Received: 12 March 2024 | Revised: 17 May 2024 | Accepted: 26 May 2024

DOI: 10.1111/jcal.13026

ORIGINAL ARTICLE

Journal of Computer Assisted Learning WILEY

More personal, but not better: The personalization effect in learning neutral and aversive health information

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Abstract

Background: According to the personalization effect in multimedia learning, the use of personal and possessive pronouns in instructional materials (e.g., 'you' and 'your') is beneficial. However, current research suggests that the personalization effect is inverted for emotionally aversive content (e.g., illnesses).

Objective: This study investigates whether a beneficial personalization effect can be observed for emotionally neutral health-related content whereas the effect may be reversed for emotionally aversive health-related content.

Methods: In this study, 139 university students learned both emotionally aversive learning content on type 1 diabetes (within-factor) that was presented in either personalized or non-personalized language (between-factor). The presentation order of the content (neutral first vs. aversive first) was controlled (between-factor), resulting in a $2 \times 2 \times 2$ mixed design. The dependent variables measured include learning outcomes (regarding retention and transfer), state anxiety, extraneous cognitive load, motivation and learning time.

Results and Conclusions: In the transfer test, learners generally performed better when learning with non-personalized instructional materials than with personalized instructional materials, regardless of whether the content was emotionally neutral or aversive. The results raise questions regarding the robustness of the personalization effect and the underlying mechanisms of the inverted personalization effect. An alternative explanation to be investigated is whether the direct reference to a disease that the participants do not have (here: 'your type 1 diabetes') leads to schema interference, which could be responsible for poorer learning performance—even if the learning content about the disease can be considered emotionally neutral.

KEYWORDS
emotional design, learning with multimedia, multimedia design principles, personalization effect

1 | INTRODUCTION

There is a growing interest in seeking health-related information through digital media (Jia et al., 2021). The means to best convey this information may lie in applying multimedia design principles (Mayer, 2021), which consider learners' cognitive architecture to adapt learning content to cognitive processes (Mayer & Fiorella, 2022). Relevant design principles are mainly based on the

Cognitive Load Theory (CLT; Sweller et al., 1998) and the Cognitive Theory of Multimedia Learning (CTML; Mayer, 2022). These theories were extended to affective factors, such as the Cognitive-Affective Theory of Learning with Media (CATLM; Moreno & Mayer, 2007; Schrader et al., 2022), the Cognitive-Affective-Social Theory of Learning in Digital Environments (CASTLE; Schneider et al., 2021) and the Integrated Cognitive Affective Model of Learning with Multimedia (ICALM; Plass & Kaplan, 2016). These more recent theories instigate us to rethink the applicability of well-studied design principles in contexts where emotions are especially relevant, such as health information, where contents are not always neutral but can also be emotionally aversive. There is some evidence that certain design principles do not apply to emotionally aversive content, such as the multimedia principle (Kühl & Münzer, 2023) or the personalization principle (cf. for a meta-analysis Liu et al., 2023). The personalization principle states that learning is more effective if multimedia messages are conveyed in a more conversational style compared with a formal style (Fiorella & Mayer, 2022), including addressing learners directly with personal and possessive pronouns.

There is strong empirical evidence for the beneficial effect of personalization on learning about neutral health-related topics (e.g., Lin et al., 2020), while there are some findings showing an inverted personalization effect for health information considered emotionally aversive (e.g., Kühl & Zander, 2017; Liu et al., 2023). In the current study, we thus focus on the personalization effect and investigate whether it applies to emotionally neutral health-related learning content but reverses with emotionally aversive health-related learning content. To this end, we designed one instructional material about one topic that is divided into an emotionally neutral and an emotionally aversive part.

1.1 | Explanations of the personalization effect

Personalization is characterized by replacing impersonal articles of formal style (e.g., 'the') with personal and possessive pronouns (e.g., 'you' and 'yours', Moreno & Mayer, 2000). For example, a personalized instructional material about type 1 diabetes (T1D) might read, 'Your insulin therapy compensates for the lack of insulin in your body and lowers your blood sugar,' instead of 'Insulin therapy compensates for the lack of insulin in the body and lowers the blood sugar'.

The possible mechanisms of a positive personalization effect on learning are commonly explained from motivational and cognitive perspectives. For instance, the social agency theory (SAT; Mayer et al., 2003; Mayer, 2021) proposes that personalized language implies social situations that lead to the activation of a social response which positively influences learners' motivation and their engagement with the learning material, leading to better learning outcomes (Mayer, 2021; Schneider et al., 2021). Parallel to this aspect, self-reference is also discussed as a mechanism of the personalization effect (e.g., Moreno & Mayer, 2000, 2004). Accordingly, instructional materials that use personalized language that directly addresses the self, for instance, by personal pronouns, increase students' probability of referring learning messages to themselves (i.e., self-referencing). The self-reference theory suggests that information can be more efficiently organized and elaborated when it is referenced to the self (cf. Liu et al., 2023; Rogers et al., 1977; Symons & Johnson, 1997), leading to better learning of this information.

1.2 | Empirical evidence for neutral contents

Overall, the personalization effect is well supported (for meta-analyses, see Ginns et al., 2013; Liu et al., 2023; for reviews, Çeken & Taşkın, 2022; Fiorella & Mayer, 2022; Mayer, 2018, 2021; Noetel et al., 2021). A meta-analysis of the personalization effect by Ginns et al. (2013) revealed a medium positive effect size of personalization on the learning outcomes transfer and a small positive effect size on retention (Ginns et al., 2013). Recently, Liu et al. (2023) conducted a meta-analysis on self-referential encoding techniques in education, including investigations of the personalization effect in learning and yielded results similar to those of Ginns et al. (2013), demonstrating a small to moderate effect size of self-referencing on learning performance. Recent studies not considered in both meta-analyses also most often show a positive effect of personalization for non-aversive topics (e.g., Dinç & Kim, 2021; Lin et al., 2020; Riehemann & Jucks, 2018; Schrader et al., 2018; Yang et al., 2022), but not always (de Koning & van der Schoot, 2019).

