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Master's Thesis

Effect of Applying Color-Coding Technique to Different Leaning Methods on the Acquisition of Grammatical Gender in the German Language

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Abstract

As all parts of the world being brought together by the internet and other electronic communication interconnections, people are exposed to more options and possibilities. To seize the opportunities, many of them make their first step by starting to learn a new language. Being the official language of Germany and Switzerland as ones of the top developed countries, the German language appears on the to-learn list of many dream finders. However, one of the most important features in German language, the *grammatical gender system*, has stopped many adventurers from continuing the journey of learning. This system continues to pose a challenge to second language learners.

To support the L2 learners to learn the target language in a more effective way, color-coding technique has been applied to the learning/teaching materials as a useful visual enhancement. In the case of Germen language, this technique has been particularly applied to the improvement of acquisition of grammatical gender. Based on the possessing grammatical gender, blue is assigned to masculine nouns; red is assigned to feminine nouns; and green is assigned to neuter nouns.

In this research, we modified the existing color-coding technique combining with three learning techniques, which were wordlist, writing and drawing, to enhance the effectiveness of learning the grammatical genders for German nouns. As implementation of the three methods, the learning materials for learning vocabulary using the three methods were created on PowerPoint and were later used in the learning process.

The study was carried out with 24 graduate/undergraduate students differing in backgrounds, majors but having no experience in learning German language. Since the experiment was conducted in English, the participants were able to speak basic level of English. The learning process in the experiment was divided into three sections, where the participants were asked to learn the target words in three different word packages with the three tested learning method respectively. To be precise, the participants learnt one of the word packages in each learning section with one of the tested methods, i.e., color-coded wordlist, color-coded writing, and color-coded drawing. All participant completed the learning process, leaning 12 German nouns with color-coded wordlist material; 12 German nouns with color-coded writing material; and 12 German nouns with color-coded drawing material. Keeping in mind that an order effect could occur in within-subjects design, counterbalancing was used as a solution to reduce the effect so that the participants were designed to apply the method in different order. After the learning process, an immediate posttest, following with the first survey, was given to the

participants. Two days later, an email with two links for a delayed posttest and the second survey was sent to all participants.

To evaluate the effectiveness of the three tested methods, we compared the mean score of learning of grammatical gender on both the immediate posttest and the delayed posttest, using repeated-measures ANOVA test, which is for analyzing data where same subjects are measured more than once, to find out whether a significant difference could be found. The ANOVA tests were conducted in R and the results were visualized using different types of charts. Results from the analyses showed that there was a statistically significant difference between three conditions on both posttests, with the highest mean score in color-coded drawing condition. Observing the responses in the second survey, over 90 percents of the participants showed their preference for the color-coded drawing over the other two methods, while two third of the participants considered this method to the most useful method for leaning German nouns.

In conclusion, color-coded drawing method proves its worth by providing a more interesting learning environment and supporting the learners to learn the grammatical gender for German nouns in an effective way. Learning German nouns with color-coded drawing method, a strong impression of the color-coded illustration is given to the learners, which enable them to recall the color assigned and the meaning of a German noun days later. Nevertheless, the materials utilizing the combination of color-coding technique and drawing method are yet imperfect. A balance between drawing tasks and vocabulary learning should be taken into consideration. Several limitations, such as time constraints, imperfection of the color-coded drawing method and difficulty of implementation, are discussed, and suggestions are given to the future researchers. This paper suggests that color-coded drawing is an effective and promising method for the German as second language learners to learn grammatical gender along with the vocabulary.

Acknowledgments

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Lastly, I would like to thank Tobias Deinböck for his company for the passing two years. He did not only help me with my research by offering his opinions, but also encouraged me to keep going and never give up on what I want. Thank you.

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CHAPTER 1

INTRODUCTION

1.1. Background

To discover the world in different aspects, more and more people find it important to invest in themselves in their free time. One of the common ways is to learn a second foreign language, which enables the learners to pursue their dreams such as working and studying abroad without communication problems. Due to the strong economic and welfare system, Germany is getting more and more popular among the people who all share a dream about living abroad. Without a doubt, the first problem they are going to face is the language barrier, which is built by the high difficulty of the German language.

Languages of the world differ in whether they have a semantic gender system or a grammatical gender system (Corbett, 1991; Corbett & Fraser, 2000; Saalbach, Imai & Schalk, 2012). In languages with grammatical gender, including German, French, Italian, and Spanish, gender is assigned to all nouns regardless of whether the referents have a biological sex. In German, where all nouns possess one of the three grammatical genders, i.e., masculine, feminine and neuter, and are very complex (Bender et al., 2011), the masculine pronoun er (he) and the masculine article der (the[MAS]) are used regarding grammatically feminine nouns regardless of whether the noun's referent is an animal without a known biological gender (e.g., a bear) or an inanimate object (e.g., an apple). This poses difficult and persistent challenges to German as second language (L2) learners for both advanced learners (Rogers, 1987) and beginning learners (Arzt & Kost, 2016) since it is equally important to learn and identify the gender of each noun and how each of the three genders, masculine, feminine, or neuter, interact other language elements so everything coordinates in a grammatically correct utterance. Understanding the fact that the grammatical gender of a noun, being the most important linguistic feature of the German language (Tanir, 2023), and syntactic considerations of the sentences are inseparable, learning this grammatical element is a vital step toward proficiency in German.

To support the learners to overcome the difficulties in distinguishing grammatical genders, Tanir (2023) suggests future language teachers to design more creative and effective learning materials specifically on this topic and to integrate it into the learning process. Considering the fact that L2 learners have difficulty acquiring grammatical gender because they do not process nouns together with gender information (Arnon & Ramscar, 2012; Henry, 2022), some learning or teaching techniques show their possibility of solving this heavy problem. Arzt & Kost (2016) conclude that color-coding might be an effective and work-intensive technique for instructors to implement on learning grammatical gender since the visual enhancement provides the connection between the grammatical genders and the nouns with the help of colors. Having these considerations in mind, this paper will be working on the question "How to design a more creative and effective vocabulary learning method combined with the color-coding technique?"

1.2.   Research question

To support the German as L2 learners, three vocabulary learning methods combined with the color-coding technique, namely *color-coded wordlist*, *color-coded writing*, and *color-coded drawing*, are used in our experiment. This study compares the grammatical gender acquisition of complete beginners in learning German under experimental conditions utilizing modified color-coded learning materials. The experiment seeks to answer the following research questions:

1. Do different types of color-coded combined techniques (wordlist, writing and drawing) have different effects on students' immediate learning of the grammatical gender of the target words?
2. Do different types of color-coded combined techniques (wordlist, writing and drawing) have different effects on students' retention regarding learning of the grammatical gender of the target words over time?
3. Do the learners find three types of color-coded combined techniques (wordlist, writing and drawing) useful in terms of learning the grammatical gender and spelling respectively?
4. Do the three types of color-coded combined techniques (wordlist, writing and drawing) successfully create a fun learning environment in terms of learning of the German nouns?

CHAPTER 2

LITERATURE REVIEW

2.1. Color-coding in language learning

As a useful visual enhancement, which can facilitate the vocabulary acquisition process and improve the memorization abilities (Shatz, n.d.), color-coding technique is widely used in language learning in terms of grammar, vocabulary, and tonality.

Table 1 Few examples of color-coded words in various languages. (Shatz, n.d.)

Case	Example sentences
Color-coded words in *French*, based on *grammatical gender*	*L'enseignant fâché cuisinait dans la vieille camionnette.* *The angry teacher cooked in the old van.* (blue for masculine, pink for feminine)
Color-coded words in *Spanish*, based on *part of speech*	La madre rubia finalmente consiguió sus naves. The blonde mother finally got her ships. (green for nouns, orange for adjectives, blue for verbs, and light blue for adverbs)
Color-coded characters in *Mandarin Chinese*, based on *tonality*	媽 1st tone = red 麻 2nd tone = orange 馬 3rd tone = green 罵 4th tone = blue 吗 neutral tone = black

A contribution to a better memorization of educational material could be made by studying grammatical categories of the Ukrainian language using a combined table with the help of color-coding (Zavaruieva, Bondarenko & Fedko, 2022). Moreover, a more attractive and interesting learning process could be provided to the learners by applying the color-coding technique to teaching materials (Nurdiansyah, Asyid & Parmawati, 2019). This visual enhancement was taken to enhance the acquisition of grammatical gender by beginning German 2L learners by Arzt and Kost (2016). This study compared two types of visual enhancement, i.e., color-coding and gendered actors, with the control condition to find out whether these visual enhancements have different effects on students' learning of grammatical gender of the target words. Two types of visual enhancement were applied to modifying the teaching materials, which were used to introduce the target words in the classroom. After the learning section, the students were asked to complete a set of immediate- and delayed posttests. Based on the results, the retention of gender seemed to be more affected by the two forms of visual enhancement tested with color-coding showing the overall most positive results. However, no significant results using the analysis of variance (ANOVA) were found between the conditions for the immediate posttest while scores approaching significance as a result of condition were found as the results for the delayed posttest. For the future works, different forms of visual input enhancement were suggested. Another suggestion was that the technique could be applied by the students actively to close the gap between teacher-formatted input and student intake.

2.2. Drawing as active learning in language learning

To create an interactive learning situation, active learning strategies are considered to be useful and helpful (Yahyazade, Morady Moghaddam & Attaran, 2014). Ainsworth & Scheiter states (2021) that drawing does more than externalizing what learners have in mind; it indeed changes their mind. As a most frequently seen practice, learners are asked to read textual material and then transform some of that text into a drawing based on this new input and their prior knowledge. In 2016, a study of drawing information as a strategy to enhance memory was carried out (Wammes, Meade & Fernandes, 2016), which found that the drawn words were recalled twice as many as the written words, regardless of the artistic skill. A list of simple words, such as "apple", was given to the participants, and 40 seconds to either draw a representation of the word or write it repeatedly. They were later asked to recall as many words as possible. As one of the findings in this research, drawing

contributed to creating a stronger impression than the other methods such as listing physical characteristics, creating mental images, and viewing images depicting the words.

Despite the fact that the drawing method has already proved its worth in diverse fields, some considerations, such as the role/roles of drawing, proper explanations for drawing activity and assessment criteria to the function of the drawing, should be taken while designing drawing activity since an unbalanced design could reduce the effectiveness of this method (Ainsworth & Scheiter, 2021).

In this research, the color-coding technique is combined with one passive learning method, which is *wordlist*, and two active learning methods, which are *writing* and *drawing*, with the aim of improving the effectiveness of this existing technique in learning grammatical genders for the German nouns by closing the gap between teacher-formatted input and student intake. Moreover, a reasonable and helpful drawing activity is designed in the hope of providing the learners a better alternative to traditional learning methods.

CHAPTER 3

METHODOLOGY

3.1.   Proposed learning method

3.1.1. Color-coded wordlist

To help learners learn the grammatical gender effectively, the target words will be made into a list, where both the grammatical gender and the noun appear written in blue for masculine words, in red for feminine words, and in green for neuter words. Similar setting could be found in related work (Arzt and Kost, 2016). Since the words are already labeled in colors, the only task for the learners is to memorize the target words.

3.1.2. Color-coded writing

The "writing" in color-coded writing refers to *dictation*, which is a widely used method, especially for vocabulary learning. By writing down the target words in specific colors according to the grammatical genders, the participants label the color actively and can learn grammatical gender and spelling at the same time. In the color-coded writing condition, the *grammatical gender* of the target words is manipulated and appear in red for feminine words, in blue for masculine words, and in green for neuter words, while the noun itself is written in light gray. The learners do not have to spend time on finding the correct color on their own, thereby being able to pay more attention to writing and learning.

3.1.3. Color-coded drawing

In view of making the drawing activity purposeful, valuable, and nonthreatening, the "drawing" in this research refers to the puzzle game dot-a-dot, where the task of the players is to reveal a hidden picture by connecting the dots, instead of freehand drawing.

