of the odor provided. One student felt little sick afterwards. Some of the students of the control group couldn´t understand the intention of the procedure.

In order to answer the first research question about the effect of odor on vocabulary learning, a look at the comparison between learning with or without odor shows no significant difference. For some students odor provided support, wheras others might have been distracted by the odor or didn´t like to learn with support of odor so their individual score was lower than without odor.

To make sure that a higher score was not caused by a learning effect the odor was given alternatingly for the first or second set of words for each group. To eliminate the difficulty of the chosen words having an influence on the retention rate the order of words was changed in each group.

As far as motivation and concentration is concerned, both didn´t show any difference comparing using odor vs. not using odor. That means the next two assumptions implied by the research questions have to be denied: It seems that odor has no influence on the effect of learning, no effect on concentration, no effect on motivation. But does those first findings indicate that using odor as support for learning is only a matter of individual preference?

It is notable to take a look at the correlation with the time of school day in order to find answers to the 4th research question. Surprisingly to the prior findings, odor helped students significantly later during a school day. This finding is directly in line with previous findings of Diego et al. (1998), but this time using a mix of lemon, citrus and lavender oil, instead of rosemary oil. This could be in accordance with studies conducted by Steflitsch et al. using lemon and citrus oil to enhance concentration (2013). But both studies stated an increase of concentration in general and did not differenciate between different times of day. So what caused the increase of effect later in the school day? It might be revealing to analyze the mixture of essential oil being used and bring it together with the different stages of concentration a student is going through during a typical day of school.

Taking in consideration that the compounds of the used mix of essential oils were not only having the activating effects of lemon and citrus oils, but also the relaxing effects due to lavender oil, the oil could hypothetically activate the arousal state after a tiresome morning at school on one hand, or help to calm down and reduce anxiety after stressful lessons. Further studies have to be conducted with only one essential oil each to tell what compound caused the shown effect.
Interesting enough, the use of odor was counterproductive in the morning or after the break (group 1 and 3). So why did many students score lower with odor in the morning? It can only be speculated whetherthat was due to the relaxing effects of lavender oil being counterproductive with an already aroused state, or enhancing effects of lemon and citrus on concentration not working when the system is still alert and fresh in the morning. Or it might be due to the intensity of odor being applied. As stated before, controlling the intensity of smell is a crucial point when conducting experiments with odor (Raab, 2001). It was tried to apply the smell evenly before each treatment on a paper strip for the participants, although, the exact dosage could not be measured. Furthermore, the perception of intensity varies individually. So for some students the offered intensity of odor might have been to strong and that´s why some student complained during the test about the intensity. Other students might not have liked the smell as some stated their dislike during the procedure in written or oral form. But in spite of the personal preference, the impact of the compounds of the essential oil should be independent of the like or dislike of the smell.Therefore, even if the participants stated their preference for the smell as indifferent, they scored very well. On the other hand the results showed that a stated dislike of odor was correlated to lower scores in the vocabulary test. Smell is not only having an effect

through the compounds like camphor, it can also erouse dislike as olfactory sense is connected with the limbic system (Wright, 1997).

But why were the effects of the essential oils not much stronger? The results could have been influenced by the fact that attention as a crucial factor of noticing new vocabulary (Nation, 2001) could have been distracted by offering the paper strips with odor. Handling the paper strip and sniffling while trying to memorize the presented words might have cause less personal involvement and less processing of the new words.

On the other hand, the correlation between low grades in math and support by odor might be a hint that those were students facing problems with focusing on a task and thereby benefitting from the support.

The difference in effectiveness between girls and boys could underpin the results of a huge meta-analysis indicating that women generally outperform men in olfactory abilities (Sorokowski et al., 2019).Especially girls stated that they would like the smell. The gender difference of the results also ties well with the studies of woman doing better at vocabulary learning tasks by using more strategies (Oxford, 2002). Even if the use of memorization strategies was limited to only reading the words, the participants could have still used other strategies like mental clustering. Especially those students with higher visual abilities and better memory capacity could have used those strategies. Though, the finding that students with no strategies improved best with using odor undermines the presumption that girls scored better because of using strategies.