Concerning the underlying mechanisms of the personalization effect, several studies linked personalized language to higher motivation (e.g., Dutke et al., 2016; Kuhlmann et al., 2023; Lin et al., 2020; Reichelt et al., 2014; Skrupky et al., 2024), in line with the SAT (Mayer, 2021). Correspondingly, Dutke et al. (2016) found that learners spent more time learning with personalized instructional material than with non-personalized instructional material, whereby learning time can be considered as an indirect measure of motivation. In addition, the meta-analysis by Ginns et al. (2013) found that personalization leads to more effective cognitive processing, as indicated by lower difficulty ratings of the contents (medium effect size). In the context of the CLT (Paas & Sweller, 2022), difficulty ratings are often associated with extraneous processing that hampers learning, which is termed extraneous cognitive load (ECL)—indicating that personalized language may reduce ECL.

1.3 | Empirical findings for aversive contents

Next to this overall positive effect of personalization, the meta-analysis by Liu et al. (2023) also considered the nature of the content learned and concluded that the valence of the learning material plays a significant role as a boundary condition for the effect of self-referencing on learning. While a positive effect of self-referencing for non-aversive materials was found, a negative effect was observed for emotionally aversive materials. This negative effect of personalization on learning outcomes was based on a few studies that

investigated the personalization effect when learning about a serious disease, namely cerebral haemorrhage (Kühl & Münzer, 2021; Kühl & Zander, 2017; Zander et al., 2017). Concerning the underlying mechanisms of the observed inverted personalization effect for this aversive content, the findings are somewhat mixed. While it was reasoned that learning about cerebral haemorrhage may lead to a more pronounced increase in state anxiety with personalized content, it was found that the increase in learning the content was similar for learners in the personalized and the non-personalized condition. With respect to ECL, Kühl and Zander (2017) found significantly higher levels of ECL when students learned about an emotionally aversive topic with personalized compared to non-personalized language. This effect, however, was observed only when the learning was self-paced (Exp. 2), but not when system-paced (Exp. 1). Regarding motivation and learning time, the authors argued that learning about a serious disease may be demotivating with personalized language. Kühl and Münzer (2021) reported a significant negative effect of personalization on learning time when subjects learned aversive content, particularly when sad mood was induced prior to learning, while no differences in learning time were observed by Kühl and Zander (2017). Motivation assessed by a dedicated questionnaire was not reported in these studies.

1.4 | Summary of the literature review and rationale

Summing up, for emotionally neutral learning contents, the personalization effect on learning outcomes is well supported. Considering the underlying mechanisms, there is support for the assumption that personalized language can be motivating and reduce ECL. The findings of an inverted personalization effect for aversive contents are still in their infancy and support the notion that personalized language hampers learning of aversive content. However, findings are not consistent regarding possible causes of the effect. It is discussed that personalized language may increase state anxiety and ECL and decrease motivation and time spent with the learning material. Thus, the rationale for developing the research question lies in the need to replicate the personalization effect for emotionally neutral contents and its inversion for emotionally aversive contents. and to explore the mechanisms driving the different effects, aiming to enhance our understanding of how instructional design can be optimized in this field. To be better able to directly compare these effects for neutral and aversive contents, we designed one instructional material about one topic that is divided into an emotionally neutral and an emotionally aversive part.

1.5 | The present study: Research question and hypotheses

For the present study, we used the topic of T1D, which is a chronic autoimmune disease characterized by significantly reduced or no insulin production due to the destruction of pancreatic beta cells by the immune system (Burrack et al., 2017). A meta-analysis by Mobasseri et al. (2020) estimated a global T1D prevalence of 0.01%. T1D can occur at any age and in contrast to type 2 diabetes, which is strongly associated with diet and exercise, the causes and prevention strategies of T1D remain unclear (World Health Organization, 2016). T1D instructional materials can be found on the internet, in brochures and books, etc. The topics that constitute conventional T1D education differ in their aversiveness. They address, for example, the basic functioning of the endocrine system (neutral) vs. amputations or life-threatening emergencies during sleep (aversive, e.g., Wood & Peters, 2018). Therefore, diabetes instructional materials provide a valuable background for studying the effect of personalization on the same general topic but with variations of aversiveness. We designed instructional material on T1D comprising an emotionally neutral and an emotionally aversive part. The material was pretested in a pilot study.

The overarching research question of the study is: Can—within one instructional material about a specific disease—a beneficial personalization effect be observed for emotionally neutral health-related content while a reversed effect can be observed for emotionally aversive health-related content? At this, the aim of the present study is to investigate how personalization (non-personalized vs. personalized) affects learning emotionally aversive compared to neutral health-related content that is specific for a disease. Thereby, this study's main focus lies on learning outcomes. As a subordinate goal, we also examine potentially underlying mechanisms for the assumed effects on learning outcomes by assessing state anxiety, cognitive load, motivation and learning time. Given the empirical evidence of a positive effect of conversational language style on learning for non-aversive health-related topics (e.g., Dutke et al., 2016; Ginns & Fraser, 2010; Lin et al., 2020; Mayer, 2018; Mayer et al., 2004), and based on recent research suggesting an inverted personalization effect for emotionally aversive health-related content (e. g., Kühl & Münzer, 2021; Kühl & Zander, 2017; Zander et al., 2017), we arrive at the following hypotheses for learning outcomes of retention and transfer:

We hypothesize an interaction of personalization (non-personalized vs. personalized) and emotional content (neutral vs. aversive) for the learning outcome measures of retention and transfer. More specifically, we assume that learning outcomes for neutral content are higher in the personalized condition than in the non-personalized condition both for retention (Hypothesis 1a) and transfer (Hypothesis 2a), while we assume for aversive content that learning outcomes are lower in the personalized compared to the non-personalized condition, both for retention (Hypothesis 1b) and for transfer (Hypothesis 2b).

Intending to understand the personalization effect's underlying processes, further hypotheses are proposed. For state anxiety, we examine whether state anxiety scores after aversive contents are higher in the personalized condition than in the non-personalized condition (Hypothesis 3). For ECL, we assume an interaction of personalization and content in that ECL for neutral content is supposed to be lower in the personalized condition than in the non-personalized condition (Hypothesis 4a), whereas ECL for aversive content may be

higher in the personalized condition than in the non-personalized condition (Hypothesis 4b). Similarly, we also assume an interaction of personalization and content for motivation and learning time: For neutral content, we assume that motivation (Hypothesis 5a) and learning time (Hypothesis 6a) are higher in the personalized condition than in the non-personalized condition, whereas we surmise that for aversive content motivation and learning time may be lower in the personalized condition than in the non-personalized condition. Especially Hypotheses 4–6 mirror the expected pattern of results for learning outcomes; mediation analyses would be performed if one or more of these hypotheses would be met.