A valid objection at this point would be why the learners are not simply allowed to draw freely. It seems as if the specification of the dots would limit their creativity. However, letting learners draw freehand can negatively impact the quality of the learning experience when the learners (1) are not good at drawing and thus fail to complete the task or (2) focus more on drawing and thus fail to learn the spelling, since it is extremely important that the learners should be able to complete the drawing and learn the spelling within the given time. The dot-to-dot puzzle helps to somewhat limit the most gifted drafters, but in a positive sense, and supports the ones who have difficulty in drawing. Moreover, the dot-to-dot puzzle guarantees that a picture is drawn for each word that is actually identifiable as the word and is also of good quality. As visual supports, the drawings should be easily identifiable so that a strong connection between the word and the image can be made. In this research, a dot-a-dot puzzle, which consists of 10–15 dots, is generated for each target word. By connecting the target words with a line in specific colors according to the grammatical genders, the participants label the color actively and are able to learn grammatical gender and meaning at the same time. In the color-coded drawing condition, the *simple guidelines* of the dot-a-dot puzzles are manipulated and appear in blue, red, and green according to the possessing grammatical gender, while the noun itself is written in black. The learners do not have to spend time on finding the correct color on their own, thereby being able to focus on drawing and learning.

Table 2 Comparison of existed method and proposed methods

	Controlled condition	**Experimental condition 1**	**Experimental condition 2**
Method	color-coded *wordlist*	color-coded *writing*	color-coded *drawing*
Variable	passive learning	*active* learning	*active* learning

3.2. Application

This study revises the existing color-coding technique, which sought to be most effective on learning of grammatical gender according to Arzt and Kost (2016), combining passive/active learning outlined above, and applies them to the learning materials with the aim of investigating whether learning German nouns using color-coded materials in an active way can contribute more to the enhancement of the acquisition of grammatical gender than learning with the help of color-coding technique but in a passive way.

3.2.1. Word Packages

A total of 36 target German nouns, fitting into the category *Essen* (food), were chosen. Moreover, to ensure the words have similar difficulty, all words are chosen from the CEFR A1/A2 word list provided by Goethe-Institut, which is a non-profit German cultural association and well-known for supporting the study of the German language overseas and promoting international cultural exchange and relations. The chosen words were all concrete nouns and could be categorized by the possessing grammatical gender into three groups containing the same number of target words. In addition, it was noteworthy that plural-only nouns, which did not have a singular form or were only used in plural form, were excluded from the vocabulary packages. All words were later divided into three vocabulary packages randomly so that each vocabulary package is made up of 12 German nouns.

Table 3 Three vocabulary packages (GG = grammatical gender)

vocabulary package 1			vocabulary package 2			vocabulary package 3		
GG	German	English	GG	German	English	GG	German	English
der	Apfel	apple	das	Brot	bread	die	Butter	butter
die	Birne	pear	das	Brötchen	bun	das	Ei	egg
der	Salat	salad	das	Öl	oil	die	Kartoffel	potato
das	Wasser	water	der	Schinken	ham	das	Hähnchen	chicken
die	Wurst	sausage	die	Orange	orange	das	Schwein	pork
der	Zucker	sugar	die	Pizza	pizza	die	Suppe	soup
das	Bier	beer	die	Banane	banana	der	Saft	juice
der	Fisch	fish	der	Kaffee	coffee	der	Tee	tea
das	Gemüse	vegetable	der	Reis	rice	die	Tomate	tomato
die	Milch	milk	das	Salz	salt	der	Wein	wine
das	Eis	ice cream	der	Hamburger	hamburger	das	Rind	beef
die	Schokolade	chocolate	der	Käse	cheese	die	Zitrone	lemon

3.3.   Learning material

To keep the vocabulary learning process simple and reduce the burden on participants of familiarizing themselves with new techniques, the learning material was made in PowerPoint, where the pen and highlighter tools within the slide show view in PowerPoint can be used to complete simple drawing and writing tasks. Three sets of three PowerPoint presentations were created. Each set corresponded to one of the three learning methods. In order to control the learning time for each target word, the PowerPoint slides are set to advance automatically after 24 seconds. Without the stress of time controlling, participants can focus more on following the instructions and memorizing the words. On each slide is only a single target word to be found, which is written in both English and German. All the words are designed to come up twice in the PowerPoint slides so that the participants will spend 48 seconds on learning each German noun.

3.4.   Examples

Taking the following combinations as examples, the target German nouns in vocabulary package 1 are designed to be learned with color-coded wordlist; the ones in vocabulary package 2 with color-coded writing; and those in vocabulary package 3 with color-coded drawing. Three PowerPoint presentations are created corresponding to each combination listed above respectively.

As shown in figure 1, the target words on the PowerPoint slides, which are from vocabulary package 1, are labeled in either blue, red or green depending on the grammatical gender the German noun possesses. On the other hand, only the grammatical genders of the German words are labeled in colors in figure 2, while the nouns are written in gray where overwriting in the same color as the labeled grammatical gender can be applied by the learners. As demonstrated in figure 3, the words in vocabulary package 3 remain written in black. Instead of labeling the target words in colors, a dot-a-dot task with color-labeled simple guidelines appears on each presentation slide.

der Apfel apple	die Birne pear	der Salat salad	das Wasser water
die Wurst sausage	der Zucker sugar	das Bier beer	der Fisch fish
das Gemüse vegetable	die Milch milk	das Eis ice cream	die Schokolade chocolate

Figure 1 Learning material for vocabulary package 1 with color-coded wordlist

das Brot bread	der Schinken ham	das Brötchen bun	die Pizza pizza
die Orange orange	der Kaffee coffee	die Banane banana	der Reis rice
das Salz salt	das Öl oil	der Hamburger hamburger	der Käse cheese

Figure 2 Learning material for vocabulary package 2 with color-coded writing

die Butter
butter

das Ei
egg

das Schwein
pork

das Hähnchen
chicken

die Suppe
soup

die Kartoffel
potato

der Saft
juice

der Tee
tea

die Tomate
tomato
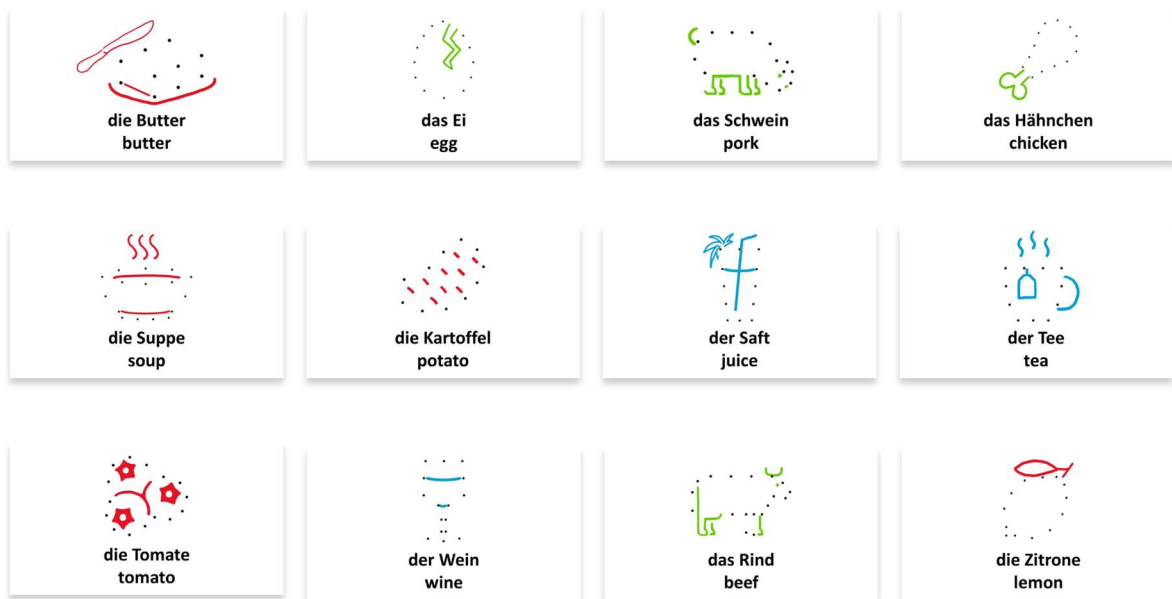
der Wein
wine

das Rind
beef

die Zitrone
lemon

Figure 3 Learning material for vocabulary package 3 with color-coded drawing

CHAPTER 4

EXPERIMENT

4.1. Participants

The participants of this study were 24 international undergraduate/graduate students (13 males and 11 females) coming from all over the world and speaking different languages as their mother tongue. To be precise, Taiwan, China, Hong Kong, India, Indonesia, Mongolia, Pakistan and Vietnam. The age of the participants ranks between 18 and 32. All participants have no experience in learning German but basic English level as a prerequisite for participation in the experiment.

4.2. Materials

For this experiment, three sets of three PowerPoint presentations each were created. Each set corresponded to one of the three learning methods, namely color-coded wordlist, color-coded writing and color-coded drawing, and each PowerPoint presentation in a set consisted of the words of one vocabulary package. Therefore, there were nine PowerPoint presentations.

4.3. Experimental design

To assess the effectiveness of three different ways of learning German nouns, 24 participants were split into six groups and within-subjects design was applied, where all participants were exposed to every treatment or condition. Although participant variables (i.e., individual differences) are reduced in within-subjects designs, as the same participants are used in each condition, there may be order effects, which refers to the order of the conditions affecting the participants' behavior. To control this limitation, counterbalancing was used in this experiment, which means that all six groups were designed to learn the three vocabulary sets with three proposed learning methods in

different order. In this way, order effects balanced each other out in the results, since they occurred equally in all groups.
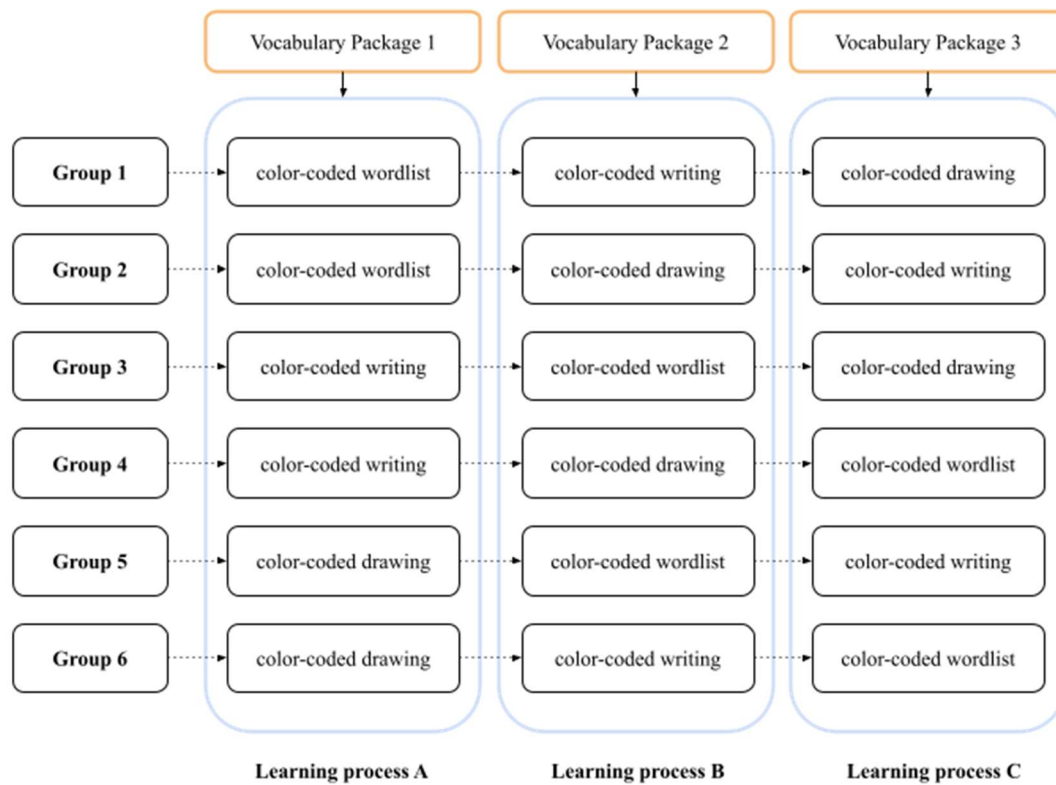
Figure 4 Within-subjects design with counterbalancing

As shown in figure 4, the learning process in the experiment was divided into three learning sections A, B and C, where the words in three vocabulary packages were learned by the participants accordingly. To reduce order effects, each group applied the three learning methods, namely *color-coded wordlist, color-coded writing and color-coded drawing*, in different order. For example, the participants in group A were asked to learn the German nouns in vocabulary package 1 with color-coded wordlist; vocabulary package 2 with color-coded writing; and vocabulary package 3 with color-coded drawing.