Regarding the finding that students with the best grades in German and math did not really do better with support of odor, whereas students with medium grades in German and low grades in math improved their retention rate with odor support, significantly among bilingual students, it can only be speculated about the reasons why. Good students might be in posession of good memorizing and learning abilities and therfor don´t gain through additional support or they felt distracted when forced to sniffle on a paper while learning. Wheras students with low grades in math often show problems with concentration and therefor might be able to improve their scores through additional support. Most of the bilingual students in the study came from poorly educated parents and therefor were significantly among those with lower grades in math. Bilingualism, in many cases helpful when learning another language, in this case it turned out to have negative influence on performing well at memorizing tasks.

Interesting enough, the effect of odor on concentration and motivation didn´t seem to match the results for the retrieval score. Early in the morning, the retention rate with odor was low, but motivation and concentration stated by the students was high. Later in the morning the retention rate with odor was high, motivation and concentration stated as low.

Not all students might have understood the logic ofthe provided test with stating their momentary individual state of concentration and motivation. For high concentration (and motivation) the students were supposed to tick number 1, and number 10 if it was very low. All students got verbal instructions and an example was given in the test in addition to that. Even if

school marks in Germany have a similar sequence with number 1 being the highest score, student could have been confused by the normal numeric scale, as being 1 very low and 10 very high.

Some might have felt distracted in their concentration by using smell as a learning support. Others might not have liked the smell and therefore rated their motivation low. For some the concentration of odor might have been to intense, as the accepted intensity of an odor varies individually.

It´s not possible to have onesmell that suits everybody. Some students did not like the provided odor. Some might have had negative coupling of that specific smell with some negative autobiographical event for example or they just didn´t like the predominant citric smell because they don´t like lemons in general.

To summarize the most important facts: Odor as a general support for all would not work, but for some students, especially students with no strategies, students with mediocre grades, bilinguals with mediocre grades, and for girls,it really helped to increase their score for memorizing tasks later on a school day.

For smell being used as support for the input phase, further studies could be conducted offering the students several odors and letting them pick an odor they prefer. As mentioned above, lavender and citrus oils could be tested separately to see what caused the effect on the time of school day it was given as support. The influence of smell on the consolidation phase of vocabulary learning by using odor while repeating the vocabulary for a period of time, would also be a very interesting path to follow up, even if the methodology would be a challenge. As studies suggest, sleep is playing a rich and multifaceted role (Walker &Stickgold, 2004) in the processing of human declarative memories (De Koninck et al., 1989, Gais et al., 1997), and like Schreiner & Rasch found for verbal cueing during sleep (2015), and Shanahan et al., (2018) for enhancing retrieval through delivery of the same cue during sleep that was presented during encoding, the scant results need to be expanded. Though, the implementation of those results to effective learning in classroom surroundings might be difficult, as learning and retrieval would be dependent on using the same odor. It might work for combining sensorimotor experience (Picard et al., 2010) with odor when learing from context. In order to learn the names of plants, students should actually go outside the classroom and sniffle and touch the objects that has to be memorized. A lot of teachers already do so. The effect still needs to be proven by experimental case studies.

Picking up the threat of the effects some odor has on concentration and stamina, odorslike rosemary, lemon or coriander/cilantro oil, could also be tested as support for activating alertness during retrieval phase. As anxiety can prevent students from retrieving the words, odors like lavendula oil could help to reduce fears and perform better.

Regarding the fact that the correct use of subject-specific vocabularyis only one pitfall for understanding science, others like using the correct functional verb structures or complex attributes as the general academic vocabulary might be supported by odor as well through enhancing concentration and vigilance. To end the listing, considering that both are core factors

for learning a language in all dimensions and skills and for learning in general, interesting follow up studies will be opened.

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