2 | METHODS

The American Psychological Association's guidelines for the ethical treatment of human research subjects and the European General Data Protection Regulation (GDPR) prescriptions were strictly adhered to at every research stage. Furthermore, this project was approved by the University's ethics committee. The participants could withdraw from the study at any time. No personally identifiable information was obtained, and pseudonyms were generated to be able to exclude a participant in case of future withdrawal. At the end of the study information leaflets about T1D were handed out to the participants. To ensure transparency, the study design, stimuli, hypotheses and analysis plan were pre-registered on the Open Science Framework (OSF) before data collection commenced. Additionally, Supplementary material, such as further information about our pilot study, descriptions of the measures used, and detailed results, can be accessed at https://osf.io/c26m8/.

2.1 | Participants

The study was conducted at a German University. The eligibility criteria for participation included being at least 18 years old, current enrolment at the University, having fluent German language skills, and not having previously participated in pilot studies of the instructional material and learning tests used in this research. We estimated that $N = 128$ participants would be required for the study, assuming a medium effect size for our hypothesized interaction, a power of 0.8 and $\alpha = 0.05$.

In total, $N = 143$ participants were recruited. Although one participant reported having T1D, further examination revealed that this individual had mistakenly chosen the T1D option, as the subsequent answers were incongruous with this condition (e.g., low prior knowledge). Among the participants who claimed to have close relatives (parents or siblings) with T1D, none met the exclusion criteria. However, the data from four participants were excluded from the data analysis based on the exclusion criteria defined in the pre-registration. One excluded participant essentially refused to provide meaningful responses. The second and third excluded participants were identified as extreme outliers in the prior knowledge assessment (i.e., falling outside the third quartile ranges plus three times the interquartile range), exhibiting an exceptionally elevated understanding of T1D. Finally, one last participant was excluded because of a very high state anxiety after learning with neutral material, being also identified as an extreme outlier according to the predefined criteria. Thus, data from $N = 139$ students were included in the analysis ($M = 21.1$ years, SD = 1.7; 104 females, 35 males). Students received course credit for their participation.

2.2 | Design

The experiment took place in the laboratory. Participants were randomly assigned to either the personalized or non-personalized condition (between-subject factor) and received both, the emotionally neutral as well as the emotionally aversive learning content (within-subject factor). Next to these independent variables that were in the focus of this experiment, the presentation order of the content (aversive first vs. neutral first) was also included as a between-subject factor to be able to control for it. Thus, a $2 \times 2 \times 2$ mixed design was used. Participants received both contents either in personalized language or both contents in non-personalized language (and never mixed). Although the instructions informed the participants that the learning material comprises two modules, they were not informed that these modules differ in their aversiveness nor that the order of presentation was randomized. Moreover, they were unaware of the existence of two different conditions (personalized and non-personalized).

2.3 | Diabetes instructional material

The computer-based instructional material on T1D comprised two learning modules, one with neutral content and one with aversive content, that each consisted of text and pictures. One of the modules addressed the definition of T1D, the functioning of the endocrine system, diabetes technologies and how to manage diabetes. These topics can be considered emotionally neutral. The other learning module addressed topics related to emergencies, death, or severe comorbidities of T1D (e.g., amputation), which can be considered emotionally aversive.

In an online pilot study with a within-subject design and $N = 40$ participants, the aversive module was regarded as such by the learners, as they showed significantly higher subjective ratings of avoidance, $F(1, 38) = 9.67$, $p = 0.004$, $\eta_p^2 = 0.203$, disgust $F(1, 38) = 22.12$, $p < 0.001$, $\eta_p^2 = 0.368$, threat, $F(1, 38) = 21.76$, $p < 0.001$, $\eta_p^2 = 0.364$, more depressed mood $F(1, 38) = 13.50$, $p < 0.001$, $\eta_p^2 = 0.262$ and higher self-reported levels of state anxiety, $F(1, 38) = 3.77$ $p = 0.030$, $\eta_p^2 = 0.090$, after dealing with it. In addition, anxiety levels were not significantly higher after learning with neutral material compared to a baseline measurement, $F < 1$, *ns*, indicating that the neutral material was perceived as such. Therefore, the learning material was considered to be suitable for the principal experiment of this investigation.

The contents of the two modules did not build up on each other. The implementation of personalization was carried out only through the substitution of articles and pronouns to keep the conditions similar in their extent. All variants of the instructional material had a similar number of words (ca. 270) and the same number of text blocks and images (3).

2.4 | Measures

All variables were surveyed using the SoSci Survey platform for data collection. The computer-based measures consisted of (1) control variables, including prior knowledge and a baseline measure of state anxiety, (2) knowledge tests for the emotionally aversive as well as neutral content, (3) a state anxiety questionnaire, (4) an ECL questionnaire, (5) a motivation questionnaire, (6) learning time and (7) a participant questionnaire. These measures will be introduced in the following.

2.4.1 | Control variables

The assessed control variables included prior knowledge, interest in the topic of T1D, final high school grades and a baseline measure of state anxiety. Prior knowledge was quantified based on the participants' answers to 'Please write down everything you know about T1D'. The answers were corrected using a coding scheme. Correct statements were awarded 1 point, incorrect statements received 0 points and partially correct statements were assigned 0.5 points. Two raters (the first Author and a student research assistant) corrected the answers independently, and considering the high inter-rater reliability, indicated by the intraclass correlation coefficient (ICC), $r = 0.91$, the average between the two evaluations was calculated and used in the analysis. In the case of five participants, the evaluation from the raters differed by more than three points; these cases were discussed, and a consensus was reached. One of these five participants was excluded since this person was identified as an extreme outlier (see also Section 2.1). Interest was assessed using the question, 'How interested are you in the topic of T1D?' (1 = *not at all* to 7 = *very much*). Lastly, state anxiety was assessed with the short version of the state–trait anxiety inventory (STAI-6; Marteau & Bekker, 1992). Six items (e.g., 'I am worried') had to be rated on a 4-point Likert scale ranging from 1 = *not at all* to 4 = *very much so*, where a higher score corresponds to a higher anxiety state. The internal consistency at baseline was acceptable ($\alpha = 0.72$).