4.4.   Instruments

4.4.1. Immediate posttest

The immediate posttest with a time limit of 12 minutes was conducted on the online testing platform Quilgo. For each of the 36 words learned in the learning process, there were 36 sections, which consisted of one multiple choice question for grammatical gender and another for spelling, in the immediate posttest.

4.4.2. Delayed posttest

The delayed posttest with a time limit of 5 minutes was created using Google Forms with Quilgo add-on. In this test, there was a multiple-choice grid question, where only one answer should/could be chosen per row and only the retention of grammatical genders regarding the learned words will be tested.

4.4.3. Survey

Two surveys were given in the whole process with Google Form. The aim of the first survey was to understand if the given dot-a-dot tasks in the learning material of color-coded drawing could be identified by the participants or not, while the second survey was to investigate the subjective opinion of the participants on the proposed methods.

4.5.   Procedure

The main experiment was divided into two parts. The first part, which consisted of introduction, learning process, an immediate posttest and the first survey, was conducted in the classroom, while the second part two days later, which contained a delayed posttest and the second survey, was designed online.

4.5.1. Introduction

Considering that the participants have no experience in learning German language, an introduction to the grammatical genders in German language was given in the first place. However, the significance of the grammatical genders was not intentionally stressed to

avoid bias due to the overconcentration on the grammatical genders. Moreover, the experimental flow (Figure 5) was shown and explained in this section before the participants proceeded to the learning process.
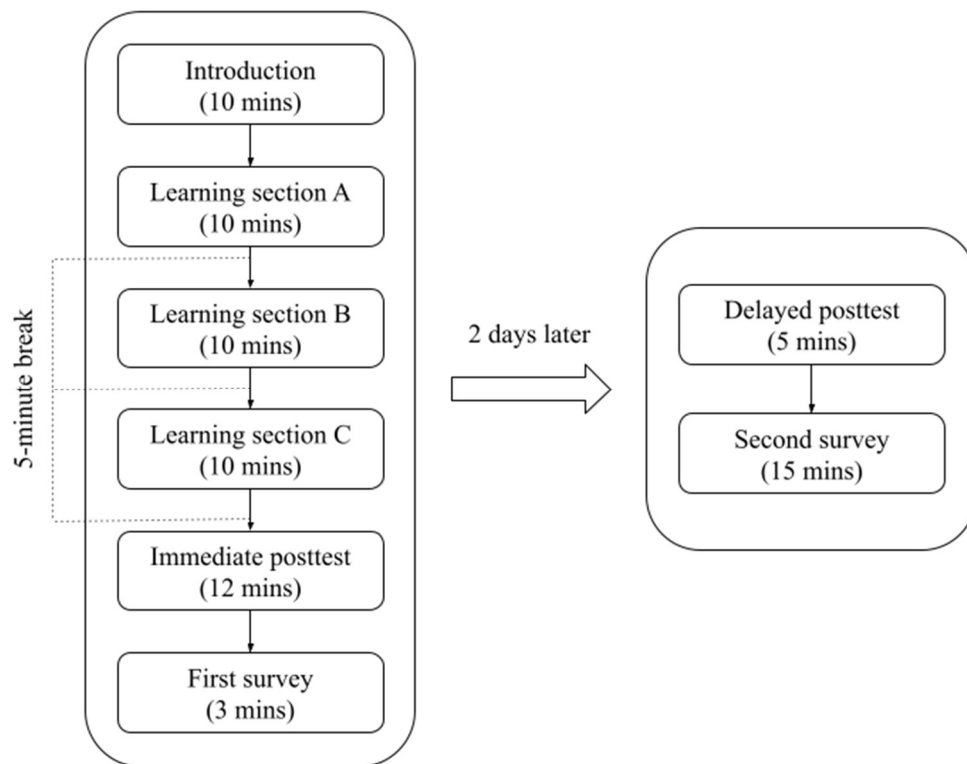
Figure 5 Experimental flow

4.5.2. Learning process

The learning process consisted of three sections, where the participants were requested to learn 12 German nouns with different learning methods, namely color-coded wordlist, color-coded writing, and color-coded drawing, respectively. After completing each section, there was a five-minute break before the participants moved on to the next section. During the first and second five-minute breaks, a discussion on culture and language learning was conducted with all the participants to prevent them from focusing on memorizing the words, which were given in the last learning section. In the last five-minute break, the participants were asked to send their edited PowerPoint files as email attachments, so their learning situation during the learning process could be revealed.

4.5.3. Immediate posttest and first survey

After the last five-minute break, the participants moved on to the next section, where an immediate posttest and a simple survey were given. The immediate posttest took approximately 12 minutes and both spelling and grammatical genders regarding the learned words were tested. As for the last part on the first experiment day, the participants were asked to fill out a simple survey to find out whether they could identify the item in the dot-a-dot tasks, which were given in the color-coded drawing material.

4.5.4. Delayed posttest and second survey

Two days after the learning process, an email, where the links for the delayed posttest and the second survey could be found as attachments, was sent to all the participants. The time limit for the delayed posttest, where only the retention of grammatical genders regarding the learned words will be tested, was set to five minutes. After completing the delayed posttest, the participants were asked to fill out a survey to find out whether they consider the proposed learning methods to be beneficial, distracting, or if they had other comments.

4.6. Data analysis

In this study, both quantitative and qualitative data were obtained to carry it out and come to conclusive results. Test scores were analyzed using repeated measures analysis of variance (ANOVA), which is also referred to as a within-subjects ANOVA, for both immediate posttest and delayed posttest, with the three independent variables being the three tested conditions (Color-coded wordlist, Color-coded writing, and Color-coded drawing), to test if condition as a main effect had any notable impact on mean scores. To identify exactly which groups differ from each other, post-hoc comparisons using the Bonferroni test are also conducted. Moreover, students' opinions in the survey were also taken into consideration while interpreting the results of statistical data.

CHAPTER 5

RESULTS

This study compared the effects of three vocabulary learning methods on participants' performance in immediate posttest and delayed posttest. In the three learning sections of the experiment, 24 participants were assigned to learn the German nouns in three vocabulary packages with three learning methods: *color-coded wordlist*, *color-coded writing* and *color-coded drawing*, respectively. To test if the learning methods as a main effect had any significant effect on mean scores, test scores were subjected to a one-way repeated measures ANOVA (i.e., within-subjects ANOVA) for both immediate- and delayed posttest, with the three independent variables being the three learning methods.

The repeated measures ANOVA tests were performed in R. The following R packages were used: *tidyverse* for data manipulation and visualization, *ggpubr* for creating easily publication ready plots and *rstatix*, which provides pipe-friendly R functions for easy statistical analyses. The code was adapted from the following website: https://www.datanovia.com/en/lessons/repeated-measures-anova-in-r/.

5.1. Result in immediate posttest

Table 4 Mean scores, standard deviation by learning method in immediate posttest

Learning method	n	M	SD
color-coded wordlist (CWL)	24	7.96	3.13
color-coded writing (CW)	24	7.33	2.58
color-coded drawing (CD)	24	9.38	2.00

The mean scores (out of 12) and standard deviations for the immediate posttest were M = 7.96, SD = 3.13 for color-coded wordlist; M = 7.33, SD = 2.58 for color-coded writing; and M = 9.38, SD = 2.00 for color-coded drawing (Table 4).
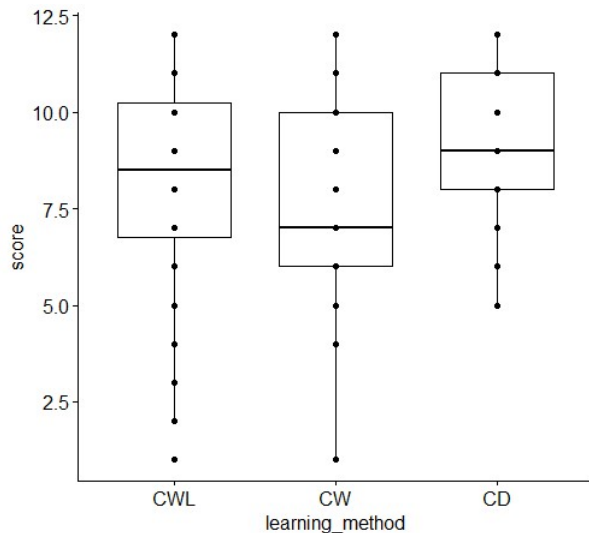

Figure 6 Summary statistics of the immediate posttest score by conditions (learning method)
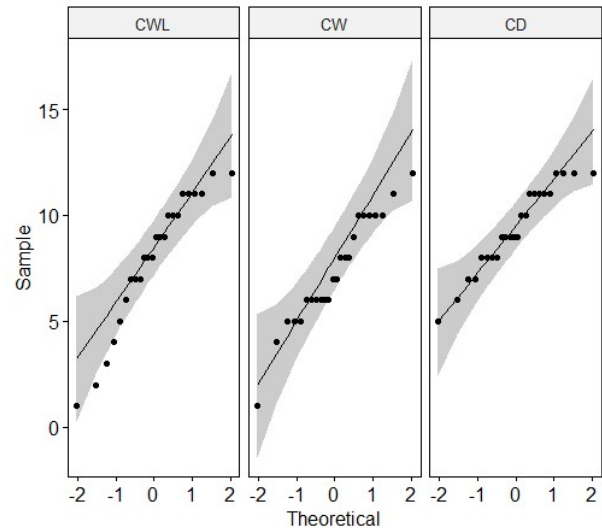
Figure 7 The normality assumption of data in immediate posttest using Shapiro-Wilk's test

While checking if there are significant outliers in the data, an outlier is found in the color-coded wordlist condition (Figure 6). However, no extreme outliers were found. Due to a small sample size in the experiment (n = 24 < 50), a Shapiro-Wilk's test is performed to check if the data is normally distributed. As assessed by Shapiro-Wilk's test (p > 0.05), the scores were normally distributed in each condition: color-coded wordlist (CWL), p = .0783; color-coded writing (CW), p = .318; color-coded drawing (CD), p = 0.137. The correlation between the given data and the normal distribution is shown in Figure 7. Since all the points fall approximately along the reference line, normality of the tested data can be assumed.

The one-way repeated measures ANOVA test revealed a significant effect of the learning method on immediate posttest performance, $F(2,46) = 4.704$, $p = 0.014 < 0.05$. The effect size, eta squared (η^2), was 0.101, indicating a medium effect (Figure 8). Post-hoc analyses with a Bonferroni adjustment revealed that the pairwise difference between

color-coded writing and color-coded drawing was statistically significantly different, p = 0.006 < 0.05. However, no significant difference was found in the other compared situations: color-coded writing - color-coded wordlist, p = 1; color-coded wordlist - color-coded drawing, p = .173.

Figure 8 Summary statistics of ANOVA test on the score in immediate posttest

5.2. Result in delayed posttest

The mean scores (out of 12) and standard deviations for the delayed posttest were M = 6.54, SD = 3.28 for color-coded wordlist; M = 5.38, SD = 2.81 for color-coded writing; and M = 7.71, SD = 2.71 for color-coded drawing (Table 5).