2.4.2 | Knowledge test

A second online pilot study was conducted with $N = 7$ participants to evaluate and further develop the knowledge tests. First participants learned with the instructional material and then filled in the preliminary knowledge test. Based on the answers and comments of the participants, the preliminary knowledge test was revised. The final knowledge test that is used in this study was divided into a test that addressed the neutral learning content and a test that addressed the aversive learning content. Each of these two knowledge tests comprised retention and transfer questions. Retention learning was assessed using 10 gap-text questions for each learning module. The questions were specifically related to the content of the respective module. An example for a retention question of the emotionally neutral learning content is: 'In type 1 diabetes, the immune system attacks the so-called (a)_____ cells of the pancreas, which produce the hormone insulin. This hormone transports glucose ingested with food from the (b)_____ into the body cells (a) beta, (b) bloodstream'. An example for a retention question of the emotionally aversive learning content is: 'The most common emergencies related to Type 1 diabetes are (a) _____ and (b) _____ (a) hypoglycemia, (b) hyperglycemia'. The participants' answers were corrected based on a coding scheme, whereby each correct answer was assigned 1 point, incorrect answers received 0 points, partially correct answers were awarded 0.5 points and the sum scores were subsequently calculated.

Transfer learning was assessed using three open-ended questions for each learning module. The questions were specifically related to the content of the respective module. An example for a transfer question of the emotionally neutral learning content is: 'Person A and B have type 1 diabetes. Both have taken the same amount of insulin and have eaten and drunk the same. After eating, however, they have different blood sugar levels. What explanations could there be for this? List as many explanations as you can'. Possible answers are: different insulin sensitivity factors, hormonal fluctuations, use of medications affecting blood sugar and different pre-meal blood sugar values (baseline). An example for a transfer question of the emotionally aversive learning content is, 'Person A has Type 1 diabetes and developed excessive fear of hypoglycemia. What unfavorable behaviors could Person A exhibit as a result of their fear? Please list as many behaviors as you can'. Possible answers are: insufficient insulin intake, excessive carbohydrate intake, avoidance of physical activity and excessive checking. The participant responses were corrected based on a coding scheme. Correct statements were awarded 1 point, while incorrect statements received 0 points, partially correct statements were assigned 0.5 points and the sum scores were calculated. Two raters (the first Author and a student research assistant) corrected the open questions independently. The responses from the second pilot study ($N = 7$) were utilized to train the raters and align their correction approach. Considering the high inter-rater reliability in the main study questions ($N = 139$), indicated by the ICC, $r = 0.97$ for both the aversive and neutral tests. The average between the two evaluations was calculated and used in the analysis. It should be noted that the raters were blind with respect to experimental (between-subject) conditions when correcting the learning tests.

2.4.3 | State anxiety

State anxiety was assessed using the same instrument as in the baseline measurement (see Section 2.4.1). The internal consistency was

satisfactory after viewing aversive content ($\alpha = 0.80$) and sufficient after viewing neutral content ($\alpha = 0.68$).

2.4.4 | Cognitive load

A 3-item self-report scale was used to measure ECL (Klepsch et al., 2017). The items (e.g., 'The design of this learning module was very inconvenient for learning'.) had to be rated on a 7-point Likert scale, ranging from 1 = *absolutely wrong* to 7 = *absolutely right*, where a higher score indicates a higher ECL. The internal consistency was satisfactory after viewing neutral ($\alpha = 0.81$) and acceptable after viewing aversive content ($\alpha = 0.74$).

2.4.5 | Motivation

Motivation was evaluated using an 8-item self-report scale developed by Isen and Reeve (2005). The items (e.g., 'The learning module is interesting'.) had to be rated on a 7-point Likert, ranging from 1 = *strongly disagree* to 7 = *strongly agree* and higher scores indicate higher motivation. The internal consistency was excellent after viewing neutral ($\alpha = 0.92$) and aversive content ($\alpha = 0.93$).

2.4.6 | Learning time

The learning time was calculated based on the time taken to complete each learning module, measured in seconds, as provided by the SoSci Survey platform.

2.4.7 | Participant questionnaire

A participant questionnaire, conducted after learning, asked for demographic data (sex, age, final school exam grade and major). Furthermore, for exploratory purposes, questions about the participants' personal and family history of T1D were collected. Lastly, a manipulation check assessed the participants' perception of the instructional material, in which the following questions were answered using a 7-point Likert scale: 'Did the language of the learning content address you personally?' (1 = *not at all* to 7 = *very much*) and 'Do you consider the language of the material you learned to be formal?' (1 = *not at all* to 7 = *very much*).

2.5 | Procedure

The study was conducted in the multimedia laboratory of the Educational Psychology Department of the University. The data collection period lasted 4 weeks, and the number of participants in each session ranged from one to six. Participants were welcomed, and standardized verbal instruction was given while the informed consent, general information and information on data protection were provided at their individual workspaces on the computer. First, participants completed questionnaires to assess their prior knowledge and level of interest concerning T1D. Afterward, the participants' baseline state anxiety was measured before they were randomly assigned to either personalized or non-personalized condition. The order of content presentation (neutral first vs. aversive first) was also randomized for each participant. Although the instructions informed the participants that the learning material comprises two modules (contents), they were not informed that these modules differ in their aversiveness nor that the presentation order was randomized.

After presenting the first module of instructional material, possible mediator variables were assessed on separate computerized pages in the following order: state anxiety, ECL and motivation. Next, the learning tests were performed (first, the retention and then the transfer tests). Subsequently, the second module was presented, and the corresponding dependent variables were assessed in the same fashion. Once this part was completed, participants filled in demographic data, and the manipulation check. Lastly, information leaflets about T1D were handed out to the participants.

2.6 | Data analysis

All analyses were performed using IBM SPSS Statistics 28. An outlier analysis was initially performed using Tukey's Hinges interquartile range and box plots. Participants indicated as extreme outliers, that is, falling outside the third quartile ranges plus three times the interquartile range or the first quartile minus three times the interquartile range, were eliminated from the sample (see Section 2.1).