Table 5 Mean scores, standard deviation by learning method in delayed posttest

Learning method	n	M	SD
color-coded wordlist	24	6.54	3.28
color-coded writing	24	5.38	2.81
color-coded drawing	24	7.71	2.71

While checking if there are significant outliers in the data, no extreme outliers were found (Figure 9). Due to a small sample size in the experiment (n = 24 < 50), a Shapiro-Wilk's test is performed to check if the data is normally distributed. As assessed by Shapiro-Wilk's test (p > 0.05), the scores were normally distributed in each condition: color-coded wordlist (CWL), p = .0658; color-coded writing (CW), p = .0591; color-coded drawing (CD), p = 0.228. The correlation between the given data and the normal distribution is shown in Figure 10. Since all the points fall approximately along the reference line, normality of the tested data can be assumed.
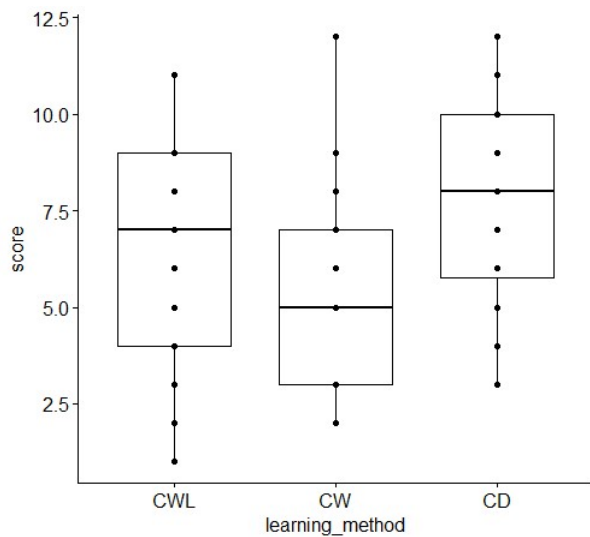
Figure 9 Summary statistics of the delayed posttest score by conditions (learning method)
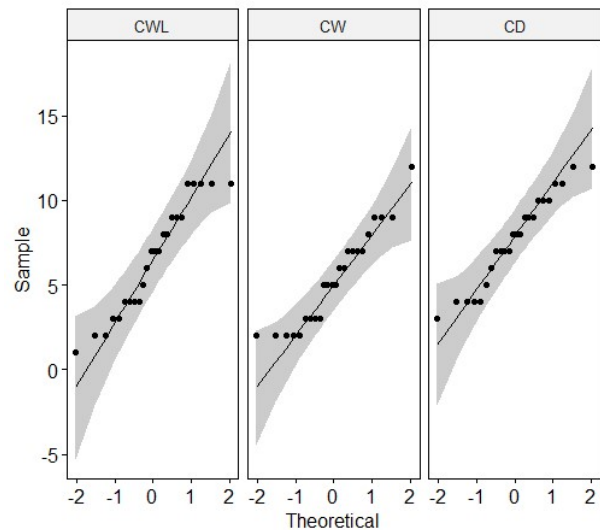
Figure 10 The normality assumption of data in delayed posttest using Shapiro-Wilk's test

The one-way repeated measures ANOVA test revealed a significant effect of the learning method on delayed posttest performance, $F(2,46) = 5.206$, $p = 0.009 < 0.05$. The effect size, eta squared (η^2), was 0.098, indicating a medium effect (Figure 11). Post-hoc analyses with a Bonferroni adjustment revealed that the pairwise difference between color-coded writing and color-coded drawing was statistically significantly different, $p = 0.004 < 0.05$. However, no significant difference was found in the other compared

situations: color-coded writing - color-coded wordlist, p = .378; color-coded wordlist - color-coded drawing, p = .447.
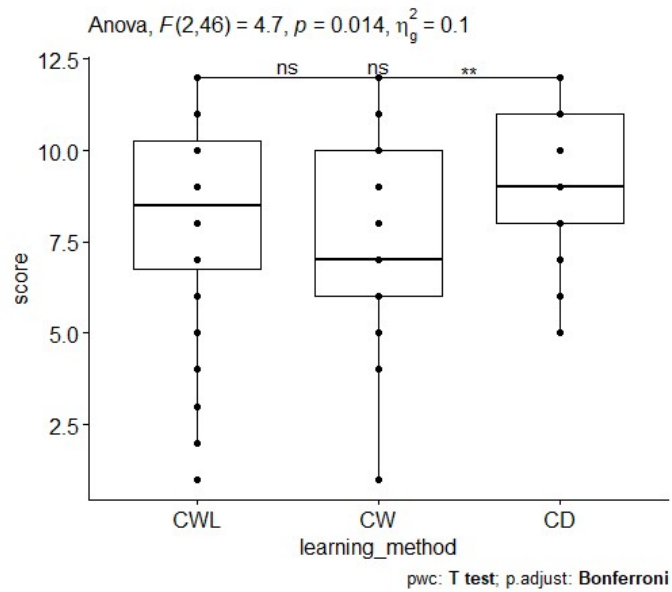

Figure 11 Summary statistics of ANOVA test on the score in delayed posttest

CHAPTER 6

DISCUSSION

6.1. Evaluation of proposed methods

6.1.1. Immediate posttest and delayed posttest

6.1.1.1. Evaluation of three learning methods for learning the grammatical gender

This study compared three different techniques combined with color-coding for learning the grammatical gender of German nouns, finding the answer to the question whether modifications easily done to existing leaning method, based on active l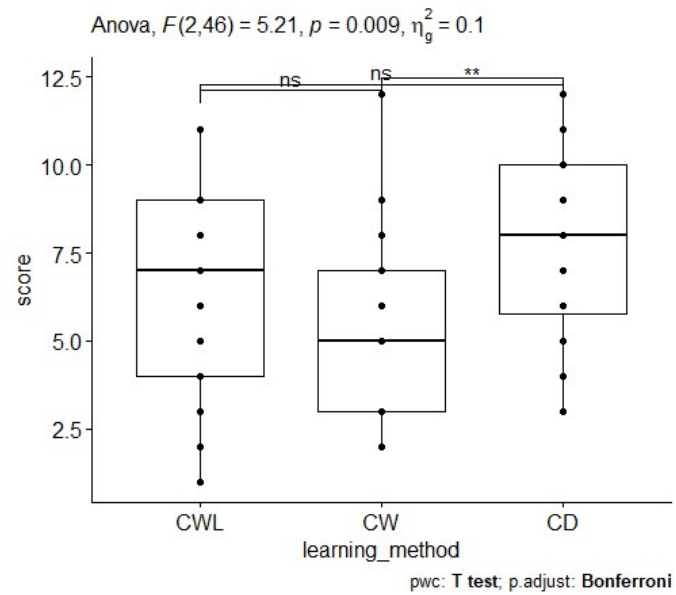earning, had an impact on the first learning process as well as retention after a while of grammatical gender information among complete beginners of German language. The experimental methods were intended to improve the effectiveness of the color-coding technique on acquisition of grammatical gender, increasing the engagement via active learning by drawing and writing which might simultaneously contribute to improving the vocabulary recall.

To find out whether the three conditions (color-coded wordlist, color-coded writing, and color-coded drawing) being three independent variables had any a noticeable impact on mean scores, test scores on the tasks regarding grammatical gender of target words were analyzed using a within-subjects analysis of variance (ANOVA) for both the immediate posttest and delayed posttest. ANOVA results revealed a statistical difference between conditions for the immediate posttest, $F (2, 46) = 4.7$, $p = .014$, and for delayed posttest, $F (2, 46) = 5.21$, $p = .009$ with $\alpha = .05$. With a statistically significant result, a Post-hoc test was conducted for both the immediate- and delayed posttest to determine where the differences truly came from. Post-hoc comparisons with the Bonferroni adjustment indicated that a significant result was found in the comparison of the color-

coded drawing and color-coded writing in both the immediate, p = 0.006, and delayed posttest, p = 0.004. The color-coded drawing method successfully brought more attention to the grammatical information of the noun and stood out from the other methods. While there is no significant difference between the other two comparisons, the color-coded drawing - color-coded wordlist and color-coded writing - color-coded wordlist, the difference between active learning and passive learning was not statistically significant.

6.1.1.2. Evaluation of three learning methods for learning the word spelling

Table 6 Scores in immediate posttest (GG = grammatical gender, N = nouns)

ID	1	2	3	4	5	6	7	8	9	10	11	12
GG	25	24	23	18	27	21	36	28	34	26	21	23
N	30	30	11	32	27	18	30	35	35	25	23	24

ID	13	14	15	16	17	18	19	20	21	22	23	24
GG	25	19	19	29	34	28	20	23	17	19	30	23
N	33	24	22	30	29	27	31	28	31	32	34	33

Since the main goal of this study is to investigate the effect of three learning methods on the learning of grammatical gender in German language, the learning regarding spelling of the target word is only tested in the immediate posttest (Table 6). Keeping in mind that it is important to study a noun together with the grammatical gender, another observation is made to find out whether the participants were able to learn the grammatical gender as well as the spelling. Three datasets corresponding to three learning methods were prepared, where the individual mean scores of the grammatical gender and the spelling could be found. To visualize the data, three scatterplots in terms of three datasets were created with individual mean scores of the grammatical gender and the spelling on the immediate posttest as two variables.

Some interesting results in terms of comparing scores between the grammatical gender and the nouns in immediate posttest regarding three learning methods could be found. In the color-coded writing condition, it could be observed that most participants performed better in the word spelling tasks than the grammatical gender tasks if the x=y line was added to the scatterplot, with 14 participants lying above, 8 under and 2 on the x=y line (Figure 12). This tendency could be found in the color-coded wordlist condition as well, with 17 participants lying above, 3 under and 4 on the x=y line (Figure 13). On the contrary, a better balance was achieved in the color-coded drawing condition with 11 participants lying above, 9 under and 4 on the x=y line (Figure 14). Based on the result, the color-coded writing and the color-coded wordlist have proved to be more supportive of learning for the spelling than the grammatical gender, while the color-coded drawing shows its possibility for providing a more well-balanced learning outcome.
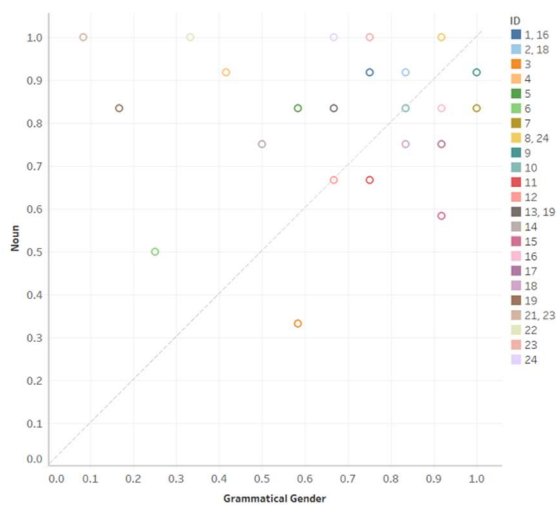

Figure 12 Individual mean scores of grammatical genders and noun in immediate posttest by color-coded wordlist
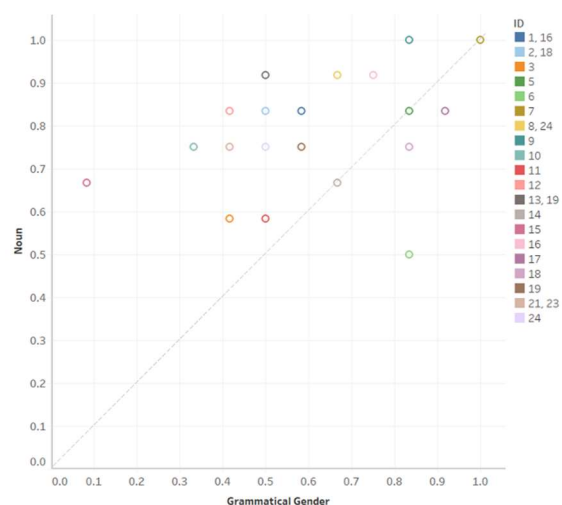

Figure 13 Individual mean scores of grammatical genders and noun in immediate posttest by color-coded writing
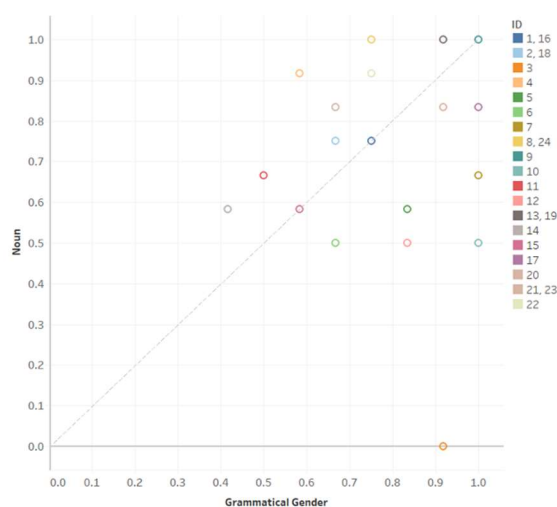
Figure 14 Individual mean scores of grammatical genders and noun in immediate posttest by color-coded drawing

6.1.2. Second survey

6.1.2.1. Evaluation of effectiveness of three learning methods

The questions in the second survey, which was conducted on the same day as the delayed posttest, were divided into three sections. In the first and second sections, the effectiveness of applying three methods to learning the grammatical gender and the spelling was investigated respectively. A five-point Likert scale question was used in the second survey to ask participants' opinion on the three learning methods. An example for the questions regarding the color-coded wordlist in both sections is shown below. Moreover, an instruction was given in advance to prevent the participants from misunderstanding the questions (Figure 15).