Two 2 × 2 ANOVAs were conducted to check whether the investigated conditions (personalization and presentation order) differed in any control variables. Since conditions differed a priori for prior knowledge, this variable was included as a covariate for all analyses where prior knowledge had a significant influence on the dependent variables. This was the case for all knowledge tests of retention and transfer, but not for the manipulation check, state anxiety, cognitive load, motivation and learning time. Note that for the latter three variables, the assumption of homogeneity of regressions slopes was not met, which also speaks against using prior knowledge as a covariate for these instances.

To investigate the hypotheses, 2 × 2 × 2 mixed AN(C)OVAs were conducted, considering the within-subjects content nature (neutral vs. aversive) for the respective dependent variables and the between-subjects factors personalization (non-personalized vs. personalized) and presentation order (neutral first vs. aversive first) as well as the covariate prior knowledge. For state anxiety, a 2 × 2 × 3 mixed ANOVA was conducted since it was measured three times (at the baseline, after neutral content and after aversive content).

The inference criteria followed the standard $p < 0.05$. For neutral content; it was hypothesized that personalization compared to no personalization would lead to better retention and transfer performance,

lower ECL, higher motivation and longer learning time. These hypotheses were planned to be tested one-tailed. For aversive content, it was hypothesized that personalization, compared to no personalization, would lead to worse retention and transfer performance, higher state anxiety, higher ECL, lower motivation and shorter learning time. Also, these hypotheses were planned to be tested one-tailed. However, to present the results concisely, we decided only to report the one-tailed tests, as long as the data went descriptively in the hypothesized direction and an interaction of personalization and content nature or a main effect of personalization was at least observable (i.e., the one-tailed tests are only reported when necessary). All further analyses were tested two-tailed. These included the analyses for the influence of the presentation order of the content, the examination of control variables, the manipulation check and additional exploratory analyses.

3 | RESULTS

The means and standard deviations for the non-personalized and personalized conditions for the dependent variables investigated in Hypotheses 1–6 are summarized in Table 1. Presentation order was only included in the statistical model to control for this factor, as none of the investigated hypotheses addresses this condition.

3.1 | Control variables

We conducted three 2 × 2 between-subject ANOVAs with personalization (non-personalized vs. personalized) and presentation order (neutral first vs. aversive first) as independent variables and prior knowledge, interest and grade as dependent variables. The 2 × 2 ANOVA for prior knowledge revealed a marginally significant main effect of presentation order, $F(1, 135) = 3.00$, $p = 0.085$, $\eta_p^2 = 0.022$, with higher prior knowledge scores for the group that started with emotionally aversive content. Since the study conditions cannot be considered equal, we included it as a covariate for the analyses where prior knowledge had a significant influence on the dependent variables (see Section 2.6). The analysis showed no main effect of personalization, $F(1, 135) = 2.15$, $p = 0.145$, $\eta_p^2 = 0.016$, and no interaction between personalization and presentation order, $F(1, 135) = 1.28$, $p = 0.259$, $\eta_p^2 = 0.009$. Regarding the remaining control variables, the analysis showed no differences for personalization or presentation order and no interaction for the variables interest, all Fs < 1.82, all ps > 0.180, all η_p^2 < 0.013, grade, all Fs < 1.74, all ps > 0.189, all η_p^2 < 0.013 and state anxiety at the baseline, all Fs < 0.517, all ps > 0.473 all η_p^2 < 0.004.

3.2 | Manipulation check

Two 2 × 2 between-subject ANOVAs were performed with personalization (non-personalized vs. personalized training) and presentation order (neutral first vs. aversive first) as independent variables and the questions of the manipulation check as dependent variables. The outcomes demonstrated neither differences for personalization, presentation order, nor an interaction for the answers provided to the questions 'Did the language of the learning content address you personally?' with all Fs < 1.88, all ps > 0.173 and all η_p^2 < 0.014, and 'Do you consider the language of the material you learned to be formal?' with all Fs < 1.32, all ps > 0.252 and all η_p^2 < 0.01. Therefore, the participants' perceptions concerning the learning material did not vary in the different conditions, indicating that the personalization was probably not consciously perceived by the participants (see Section 4).

3.3 | Knowledge tests

Note that no assumptions about the factor presentation order were made. Furthermore, although comparisons between tests with different contents (aversive vs. neutral) are part of the statistical model, the content as well as the tests may differ on several factors, for instance such as their difficulty. In the following, we refrain from interpreting effects of the factor presentation order as well as from interpreting comparisons of the knowledge test addressing aversive content with the knowledge tests comparing neutral content. Nevertheless, we report all results.

TABLE 1 Means and (standard deviations) as a function of the nature of the content and personalization.

	Neutral		Aversive	
	Non-personalized ($N = 70$)	Personalized ($N = 69$)	Non-personalized ($N = 70$)	Personalized ($N = 69$)
Retention	5.34 (2.02)	5.40 (2.06)	5.91 (1.86)	5.78 (1.80)
Transfer	5.53 (2.39)	5.04 (2.37)	6.05 (2.31)	5.64 (2.30)
State anxiety	1.69 (0.41)	1.76 (0.38)	1.82 (0.48)	1.91 (0.53)
ECL	2.47 (1.25)	2.39 (1.16)	2.71 (1.22)	2.65 (1.22)
Motivation	4.77 (1.27)	4.61 (1.17)	4.77 (1.23)	4.41 (1.39)
Learning time (in seconds)	148.5 (60.56)	142.54 (51.35)	160.27 (65.84)	166.57 (65.59)

Abbreviation: ECL, extraneous cognitive load.

3.3.1 | Retention

Hypothesis 1a proposes that the retention performance for neutral content is higher in the personalized than in the non-personalized condition, while Hypothesis 1b postulates that the retention performance is poorer for aversive content in the personalized than in the non-personalized condition. The 2 × 2 × 2 mixed ANCOVA revealed, in contrast to expectations, no statistically significant interaction between personalization and content nature for the retention tests, $F < 1$, *ns*, and no main effects of personalization, $F < 1$, *ns*. Thus, our results do not support Hypotheses 1a and 1b.

Further results showed a main effect of presentation order, $F(1, 134) = 4.93$, $p = 0.028$, $\eta_p^2 = 0.035$, with higher retention scores when the neutral content was learned first. Moreover, a main effect of content nature was found, $F(1, 134) = 6.37$, $p = 0.013$, $\eta_p^2 = 0.045$, with higher retention scores for the emotionally aversive compared to the neutral content test. The analysis also showed a significant interaction between the presentation order and content nature, $F(1, 134) = 7.62$, $p = 0.007$, $\eta_p^2 = 0.054$. While the aversive content was more effectively recalled when it was presented second, $p < 0.001$, the retention of neutral content did not differ due to the order of presentation, $p = 0.714$. There was no three-way interaction, $F < 1$, *ns*. Concerning the covariate prior knowledge, the analysis showed a main effect, $F(1, 134) = 24.99$, $p < 001$, $\eta_p^2 = 0.157$, supporting its inclusion in the statistical model. The interaction between the prior knowledge and content nature was not significant, $F(1, 134) = 1.26$, $p = 0.264$, $\eta_p^2 = 0.009$.

3.3.2 | Transfer

Hypothesis 2a proposes that the transfer performance for neutral content is higher in the personalized than in the non-personalized condition, while Hypothesis 2b postulates that the transfer performance is poorer for aversive content in the personalized than in the non-personalized condition. The 2 × 2 × 2 mixed ANCOVA showed again, in contrast to expectations, no statistically significant interaction between personalization and content nature for the transfer tests, $F < 1$, *ns*. However, a main effect of personalization on learning was found, $F(1, 134) = 4.90$, $p = 0.029$, $\eta_p^2 = 0.035$, with learners in the non-personalized condition performing better than learners in the personalized condition, indicating a general inverted personalization effect irrespective of the (neutral vs. aversive) nature of the content. A pre-defined contrast analysis addressing Hypothesis 2b specifically (one-tailed) revealed that the transfer performance for aversive content was poorer in the personalized than in the non-personalized condition, $F(1, 134) = 2.95$, $p = 0.044$, $\eta_p^2 = 0.022$, which is in line with Hypothesis 2b. Exploring the transfer performance for neutral content, pairwise comparisons (two-tailed) revealed that transfer was higher in the non-personalized compared to the personalized condition, $F(1, 134) = 4.09$, $p = 0.045$, $\eta_p^2 = 0.030$. Thus, Hypothesis 2a has to be rejected, and in summary, the non-personalized condition revealed better transfer performance both for aversive content as well as for neutral content.

Further results revealed a main effect for content nature, $F(1, 134) = 5.04$, $p = 0.026$, $\eta_p^2 = 0.036$, with higher transfer scores for the aversive compared to the neutral content test. Moreover, the results showed no main effects of presentation order, no interaction between presentation order and content nature, no three-way interaction, and no interaction between prior knowledge and content nature with all Fs < 1, *ns*. Additionally, the analysis indicates a robust and statistically significant positive effect for the covariate prior knowledge, $F(1, 134) = 43.45$, $p < 0.001$, $\eta_p^2 = 0.245$, highlighting its influence on transfer learning.

3.4 | State anxiety

Hypothesis 3 postulates that state anxiety scores after aversive content are higher in the personalized than in the non-personalized condition. The 2 × 2 × 3 mixed ANOVA revealed no main effects of personalization on state anxiety, $F < 1$, *ns*. Thus, the results do not support Hypothesis 3.

Moreover, content nature had a main effect on state anxiety, $F(2, 270) = 16.25$, $p < 0.001$, $\eta_p^2 = 0.107$. Bonferroni-adjusted pairwise comparisons revealed higher scores for the aversive compared to the neutral content $p < 0.001$, and to baseline $p < 0.001$, but no differences in state anxiety scores for neutral content compared to the baseline $p = 0.613$, which can be seen as further support that the neutral and aversive content were perceived as such. Furthermore, the interaction between the presentation order and content nature was marginally significant, $F(2, 270) = 2.81$, $p = 0.062$, $\eta_p^2 = 0.020$. Bonferroni-adjusted comparisons revealed that after viewing aversive content, state anxiety scores were higher than at the baseline, both when this content was presented first $p = 0.011$ and when it was presented second $p < 0.001$. After viewing neutral content, there was no significant difference in state anxiety compared to the baseline measurement, neither when this content was presented first, $p > 0.99$, nor when it was presented as second, $p = 0.181$. However, the difference in state anxiety scores between the modules was only significant when the aversive module was presented last, $p < 0.001$, but not when it was presented first, $p = 0.502$. Lastly, the analysis revealed no main effect of presentation order, and no three-way interaction, both Fs < 1, *ns*.

3.5 | Extraneous cognitive load

Hypothesis 4a proposes that ECL scores after neutral content are lower in the personalized than in the non-personalized condition, while Hypothesis 4a proposes that ECL scores after aversive content are higher in the personalized than in the non-personalized condition. The 2 × 2 × 2 mixed ANOVA revealed, against our expectations, no statistically significant interaction between personalization and

content nature and no main effect of personalization, both Fs < 1, *ns*. The results obtained thus do not support Hypotheses 4a or 4b.

However, a main effect for content nature was observed, $F(1, 135) = 6.93$, $p = 0.009$, $\eta_p^2 = 0.049$, with higher ratings of ECL for the aversive compared to the neutral content. Moreover, there was no main effect of presentation order or content nature, no interaction between presentation order and content nature, and no three-way interaction, all Fs < 1.59, all ps > 0.209 and all η_p^2 < 0.012.

3.6 | Motivation

Hypothesis 5a postulates that the motivation scores after neutral content are higher in the personalized than in the non-personalized condition, and Hypothesis 5b postulates that the motivation scores after aversive content are lower in the personalized than in the non-personalized condition. In contrast to expectations, the 2 × 2 × 2 mixed ANOVA revealed no statistically significant interaction between personalization and content nature, F < 1, *ns*, and no main effects of personalization, $F(1, 135) = 1.69$, $p = 0.196$, $\eta_p^2 = 0.012$. Thus, the results do not support Hypotheses 5a or 5b.