Explanation for Questions in Section 3

Remember that learning a noun always consists of **two parts**:

1. The definite article, or in other words, the **grammatical gender** (e g., der).
2. The noun itself, here referred to as the **word** (e g., Apfel).

Please be sure to not mix them up.

Do you feel that **color-coded wordlist** helped you memorize the **words**? *

	1	2	3	4	5	
did not help	○	○	○	○	○	helped a lot

Do you feel that **color-coded wordlist** helped you memorize the **grammatical genders**? *

	1	2	3	4	5	
did not help	○	○	○	○	○	helped a lot

Figure 15 Example questions and instruction in the second survey

In the first section, the participants gave their opinion on the effectiveness of the three learning methods regarding learning the spelling of a German noun (Figure 16). The results show that the males preferred the color-coded wordlist method over the others with the mean of 3.1, while the females found the color-coded writing method most useful with the mean of 3.5 when it came to learning for spelling. The color-coded method was in second place for both the females and males with the mean of 3.2 and 2.9 respectively.
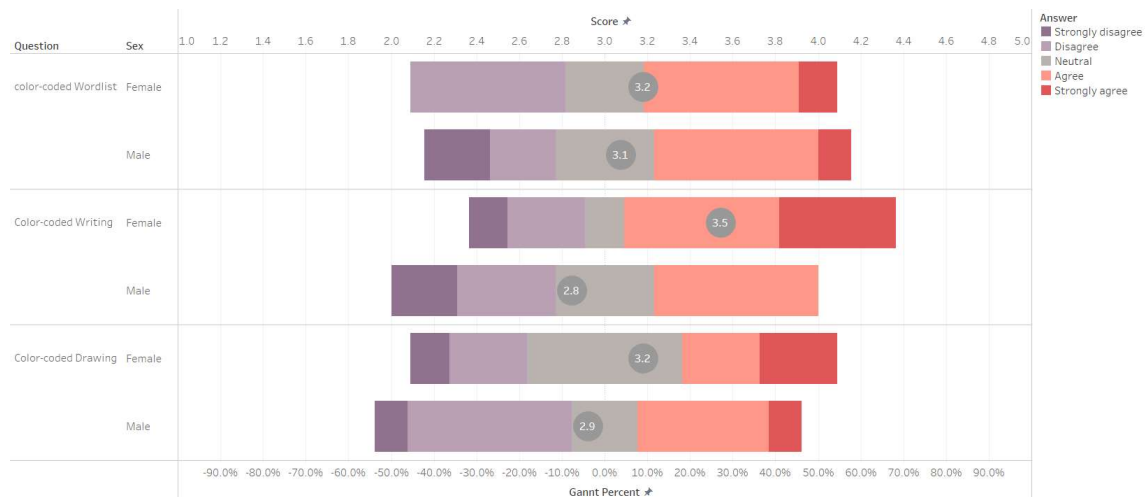

Figure 16 Response of evaluation of three methods regarding learning spelling
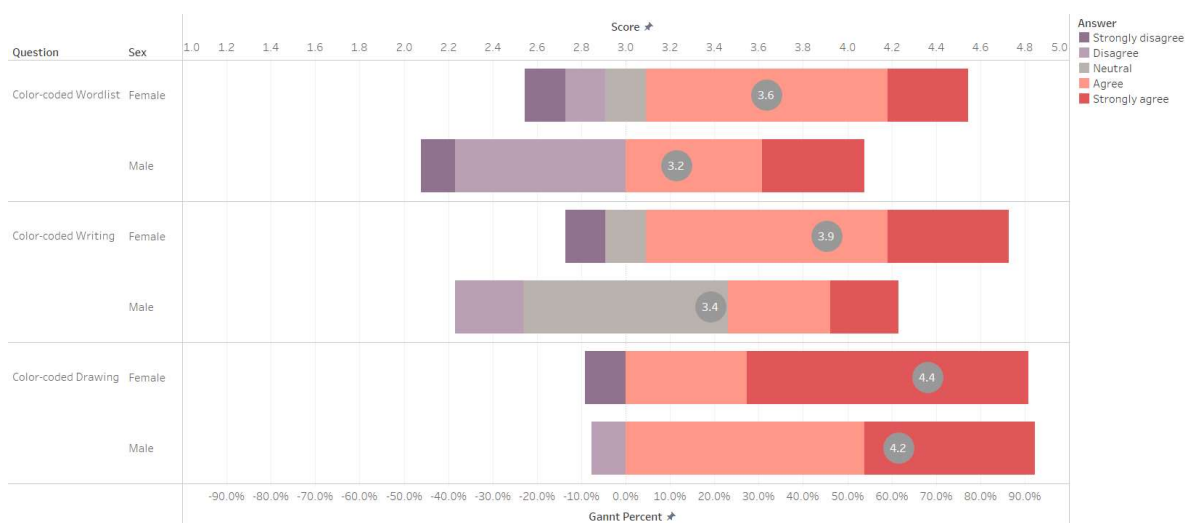
Figure 17 Response of evaluation of three methods regarding learning grammatical gender

In the second section, the participants expressed their opinion on the effectiveness of the three learning methods regarding learning the grammatical gender of a German noun (Figure 17). The results show that both the males and the females preferred the color-coded method over the other two methods with the mean of 4.4 and 4.2 respectively, followed by the color-coded writing method in second place with the mean of 3.9 and 3.4 and the color-coded wordlist method in third place with the mean of 3.6 and 3.2. The color-coded drawing method proved its effectiveness of learning the grammatical gender of a German noun, as around 90 percent of the participants were satisfied with this method.

After rating, the participants were asked to name the reasons for each of the selected answers (Appendix). In general, almost all participants agreed that color-coding indeed made the learning process easier and contributed to deepening the impression of the grammatical gender to each target word. However, the effectiveness might weaken or strengthen according to the combined techniques, which are wordlist, writing and drawing in our case. For example, most participants shared the same idea that the color-coded wordlist works for learning both grammatical gender and the spelling since the colors were already coded in the first place and the only task in this section is to memorize the target words, while the others found this method did not differ a lot from the traditional wordlist and felt bored later. Moreover, some participants mentioned that they were not able to recall the words they have learned with this method, since no active input was

required in this process. On the contrary, most participants admitted that color-coded writing and color-coded drawing helped to reinforce the memory, since more input and active learning were demanded in the learning process. Nevertheless, the participants also brought up some downsides of learning with color-coded writing and color-coded drawing. Since the participants were asked to fulfill the additional tasks besides learning the words, which were drawing and writing in our experiment, the ability of time controlling played a vital role. Some participants mentioned that they focused more on the additional tasks, and thus failed to spend more time on other important tasks. As for the color-coded writing, a majority of the participants noted that they spent much time on writing, which helped a lot with learning the spelling rather than the meaning and grammatical gender. On the other hand, most participants found that they were able to remember the grammatical gender along with the meaning of the word by applying color-coded drawing, since the connection between the grammatical gender and the meaning is strengthened with the help of color-coded drawing tasks as visual enchantments. Finally, the background of the participants differs from each other, and they prefer different methods regarding language learning. It should be taken into consideration that the preference of the participants could also affect the outcome.

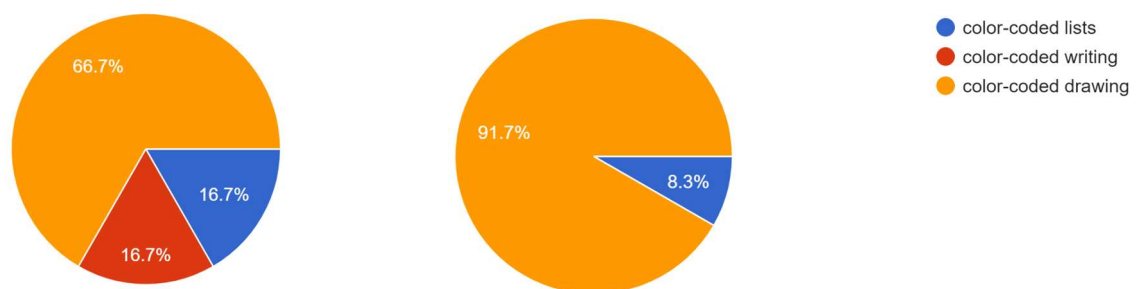### 6.1.2.2. Overall evaluation of three learning methods

Figure 18 Response in second survey regarding the effectiveness of three methods (left)

Figure 19 Response in second survey regarding the most interesting method (right)

This graph shows the result of two similar questions in the third question section of the second survey (Figure 18). Both are about how the participants themselves rate the three learning methods. Specifically, the question connected to the left chart is which of the three learning methods the participants felt was most effective. That is, which method did they feel was most effective in learning both the grammatical gender and spelling of the words. Exactly two-thirds voted for our proposed method, and half of the remaining third voted for each of the other two methods, respectively. This means that our method strongly makes learners feel that they are, in fact, learning something. This is important because motivation is necessary for learning, and this motivation is difficult to evoke if learners do not feel as if they are making any progress.

This concept of motivation is also closely related to the diagram on the right (Figure 19). The question for this was which of the methods the participants enjoyed the most. Having fun is extremely important to ensure proper learning of the given material. As can be seen from the graph, almost 92% of the participants felt that the color-coded drawing method was the one they enjoyed the most. Thus, together with the result of the graph on the left, this confirms that color-coded drawing method cannot only improve learning outcomes, but also increase the learners' motivation, self-confidence, and enjoyment of learning many times over.

6.2.   Item Analysis

Calculating the number of the correct answers for each word in the immediate and delayed posttest, bar charts for the results on both tests regarding all the target words were created to visualize the data (Appendix D). The fact that the difficulty of learning the grammatical gender for certain German nouns is lower than the other ones can be discovered in the immediate posttest and the delayed posttest.

To investigate the possible reasons behind, the top ten ranking German nouns in both tests were listed below (Figure 20 & 21). The color of the bars in both charts were assigned according to the grammatical gender of each word: *blue for masculine, pink for feminine* and *green for neuter*. German nouns such as *das Gemüße* (vegetable), *die Orange* (orange), *die Pizza* (pizza), *die Schokolade* (chocolate), *die Birne* (pear), *der Fish*

(fish) and *der Wein* (wine) can be considered as the ones with lower difficulty since most participants chose the correct grammatical gender for the mentioned words above in both the given tests. Surprisingly, the word *der Wein* also showed a low error rate on the immediate post-test in a related work (Arzt & Kost, 2016).
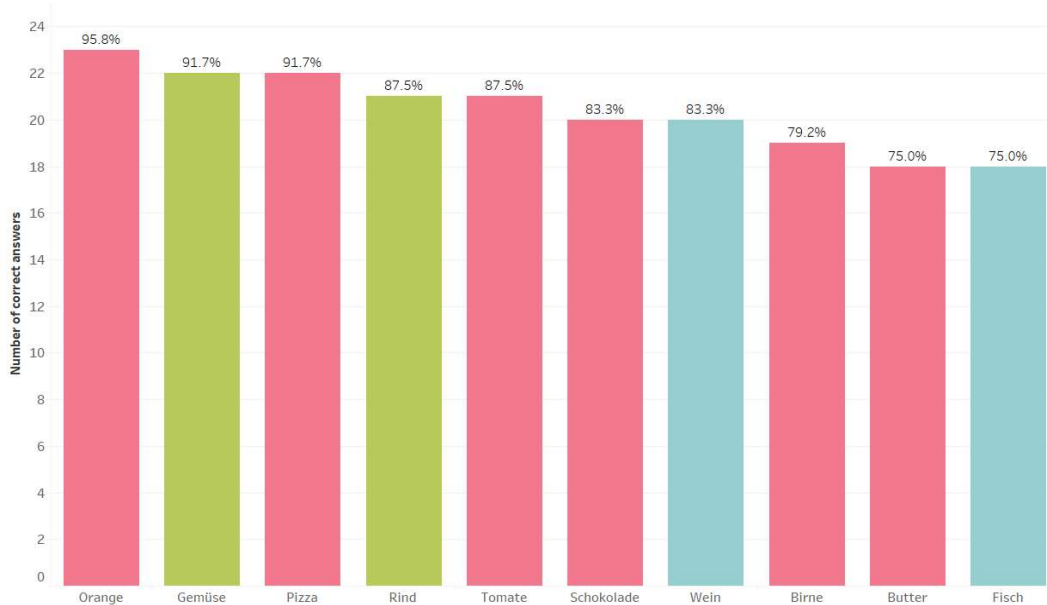
Figure 20 Number of correct answers for words raking 1-10 in the immediate posttest

Figure 21 Number of correct answers for words raking 1-10 in the delayed posttest

Taking a closer look at the listed items, the top 10 ranking items could also be categorized into three groups regarding the similarity between the assigned color (red, blue or green) in terms of grammatical gender and the original color in our real-life situation. To visualize the color feature in each word, the original color of the item is applied to the noun while the assigned color is applied to the article (Table 7).

Table 7 Three groups regarding the similarity of the assigned color and the original color

Group 1		Group 2		Group 3	
das	Gemüse	der	Apfel	die	Schokolade
die	Orange	die	Birne		
die	Tomate	der	Wein		
die	Pizza				
die	Wurst				
der	Fish				

As can be seen in the first group, the assigned color and the original color of the items are similar or same. For example, the article of the neuter word "das Gemüse" is assigned the color green and the noun is assigned the same color, since vegetables are often connected with the color green. In this situation, the effect of the visual enhancement of color-coding could be maximized, since the learners can easily memorize the grammatical gender of an item based on the original color in the real-life situation. On the other hand, taking the word "der Apfel" as an example from the second group, the article of the masculine word is assigned the color blue, which is totally different from the original color red. However, this strong contrast between the two colors might also contribute to a lower difficulty of learning the grammatical gender, since a strong impression is given when the connection between the assigned color and original color fails.

The difference between the second and third group lies in whether the original color of the item is similar to either red, blue or green or not. Since only these three colors could be chosen in the learning process and the original color is one of them, the learners

might have made contradictory choices, wherethrough a strong impression is created. Taking another word, *der Wein* as an example, the learners might feel confused when the color "blue" should be chosen instead of the original color "red". These results indicate a necessary further consideration of how positively/negatively the similarity between the assigned color regarding the color-coding method and the original color in the real-life situation affect the difficulty of learning the grammatical gender for German nouns.

6.3.   Experimental design

6.3.1. Dot-to-dot puzzle

Considering that not everyone is good at or even interested in drawing, dot-to-dot puzzles were applied in the color-drawing method instead of free drawing. The 36 puzzles were manually made on PowerPoint, which was surprisingly time-consuming. To keep the puzzles simple, so that the participants are able to solve them smoothly and to spend more time on learning vocabulary, most of the puzzles consist of approximately 15 dots.

After the immediate posttest, all participants were asked if appearing items in the given dot-to-dot puzzles during the learning process could be identified easily or not. A set of three surveys corresponding to each three vocabulary packages was created, which consists of 12 three-point Likert scale questions for each puzzle. The following instructions were provided to the participants:

- *If you can identify the objects easily, please choose 2.*
- *If you can identify the objects, please choose 1.*
- *If you cannot identify the objects, please choose 0.*

Since all the German nouns were learned by 2 groups of 4, 8 responses were collected for each target word.
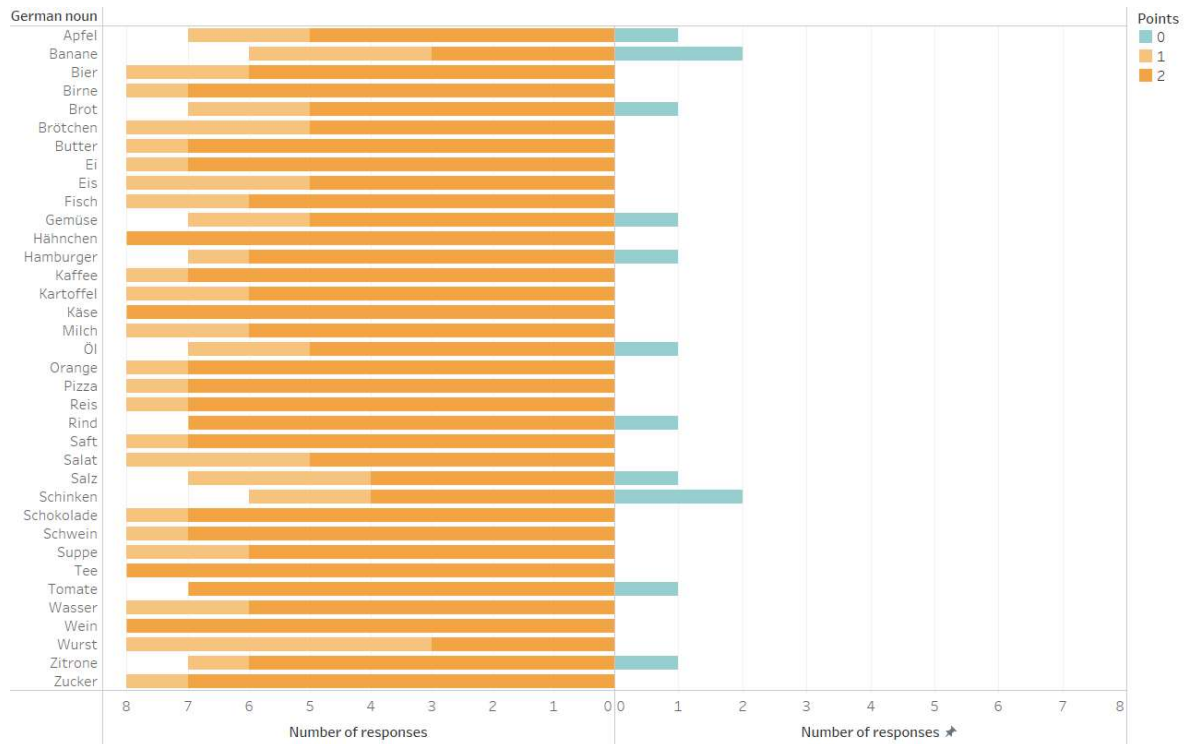
Figure 22 Responses of the participants in the first survey

As indicated in figure 22, most of the given puzzles could be considered to be easily understandable or identifiable since 1 and 2 were chosen in response to most of the questions. Among all high-rating puzzles, the ones for *Hähnchen* (chicken)*, Käse* (cheese)*, der Tee* (tea) *and der Wein* (wine) were given 2 points by all the participants.

6.3.1.1. Difficult puzzles in participants' point of view

Some participants mentioned after the learning section that some items in the puzzles are hard to recognize due to the different living experiences and the complexity of the puzzles. Two detailed feedback on the lowest rated puzzles, namely *die Banane* (Figure 23) and *der Schinken* (Figure 24) from the participants are as follows:

"Maybe it will be better if there is only one banana instead of two. It is only more complicated for us to identify. I felt confused when I saw this picture." - Participant A

"I buy ham for my sandwich, and it is always round and sliced. Therefore, it is hard for me to connect this picture with the one I could find in the supermarket." - Participant B
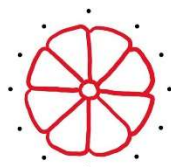
die Banane
banana

der Schinken
ham
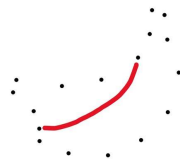
Figure 23 Dot-to-dot puzzle: die Banane

(banana)

Figure 24 Dot-to-dot puzzle: der Schinken

(ham)

6.3.1.2. Difficult puzzles in instructors' point of view

die Orange
orange

der Zucker
sugar

Figure 25 Dot-to-dot puzzle: die Orange

(orange)

Figure 26 Dot-to-dot puzzle: der Zucker

(sugar)

Since an item can be easily identified in such puzzles if the item possesses a strong characteristic or feature such as color and shape, struggles are inevitable in the puzzle generating process when an item can only be recognized easily with its original color. As shown in figure 25, *die Orange* (orange) is round-shaped, which is a common feature in the category of fruits. Without the orange color, this fruit could be mistaken for similar fruits such as lemon or tangerine.

Another difficult situation is found when an item is in a simple shape, e.g., circle and rectangle, or common three-dimensional shapes such as cube. After several revisions and testing, the final version of the puzzle for *der Zucker* (sugar) is shown in figure 26. Without the teaspoon, it might be impossible for the learners to identify the item in the picture only by its geometrical shape since it could be mistaken for anything, which is also a cube.

6.4. Limitations and future research

The findings of this study have to be seen in light of some limitations. The participants in this research were recruited to be complete beginners in learning German. The intent was to prevent two potential biases which could occur when some learners (1) have experience in German learning and thus are able to learn the grammatical gender from the suffixes of a noun and (2) spend additional time on German learning with different techniques after the experimental learning process. With this in mind, the prerequisites for the participation were that the participants should have no experience in learning German and will not attend any German language course before the end of the experiment; however, the actual effectiveness of the three tested vocabulary learning methods as a technique which supports the German language learners might be underestimated or overestimated since the participants were intentionally selected and not in fact involved in German language learning.

A further important consideration for the effectiveness of these teaching techniques goes back to the idea of enhancement of long-term memory retention. Color-coding with the color *red*, *blue* and *green* was used as a visual enhancement technique in our experiment to reinforce the connection between a German word and the possessed grammatical gender. According to the experimental outcomes, the mean scores of the both immediate- and delayed posttest in the color-coded drawing condition were higher than the mean scores in the other two conditions. From qualitative data, participants' preference for color-coded drawing over color-coded writing and color-coded wordlist could be concluded since most participants mentioned in the survey that the completed drawings etched in their memory, which might contribute to improving long-term

memory. Although both quantitative and qualitative data indicated similar results, only the short-term recall could be evaluated but not the long-term recall since the whole experiment including the learning process and both the immediate and delayed posttest were conducted within three days with a short practice time, which was not long enough to conduct an evaluation of the long-term recall regarding the learning of the grammatical gender. A more significant result might be found in a longitudinal research where different learning methods combining color-coding techniques are repeatedly used as well as the acquisition of long-term retention of grammatical genders being observed over a long period of time.

There is another limitation to this study that must be considered as well. The dot-to-dot puzzles in the color-coded drawing material were not created automatically, which turned out to be time-consuming and could become a burden on the instructors if applying this learning method to the classroom. Moreover, the preparation could be more challenging depending on how creative and imaginative a person is. Despite the fact that the required competence could be developed via training, there are still obstacles to be overcome while generating the puzzles. In our experiment, all German nouns fell into the category "Food", which could be drawn without facing large problems. However, when it comes to abstract words, which cannot be perceived with the five main senses such as *anger* and *democracy*, hardships are seemingly inevitable. Not to mention that the puzzles should be at the right difficulty level as well, which will not take up too much time to be solved but still succeed in leaving a strong impression after the learning process. Therefore, how to lower the difficulty in generating the puzzles so that the color-coded drawing method can be widely applied is a research-worthy topic.

CHAPTER 7

CONCLUSION

For all German language learners regardless of their language level, the grammatical gender system is one of the biggest challenges to be overcome. Three methods combined with the color-coding technique were designed with the aim of reducing the difficulty of acquisition of grammatical gender. To evaluate the difference of effectiveness between the color-coded wordlist, color-coded writing and color-coded drawing, the modified learning materials regarding three methods were made and given to the participants.

The first research question was to find out whether different types of color-coded combined techniques (wordlist, writing and drawing) have different effects on students' immediate learning of the grammatical gender of the target words. To seek the answer to this question, an immediate posttest was carried out, and the results were analyzed using ANOVA. The ANOVA results revealed a statistical difference between three conditions and the post-hoc comparisons using the Bonferroni adjustment indicated that a statistical difference was truly found between the color-coded writing and color-coded drawing conditions. The results of comparing scores between the grammatical gender and the nouns in immediate posttest regarding three learning methods were also discussed and visualized by using scatterplots. In color-coded wordlist and color-coded writing conditions, it could be observed that most participants performed better in the word spelling tasks than the grammatical gender tasks, while most participants were able to get the right answers for both tasks in the color-coded drawing condition, which suggests that color-coded drawing is supportive of learning for not only grammatical genders but also spelling. Based on the result, the color-coded drawing method seems to be the most effective method in terms of learning German nouns.

The second research question sought to find out whether different types of color-coded combined techniques (wordlist, writing and drawing) have different effects on

students' retention regarding learning of the grammatical gender of the target words over time. To seek the answer to this question, a delayed posttest was carried out two days later and the results were analyzed in the same way as in the first research question. As for the ANOVA results, a statistical difference between three conditions was found and the post-hoc test showed the same result as in the immediate test which supports the idea that the grammatical gender of target words learned with color-coded drawing method seems to remain in participants' memory longer and more successfully than the other ones learned with color-coded writing and color-coded wordlist.