Moreover, the interaction between the presentation order and content nature was significant, $F(1, 135) = 4.20$, $p = 0.042$, $\eta_p^2 = 0.030$. When the participants started with neutral content, there was a significant decrease in motivation after dealing with aversive content, $p = 0.024$; however, when they started with the aversive content, no differences in motivation were observed, $p = 0.548$. Furthermore, there was no main effect of presentation order and content nature and no three-way interaction, all Fs < 1.54, all ps > 249 and all η_p^2s < 0.010.

3.7 | Learning time

Hypothesis 6a proposes that the learning time for neutral content is longer in the personalized than in the non-personalized condition, and Hypothesis 6b proposes that the learning time for aversive content is shorter in the personalized than in the non-personalized condition. The 2 × 2 × 2 mixed ANOVA showed, against our expectations, no statistically significant interaction between personalization and content nature, $F(1, 135) = 1.61$, $p = 0.206$, $\eta_p^2 = 0.012$ and no main effects of personalization, F < 1, *ns*. Thus, Hypotheses 6a and 6b were not confirmed.

Furthermore, the analysis revealed a significant main effect of content nature, $F(1,135) = 16.73$, p < 0.001, $\eta_p^2 = 0.110$, as the participants engaged longer with aversive than with neutral content. Also, the interaction between the presentation order and content nature was significant, $F(1, 135) = 8.18$, $p = 0.005$, $\eta_p^2 = 0.057$. When students learned the aversive content second, they spent significantly longer time with the aversive than with the neutral content, p < 0.001, while there was no difference in learning time for neutral and aversive content when they engaged with aversive content first, $p = 0.381$. Moreover, the results showed no main effect of presentation order, and no three-way interaction, all Fs < 1, *ns*.

4 | DISCUSSION

The present study investigated the effect of personalized language on learning of emotionally aversive and emotionally neutral health-related information. It was hypothesized that a positive effect of personalization on learning would be observed for emotionally neutral content and a negative effect for emotionally aversive content. A mixed-design laboratory experiment was conducted, in which all participants learned with instructional material comprising both neutral and aversive content in either a non-personalized or personalized version. Additionally, we measured participants' state anxiety, ECL, motivation and learning time after each learning module for secondary analysis. Revisiting the research question on how personalization (non-personalized vs. personalized) impacts the learning of emotionally aversive health-related content compared to neutral content, and considering our main results, we—contrary to our expectations and the main literature—did not observe that personalization was beneficial for learning health-related neutral and hindering for learning aversive content. Rather, we found that personalization led to a decrease in transfer performance for both emotionally neutral and emotionally aversive health-related contents.

The transfer test revealed that learning outcomes in the personalized group were significantly poorer for both content categories. In line with Hypothesis 2b, the pre-defined analysis for aversive content demonstrated a significant inverted effect of personalization on transfer learning, which aligns with the results of Kühl and Münzer (2021) and Kühl and Zander (2017). As opposed to Hypothesis 2a, we even observed an inverted personalization effect for emotionally neutral content. At first glance, an intuitive explanation for this result pattern may be that both conditions were perceived as aversive. However, this notion can be rejected when analysing the development of state anxiety state in this study: There were no significant differences in state anxiety between the baseline measurement and after learning with the neutral content, whereas state anxiety was increased after learning with the aversive content compared to the neutral content or the baseline measure, which is also in line with the pilot study. An alternative explanation involves investigating whether direct references to a disease that the participants do not have (here: 'your type 1 diabetes') may be confusing for them. As a consequence, a personalized message about a disease that participants do not have may hinder them to process the contents more deeply, resulting in poorer learning performance—even if the disease-related content is considered emotionally neutral. Related to the notion of familiarity (Brom et al., 2017; Schneider et al., 2015), material that sounds unusual (unfamiliar) can lead to poorer learning. Although personalization was successfully used in health-related topics such as anatomy (e.g., Ginns & Fraser, 2010; Lin et al., 2020; Mayer et al., 2004), anatomy is a topic that relates to all individuals. When it comes to a

specific disease, personalization may cause a strangeness for non-patients, which might carry cognitive costs, thereby impairing the learning process. If this notion should be true, then it may not be the aversiveness of the content that leads to an inverted personalization effect, but the general inadequacy of a personalized language for diseases that learners do not have.

Schema theory posits that existing knowledge is stored in cognitive schemas (Kester & Van Merriënboer, 2022), which fundamentally contributes to learning since acquisition involves integrating novel information into pre-existing schemas (Sweller et al., 1998). While information consistent with pre-existing schemas is associated with enhanced memory performance, mixed effects for incongruent information are observed, indicating that schema interference can hinder memory (e.g., Bein et al., 2023; Frank et al., 2018). Applying conclusions from schema theory to our study, the information 'your T1D' conflicts with the participants' pre-existing schemas about their health, such as 'I am healthy' or 'I don't have a chronic autoimmune disease', thus possibly generating thoughts and feelings in response to the incongruent stimulus, such as 'but I don't have T1D'. This implies that cognitive resources are utilized for extraneous processing and/or reactance about the instructional material might be generated, which may result in superficial processing (e.g., 'It doesn't affect me, so I don't delve deeper into the subject').

A further explanation for the inverted personalization effect observed for contents of both natures is a negative effect of self-referencing. Despite meta-analytic findings indicating that self-referencing is primarily positive for learning, Liu et al. (2023) also discuss controversies. Self-referencing might lead to introspective thoughts, reducing engagement with the instructional material, without necessarily altering state anxiety levels or perceived difficulty. Applying this consideration to our study, information about 'your T1D' could shift attention to the perception of one's body and to thoughts related to one's health, exemplarily, 'when was my last medical check-up?', expending cognitive resources, and thereby hindering learning (Liu et al., 2023). Students in the non-personalized group might have been less exposed to this potential negative effect due to fewer self-referencing cues.

Regarding the results of the retention tests, personalization had no significant impact.

Given that the results concerning retention compared to transfer are generally weaker pronounced in the context of multimedia learning (e.g., Ginns et al., 2013), and can be considered as less important (Mayer, 2021), this study may, in this respect, align with the previously conducted studies in this research area.

Note that our analysis indicated a significant difference between the neutral and aversive knowledge tests (retention and transfer) performances, with higher scores observed for aversive content. However, this result should not be interpreted as indicating that the aversive content was generally easier to learn, as different learning tests were used that may differ in their difficulty. Therefore, we refrain from directly comparing the performance scores of aversive and neutral contents.