The third research question was whether the learners find three types of color-coded combined techniques (wordlist, writing and drawing) useful in terms of learning the grammatical gender and spelling respectively. In the second survey, the participants shared their opinions by answering the given 5-point Likert scale questions. When it came to spelling, the males found the color-coded wordlist method more useful than the others, while the females found the color-coded writing method most effective. As for learning grammatical genders, both the males and the females agreed that the color-coded method was the most effective out of three methods.

Finally, the last research question was whether the three types of color-coded combined techniques (wordlist, writing and drawing) successfully create a fun learning environment in terms of learning of the German nouns. For this, the participants of the experiment, after its conclusion, answered the question on which of the three methods they had the most fun. Not a single participant voted for the word list, indicating that simple memorization is not made more interesting by adding colors. A few voted for color-coded writing. Most importantly, almost all of the participants voted for the color-coded drawing method, confirming that this method does indeed create a fun learning environment for learners. Instead of learning in a relatively traditional way such as writing and wordlist, the participants showed a preference for a more creative and active learning method.

7.1. Future work

Taking this study as a first step for further analysis of these techniques combined with

color-coding, several additional points for future research can be considered. For a longitudinal study, the three methods could be applied to German classes and different levels of German language learners to find out the actual effectiveness of each method. An application where the dot-to-dot puzzles could be automatically generated will significantly ease the burden on the instructors. As one of the feasible ways to solve the problem on how to generate understandable puzzles or pictures for abstract words, the puzzles or pictures are generated based on a given sentence instead of vocabulary. For example, the word, die Freude (*enjoyment*), is an abstract word and thus difficult to express via drawing. However, it might be easier to generate a picture for the sentence "*Die Lehrerin hatte Freude an ihrer guten Schülerin.*", which means *"The teacher enjoyed teaching her good pupil."* in English, by drawing a female teacher, who hugs and praises her pupil for the great work. In this sentence, three feminine nouns are used, namely *die Lehrerin*, *die Freude* and *die Schülerin*, and thus should be color-coded in red. In this way, the learners are able to learn several words which possess the same grammatical gender simultaneously and the story behind the sentence might contribute to a stronger impression than a single word.

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A. Manual for Experiment

2023

Manual for experiment

JAPAN ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY

WANG, SSU-MIN

[Background]

German nouns have grammatical genders. Depending on a noun's gender, some words, including the noun itself, change their form within a sentence. Therefore, it is important to always study a noun together with its gender. However, most German language learners find it difficult to learn German nouns since the grammatical genders are assigned to all nouns regardless of whether the referents have a biological sex.

A noun can either be masculine, feminine, or neutral. This is usually indicated by definite articles ("the" in English).

- Masculine: der

  Example: der Tisch (the table)
- Feminine: die

  Example: die Schule (the school)
- Neutral: das

  Example: das Buch (the book)

[Prerequisite for the Experiment]

○ Please make sure that you are familiar with the following words in English. (See Table 1)

○ Please make sure that you have office 365 (PowerPoint) on your device.

○ Please make sure that you can draw/write in Slide Show Mode by using Pen or Highlight. (See Figure 1)

[Venue]

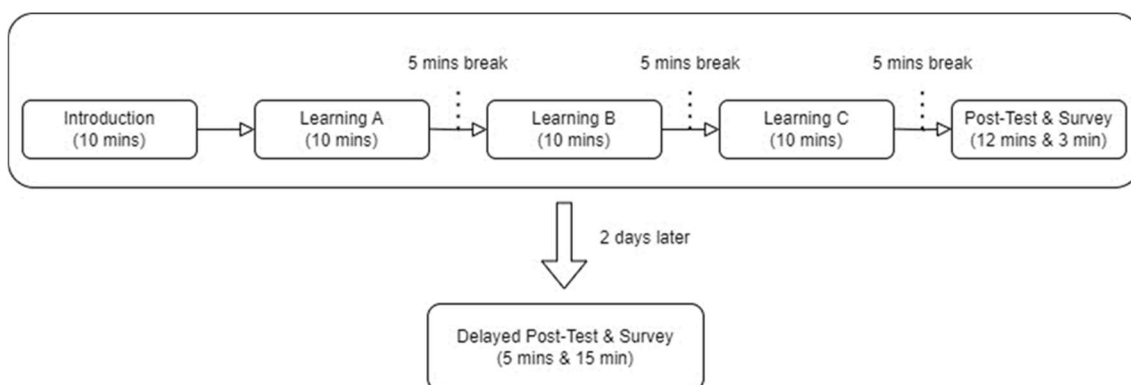The learning process and post-test take place at K23 while the delayed post-test is online.

[Reward]

The participants will be paid 1000 yen per hour for participating in the experiment.

[Experimental Procedure]

There are three learning sections throughout the whole experiment. In each section, the participants will have to learn 12 German words with specific methods (36 words in total). After each of the learning sections, there will be a 5-minute break. After finishing the last learning section, a post-test and survey will be given, which takes about 15 minutes.

An email, where the links for delayed post-test and survey are attached, will be sent to the participants two days after the experiment. The participants will have to take the delayed post-test and fill out the survey online as the last part of the experiment.

Introduction (10 mins) → Learning A (10 mins) → [5 mins break] Learning B (10 mins) → [5 mins break] Learning C (10 mins) → [5 mins break] Post-Test & Survey (12 mins & 3 min)

2 days later

Delayed Post-Test & Survey (5 mins & 15 min)

[Learning Method]

Color-coding is an often-used technique, which helps German language learners acquire vocabulary efficiently. Colors are assigned to German nouns based on their grammatical gender (blue for masculine, red for feminine, and green for neuter).

In our learning section, the participants will have to learn vocabulary with three different methods, color-coded wordlist, color-coded writing and color-coded drawing, which will be explained in the introduction section.

[Protection of Personal Information]

Personal information to be collected for statistical information includes name, contact information, age, gender and nationality. All personal information except for experimental results will be discarded after publication. Information obtained from the experiments will be used only for research purposes. Personal information such as name and contact information and experimental results will be kept strictly confidential.

The result of experiments other than personal information will eventually be published in academic conferences, paper, books, etc., but the result will not be disclosed in a form which allows individuals to be identified. Personal information, such as age, nationality and gender, may be disclosed as statistical information, but names and contact information will not be disclosed.
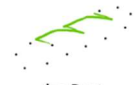
- **Table 1**

apple	milk	banana	chicken
beer	ham	butter	wine
fish	orange	egg	beef
pear	ice cream	coffee	pork
salad	chocolate	rice	soup
sausage	bun	hamburger	tea
sugar	oil	cheese	tomato
vegetable	pizza	potato	lemon
water	bread	salt	juice

- **Figure 1**

B. Materials for color-coded drawing

Please learn the following words.
- You should notice:
- You will learn all the words twice.
- The slides advance automatically, so do not click for next slide.

die Butter
butter

das Ei
egg

die Kartoffel
potato

das Hähnchen
chicken

das Schwein
pork

die Suppe
soup

der Saft
juice

der Tee
tea

die Tomate
tomato

der Wein
wine

das Rind
beef

die Zitrone
lemon

Great job!
You are at the end of this process.
Please save your drawing and send it to me as attachment after the learning part.

Please learn the following words.
- You should notice:
- You will learn all the words twice.
- The slides advance automatically, so do not click for next slide.

das Brot
bread

das Brötchen
bun

das Öl
oil

der Schinken
ham

die Orange
orange

die Pizza
pizza

die Banane
banana

der Kaffee
coffee

der Reis
rice

das Salz
salt

der Hamburger
hamburger

der Käse
cheese

Great job!
You are at the end of this process.
Please save your drawing and send it to me as attachment after the learning part.

Please learn the following words.

You should notice:
- You will learn all the words twice.
- The slides advance automatically, so do not click for next slide.

der Apfel
apple

die Birne
pear

der Salat
salad

das Wasser
water

die Wurst
sausage

der Zucker
sugar

das Bier
beer

der Fisch
fish

das Gemüse
vegetable

die Milch
milk

das Eis
ice cream

die Schokolade
chocolate

Great job!
You are at the end of this process.

Please save your drawing and send it to me as attachment after the learning part.

C. Response of open-ended questions

ID	Why do you feel that color-coded lists helped/didn't help you memorize the words?
1	Some words, such as water, this method is useful for memorization.
2	I memorize words more with the help of English.
3	It was the first test to appear, and at the beginning, I didn't know what needed to be done, so I didn't memorize it. In addition, given my personal memory characteristics, merely relying on visual memory from twice is ineffective. Memorizing German words by color-coded lists for the first time is too difficult.
4	Same as regular lists learning
5	I can remember the things based on the color but I cannot remember the spelling based on the color
6	It'll just give me a slight impression of the words.
7	By using color-coded lists, I can focus on genders and words together, which helped me memorize both.
8	When I try to remember a word, the word appears in my mind in a specific color, and it helps me to memorize the gender of the word. However, it does not help much in memorizing the meaning of the words
9	Just reading the words is a little short-memory memorization
10	Because I can't relate the color to the spelling. I just remember the spelling of words by comparing German words with English words.
11	I don't think colors help with word memorization
12	It's a traditional way to memorize words.
13	Not that effective
14	I could recall those words after recollecting those pictures.
15	I think color-coded lists are useful for memorizing the word with grammatical gender.
16	As I only need to remember the word, this is the most helper in remembering the word
17	It is because color coded makes it easier to remember the gender rather than remembering der, das and dis

18	This helped me a lot with memorizing the gender of the words. However, it did not help me much with spelling the words correctly.
19	I can remember the words by looking at them but I lost interest after a while.
20	It is easy to identify the word, for example most of the food is red.
21	I just saw them with different colors but this method was not so effective in making me involved in the task. Also, it could not really grab my attention well, and was a bit monotonous after a while.
22	got confused with colors. I used other techniques to remember names
23	Color can deepen memory
24	It is easy to understand, you just need to memorize the list directly.

ID	Why do you feel that color-coded writing helped/didn't help you memorize the words?
1	Some words, such as oil, this method is useful for memorization.
2	Spelling works for me.
3	Using writing to memorize German words is effective, but what can be remembered is not much.
4	Same as regular lists learning
5	It is opposite with the first one
6	By color-coded writing, it allows me to understand and remember words differently.
7	Color-coded writing made it easy for me to memorize words.
8	It takes time to write the words and change the pen colors. I prefer to just look and learn the words.
9	Writing is more suitable for me to memorize the words
10	Because choosing the color will waste my time memorizing the words。
11	Writing helps me remember words, but it has nothing to do with colors
12	I think it is another division to remember the words.

13	Writing helps memorize.
14	I personally use my pictographic memory to remember things. So I think it is a good way to learn new things.
15	I think color-coded writing is useful for practicing and memorizing the words, but I feel a little difficult because I focused more on writing the words.
16	I think it helped a bit, one or two word, but could be inaccurate
17	It does help to certain extent as we are involved in an activity but not like drawing
18	This helped me a lot with memorizing the gender of the words, and the spelling.
19	Re-writing the words helped me focus and remember more easily.
20	Writing can help me to remember the word more effective
21	It was better than the previous task as I spent more time and also paid more attention. It was more interactive than the previous method.
22	I got confused with colors.
23	Memorizing colors as you practice will help you remember them better
24	I am familiar and remember words through the writing practice.

ID	Why do you feel that color-coded drawing helped/didn't help you memorize the words?
1	Based on understanding the meaning of words and how to draw them, this method can strengthen memorization.
2	I memorize words more with the help of English.
3	It's hard to say; it may not work.Similar to English vocabulary, I might be able to memorize it on the day of the test, but two days later, I can no longer recall it.
4	Same as regular lists learning.
5	When I draw, I focus on it so it is easy to remember.
6	maybe the drawing more interesting

7	Drawing makes it difficult for me to focus on words. I was not sure how to spell the German words during the test.
8	The drawing helps me to imagine the concepts of the words and better memorize them. However, the action of finishing the drawing does not help. It will be better if the complete drawings were given.
9	Drawing sometimes is a little abstract.
10	Because the drawing is based on English words to draw. There was only enough time for me to draw what the English words described, and I didn't have time to connect the German words with the pictures.
11	Drawing doesn't help with memorizing the words
12	Maybe I only focus on how to draw the picture.
13	Drawing is more intuitive.
14	I could relate to my days at high school, when I used to remember things like this.
15	I think color-coded writing is also a useful tool for practicing and memorizing the words, but I feel a little difficult because I focused more on drawing the word.
16	I focused on the color and shape not word
17	It is because color codes make it easier to remember the gender rather than remembering der, das and dis. It is because color codes makes it easier to remember the gender rather than remembering der, das and dis and because connecting the dots takes a little longer for me and i am more conscious of my action than while writing , I was exposed to the word a little longer and the color and hence I think it helped the most.
18	This helped me a lot with memorizing the gender of the words. However, it did not help me much with spelling the words correctly. Moreover, drawing takes a lot of time, while memorizing takes very little.
19	I focused on the drawings more than the words themselves.
20	Those picture can't help me to memorize the words in a short time
21	Of all the 3 methods, this was the most effective as I spent more time. Because drawing was fun and I was really involved in it and involuntarily memorized a lot of words by creating abstract pictures and by trying to establish abstract connection to things I already knew. So it helped me to memorize the genders and spellings better than other methods.
22	Because I drew put more effort, I could remember

| 23 | The pattern memory method is very good |
| 24 | Drawing is awesome. The combination of image and color can emphasize the words. |

ID	Why do you feel that color-coded wordlists helped/didn't help you memorize the grammatical gender?
1	It can establish a connection between words and colors (grammatical gender) in the brain.
2	Association between grammatical gender and color works.
3	It was the first test to appear, and at the beginning, I didn't know what needed to be done, so I didn't memorize it. In addition, given my personal memory characteristics, merely relying on visual memory from twice is ineffective.Memorizing German grammatical genders by color for the first time is too difficult.
4	When I took the tests both during and after learning, the color-coded lists didn't remind me of any clues. I am not sensitive to the color of words and focus more on memorizing the words themselves.
5	I can easily remember color instead of the word
6	the color-coded lists, it'll just give me a slight impression of the words.
7	I think it was easy for me to memorize words with genders by using the lists.
8	When I try to remember a word, the word appears in my mind in a specific color, and it helps me to memorize the gender of the word. However, it does not help much in memorizing the meaning of the words
9	When connecting words with color, sometimes it is more vivid to memorize.
10	Because color can deepen my memory。
11	I can't recall the color by thinking the words
12	A traditional way to memorize the words.
13	Since I just need to memorize the color.
14	This was a little difficult for me to memorize using this technique.
15	Yes, it helps me in remembering the Masculine, Feminine and Neuter because of the color-coded list.
16	Didn't help, I think

17	It did not help as much as the drawing and since we were just reading and not much activity was involved I was not able to remember much
18	The words appeared in different colors, which helped me remember their genders.
19	I can imagine the words in the color.
20	Same reason, Easily to identify the word , for example most of the food is red color
21	Not much, same reason. Couldn't catch my attention.
22	I got confused and did not put much effort to learn
23	Can clearly know the part of genders of each word
24	I know the colors correspond to which articles.

Why do you feel that color-coded writing helped/didn't help you memorize the grammatical gender?
It can also establish a connection between words and colors (grammatical gender) in the brain.
Writing helps reinforce memory.
I regard red as a feminine（die） term and blue as a masculine(der) term, attributing anthropomorphism to them and memorizing them with feelings and color-coded writing makes my memory of them more solid.
In this learning style, I had to memorize the new words and their grammatical genders by repeatedly writing these words with matched colored pens, so I guess it might deepen the colored picture in my mind.
The same with first one
Because as I write, I'll whisper along as I write and remember it better.
I do not know why. It's always easier for me to remember things when I write them down.
I have difficulty trying to write and remember words at the same time
For me writing seems to have not too much relation with the genders.

Because I was busy remembering the spelling of the word, I thought the time was too short. When I chose to write with a colored pen, I had already skipped to the next word.
I can't recall the color by thinking the words
It's a very direct way to remember the gender.
The color helps a lot.
I have a balanced opinion regarding this.
Yes, it helps me in practicing the Masculine, Feminine and Neuter but I did more focus on writing.
Helped me in grouping, for one or two words, the word by the color in my memory even though that can be inaccurate
It did make it easier but not as much as coded drawing
The words appeared in different colors, which helped me remember their genders.
Choosing the correct color for the pen to rewrite the words helped me focus and remember more easily.
Because there is only three colors red green and blue , keep writing can help me to remember those three colors easily
Better than color-coded writing as I spent some time with it.
I got confused with colors and made it difficult to remember
Color memory plus handwriting practice can deepen the impression of single words
Since we don't need to write the articles.

ID	Why do you feel that color-coded writing helped/didn't help you memorize the grammatical gender?
1	Usually it helps a lot, but if I don't know how to draw, it will weaken the effect.
2	The shape of an object can be linked to a color, which is related to gender .
3	I imagine blue terms as a man holding them or interacting with them, and red terms as a woman holding them or interacting with them. For example, I find that coffee and tea are masculine（der） terms; I would imagine it's because, in ancient times, only men could drink tea. Milk is a feminine（die） term; I would imagine that because women have breast milk, milk is

	also a feminine（die） term. During the test, the color-coded drawing method didn't imprint on my memory as profoundly as the color-coded writing, but two days later, the image memory（the color-coded drawing method ） would emerge more deeply and quickly.
4	The point is not the picture but the color. Drawing just helps me memorize the color, which tells the gender, but it also takes up much time which should have been used to memorize the words.
5	The same with first one
6	Drawing is very interesting and in the process of drawing, the memory is also deeper.
7	I feel that it helped me a lot to memorize only genders (color).
8	The color of the drawing helps me to better memorize the gender. However, the action of finishing the drawing does not help. It will be better if the complete drawings were given.
9	There will be image in my head when drawing
10	Because color can increase my memory points. I can recall the color of the painting, and I know the relationship between color and gender.
11	Drawing by different colors allows me to associate shapes and colors of words
12	I also focused on how to draw the picture.
13	Still, color and drawing helps a lot since they are intuitive.
14	I do strongly admit this, that color coded drawing helped to memorize things.
15	Yes, it helps me in practicing the Masculine, Feminine and Neuter but I did more focus on drawing.
16	Helped me in group the word by the color in my memory even though that can be inaccurate
17	It is because color coded makes it easier to remember the gender rather than remembering der, das and dis and because connecting the dots takes a little longer for me and i am more conscious of my action than while writing , I was exposed to the word a little longer and the color and hence I think it helped the most.
18	The words and their matching images were shown in different colors, which helped me recall their genders.
19	Choosing the correct color for the pen to draw helped me focus and remember more easily.
20	Making the grammatical gender become visible Red is die

21	Same reason as before. interactive, better imagination. Therefore it makes the process a bit spontaneous.
22	I got confused with colors and couldn't remember
23	The pattern memory method is very good, but sometimes I only focus on drawing.
24	As same as the words

| ID	Why did you find this method the most interesting/fun?
1	Drawing is more interesting than just looking at words.
2	visual shape information works for me.
3	During the test, the color-coded drawing method didn't imprint on my memory as profoundly as the color-coded writing, but two days later, the image memory（the color-coded drawing method ） would emerge more deeply and quickly.
4	Compared with the other two learning methods, drawing makes my brain and hands work at the same time and I think it could reinforce my memory for new words and their grammatical genders. Besides, drawing could provide more details.
5	It is interesting to draw and memorize
6	interesting
7	feels like a game and I like to draw.
8	It is good and simple
9	because it's not only the words, but also the image.
10	Because drawing by words makes me feel relaxed and not boring.
11	Drawing by different colors allows me to associate shapes and colors of words
12	I used to memorize the words in this way.
13	The most effective way for me.
14	Because I do rely on pictorial memory recalling methods.
15	It was a fun but later I think it was a little hard for me to memorize the Masculine, Feminine and Neuter

16	Because need to imagine things
17	It is because color coded makes it easier to remember the gender rather than remembering der, das and dis and because connecting the dots takes a little longer for me and i am more conscious of my action than while writing , I was exposed to the word a little longer and the color and hence I think it helped the most.
18	Memorizing words with multiple methods, such as watching and drawing, is more interesting.
19	Drawing is fun. I also have to use my imagination.
20	Drawing is more funny than others two methods However if talking the effect I would choose writing
21	Because it was more Engaging, better imagination. Therefore it makes the process a bit spontaneous due to its multisensory approach.
22	because, I like drawing
23	I haven't tried this
24	I have never done other exercises like this before.

ID	Which of three methods did you find the most useful regarding learning German nouns (= grammatical gender + word)?
1	The other 2 need to switch colors which causes me to sometimes hurry.
2	I remember the grammatical gender by color, and the word is highly related to English words.
3	In the short time, I would think the color-coded writing is easier. In the long term, I would consider the color-coded drawing. I might use color-coded writing to memorize words and color-coded drawing for memorizing grammatical gender.
4	When I was making choices in tests, those pictures could always easily come to my mind.
5	I think drawing and writing are combined to help memorize things and spelling
6	interesting and I can use my imagination a lot while I'm drawing.
7	All of my attention was going to what I was drawing.
8	It is good and simple

9	Writing can be memorized more effectively
10	Because most of the words I remember are from word lists.
11	I can clearly recall words remembered by color-coded drawing
12	Writing makes me have a good memory.
13	Effectivity.
14	I could recall things using color coded drawing.
15	Because it easily memorized the words with Masculine, Feminine and Neuter because of the color-coded list.
16	Balanced in learning word and gender, not missing word in drawing, and not missing gender in lists
17	It is because color coded makes it easier to remember the gender rather than remembering der, das and dis and because connecting the dots takes a little longer for me and i am more conscious of my action than while writing , I was exposed to the word a little longer and the color and hence I think it helped the most. Hence more involvement while learning a language makes it easier to learn
18	This is the most fun way to memorize words, and it helped me establish a strong link between the words and their genders.
19	Most of the words I remember are from color-coded drawing slides.
20	Same reason for the question 'Which of three methods did you find the most interesting/fun?'
21	Because it was more Engaging, better imagination. Therefore it makes the process a bit spontaneous due to its multisensory approach.
22	drawing made me put more effort into understanding and remembering. It stayed in my memory that I had drawn something.
23	I am used to writing by hand to strengthen my memory
24	Drawing is impressive. I pay more attention in it. 👍 👍 👍 👍

D. Correct answers for each word in the immediate and delayed posttest

Correct answers per word in immediate posttest
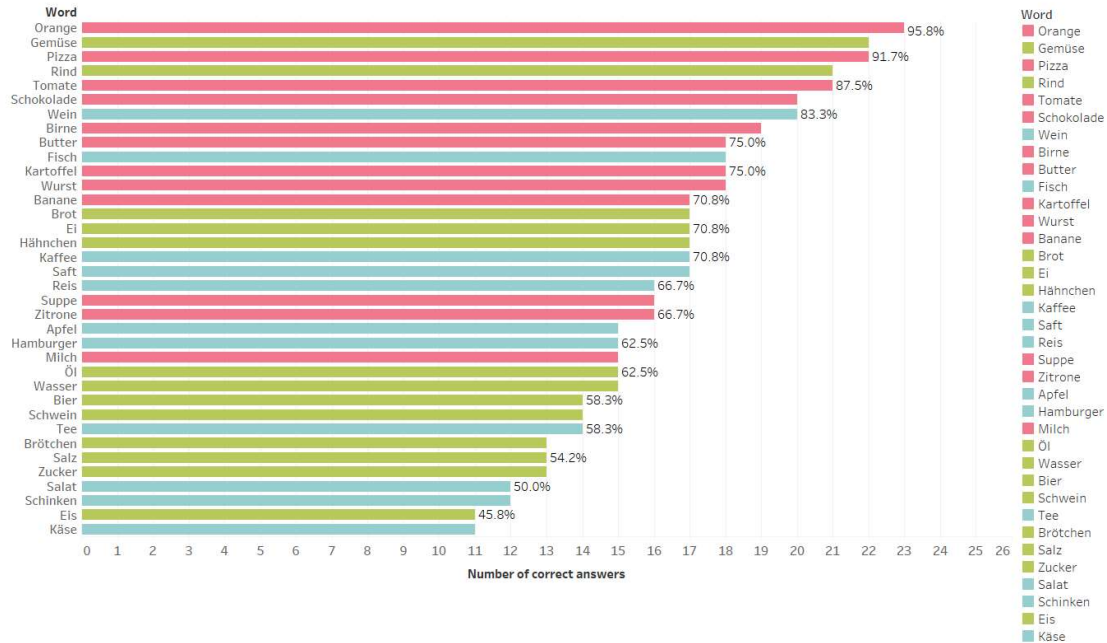
Correct answers per word in delayed posttest