Our results did not indicate significant differences between the personalized and non-personalized conditions regarding state anxiety, ECL and learning time. However, this study is not the first investigation that failed to demonstrate relationships between these potential mediating variables and personalization. Other studies also found no significant associations between personalization and state anxiety (e.g., Kühl & Münzer, 2021); ECL (e.g., Brom et al., 2017) or motivation and learning time (e.g., Brom et al., 2014). Summing up, while we observed a reversed personalization effect for transfer performance, we did not find explaining variables. One potential interpretation is that the used measures are not fine-grained enough to detect existing differences. Another interpretation is that other variables are in play that may explain the observed results but which were not surveyed—for instance that a personalized message about a disease may be confusing and thus hinder learning.

Consistently with the first pilot study, we found a main effect of content nature on state anxiety, which was significantly higher after aversive content compared to both neutral content and the baseline. However, as discussed above, it may be the case that the emotional content per se is not the driving factor for an inverted personalization effect.

The interaction between the presentation order and content nature was significant for the dependent variables retention, state anxiety, motivation and learning time. Moreover, a main effect of the presentation order on retention learning was found. Although this factor was considered to be able to control for it, no assumptions were made about the directions of possible effects. While post-hoc explanations for the observed interactions could be attempted, they are beyond the scope of this study. Therefore, the results of the interactions with the presentation order are not interpreted, and the focus remains on the hypotheses postulated in this paper.

This study has practical applicability, as health-related educational materials are both present and relevant in various contexts in the lives of patients, health students and all those interested in this subject. The personalization effect is not limited to digital texts accompanied by images and can easily be applied to various materials by changing the use of articles and pronouns in written or spoken language. Exemplarily, considering health-related instructional content, Lin et al. (2020) and Skrupky et al. (2024) apply personalization to educational PowerPoint presentations with written and spoken text.

As far as we know, this is the first study that examines a principle of multimedia learning in the context of T1D education material and investigates the personalization effect using a mixed design encompassing emotionally aversive and neutral content.

4.1 | Limitations

A significant limitation of this investigation is that the subjects were students, which may not accurately represent either the general population or a clinical population, restricting the generalizability of the

findings. Considering that the topic's relevance for patients is different than for students and that they do have the disease in question, it is possible that the effects of personalization on learning may differ in clinical samples. Therefore, future research should aim to explore personalization's effects on learning in clinical samples to assess its applicability in these specific populations. It would also be valuable to expand this research to medical students and health professionals (e.g., Skrupky et al., 2024), who frequently consult and learn from instructional materials on health. Another aspect that affects the generalizability of this study, parallel to the limited study sample, is that it investigated a specific health topic (T1D) with characteristics such as the severity of the symptoms, being a life-threatening disease, having a particular probability of outbreak for an individual person and so forth. Further studies could expand this research to other medical conditions in order to investigate whether those would moderate personalization effects.

Concerning the manipulation check, the results did not reach statistical significance, indicating that the manipulation of personalization was either unsuccessful or not consciously perceived by the participants. Possibly, the questions used in the manipulation check were inadequate and thus misinterpreted by the subjects, which is plausible since individuals unfamiliar with the concept of personalization in multimedia learning might interpret our questions differently than intended, for example, understanding 'personalized' as customized and 'formal' as non-slang. Considering this interpretation, our two conditions should not differ.

Regarding the potential explanatory factors underlying the effect of personalization on learning, the findings did not indicate any possible mediators. Since only self-report measures were used, future investigations could explore possibilities beyond this method. Jarodzka (2022) defines online-process-tracing techniques, such as analysing log files and psychophysiological measures, exemplarily, brain activity and eye-tracking, as efficient and particularly relevant to understanding the processes mediating multimedia design principles. Recent research on visual attention yielded promising results (Yang et al., 2022; Zander et al., 2017). Moreover, verbal reports, as the processes of thinking aloud during interaction with the instructional material, also account for a possibility for future research to get insights into possible mediators of multimedia learning processes (Jarodzka, 2022).

This study did not cover the potential moderating effects of content aversiveness on the personalization effect. However, the literature suggests that this might be conceivable. Kühl and Münzer (2021) observed a moderating role of mood for the inverted personalization effect. Regarding the positive effect of personalization, Schrader et al. (2018) found a moderating role of interest in the learning topic by investigating different percentiles of individual interest. Other potential moderators, such as tendencies towards health anxiety, personal relevance of the topic, personal health status, self-assessment of the risk of developing the disease in question and working memory capacity, were not included in our analysis or previous research and could be explored in future studies.

5 | CONCLUSION

This study aimed to investigate the effects of personalization on learning for neutral and aversive content in the context of T1D multimedia education. The learning performance in the transfer test revealed poorer learning outcomes in the personalized group for both content categories, and a significant inverted effect of personalization on transfer learning was observed. Possible mediating variables such as anxiety state, ECL, motivation and learning time were not suited to explain the observed inverted personalization effect. These findings may question whether it is the aversiveness of the content that led to inverted personalization effects in prior research or whether using personal pronouns for a disease that participants do not have is the driving force, but not the emotionality of the content.

Our results suggest an inverted personalization effect on learning for health-related content, in this case about a disease. Consequently, we recommend the design of educational materials, that is, preferring the use of formal language, when communicating about health-related topics, especially diseases that participants do not have. The documentation of this study offers valuable material for future research to investigate further the remaining open research questions regarding the effect of personalization in health education materials and its explanation.

AUTHOR CONTRIBUTIONS

Luciana Maria Cavichioli Gomes Almeida: Conceptualization; methodology; data curation; investigation; validation; formal analysis; resources; writing – original draft; writing – review and editing. **Stefan Münzer:** Conceptualization; methodology; supervision; resources. **Tim Kühl:** Conceptualization; methodology; formal analysis; supervision; project administration; resources; writing – original draft; writing – review and editing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Open Science Framework at http://osf.io/c26m8, reference number c26m8.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Almeida, L. M. C. G., Münzer, S., & Kühl, T. (2024). More personal, but not better: The personalization effect in learning neutral and aversive health information. *Journal of Computer Assisted Learning*, 1–13. https://doi.org/10.1111/jcal.13026