

Does Learning Method Matter in Cyber Security Behaviour? Spaced Vs. Massed e-Learning*

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Abstract—Besides acquiring knowledge and skills, learning can also have a behavior change purpose. The case of learning compliance and cyber hygiene is an example. It remains a largely unexplored question whether learning methods affect the degree of intention to follow the learned behavior. Spaced learning has been established as a useful presentation style for the retention of information and building skills, but many organisations continue to use a massed e-learning format. This study compares three presentation formats (spaced, massed, and mixed) using a newly developed e-learning tool for the European General Data Protection Regulation (GDPR). Mixed methods are used to examine differences as well as to explore user perceptions and preferences. Forty-seven participants completed baseline tests and were randomly allocated to one of the three presentation style conditions. All participants completed immediate post-tests, delayed post-tests, and behavioral intention questionnaires. Despite some large observed differences between individuals, the univariate analyses showed that the gain scores between immediate post-test and delayed post-tests were not significantly different between participants across the three presentation formats. The qualitative analysis revealed emerging themes of presentation, delivery, messenger effects, and motivations.

Index Terms—component, formatting, style, styling, insert

I. INTRODUCTION

Organizations are required to show compliance in running cyber-security awareness programs, but this does not necessarily mean staff will change their behavior. There is a challenge to ensure that cyber-security behavioral changes are made and maintained in organizations. Professional e-learning projects have received a great deal of investment from enterprises to increase the standard of e-learning courses [1]. Despite impressive figures of such investments, the impact of projects using new e-learning technologies remains limited so far. Many e-learning tools involve an hour-long session which may not be effective to change behavior in the long term. Ebbinghaus [2] first demonstrated the spacing effect which led to enhanced memory following intermittent repetitions, compared to those whose repetitions were massed. This is also

known as intermittent learning and has recently been applied to the Nudge Technique [40]. Although this phenomenon is reliable in laboratory settings, findings of practical application are less common. Further, Sweller, J. [3] found that in an e-learning scenario there was a greater working memory capacity after spaced learning practice, compared to after massed learning practice, and attributes this to cognitive load theory.

Interactive online system like the COMPANY which enable the adaptation of risk and resilience and encourage behavioral change in organizations. Given the speed of change in technology and processes, people need to do more than learning new rules, they need to change behaviors. Using a combination of storytelling, social cognitive theory, and gamification, self-directed learning tools are used to facilitate changes of habit [4].

Currently, the high risk to companies in the European Union (EU) is to conform to the change presented in the recent change in data protection, the GDPR act. This new legal framework is for the collection and processing of personal data of individuals within the EU and was enforced on 25th May 2018. The challenge for all companies is to reassess how they deal with personal data and have all their employees understand the regulations of handling the information of clients, to avoid large fines. In the past, LT has used massed learning techniques to teach GDPR awareness in a forty-five-minute learning tool. The tool uses a blend of animated text, with progress controlled by the learner to suit absorption rate; documentary video to explain context; fictional drama to immerse; interactive learning games; quizzes with correct answers as a learning technique; and a final assessment test. The challenge is to ensure that cyber-security behavioral changes are retained permanently and currently the COMPANY is exploring the potential impact of using spaced presentation style, in the form of a video-style magazine. The spaced learning tool will be delivered over a longer period, in very short stimulus packages. It will put GDPR information into manageable

learning chunks, whilst providing a delivery mechanism that maintains an element of interest and enjoyment.

In this paper, we test whether the learning format of cyber-security behavior, taken GDPR compliance as an exemplar, has an effect on the adoption of compliant behaviors. We specifically test the difference amongst spaced, massed e-learning and a combination of both. Our study showed no significant differences. However, follow-up qualitative interviews showed that the other variables in the e-learning environment including the presentations, timing, messenger effect, and other persuasive elements, would matter in persuading a sustainable behavior change.

II. LITERATURE REVIEW

A. Background to existing e-learning tools

E-learning training has become prevalent in the workplace, where many organizations choose to supply their learning online, usually infrequent but for long periods. Usually, the training institute would provide a username and a password for each learner to access the course and complete the training in one sitting. Despite many advantages, according to Smedley [5] organizations lose some control over knowledge transfer by using ‘off the shelf’ e-learning programs. These programs are often massed e-learning, which refers to the presentation of large amounts of information in one continuous sitting, for example, university lectures or by students ‘cramming’ information as part of a revision technique. This can decrease communication and relationships that sustain the learning for long periods. Additionally, Caraban et al. [6] states there have been doubts with the initial premise of long-term behavior change tools and the dependability on self-monitoring and self-regulation where subliminal attitude change influences may motivate behavior change learners in the long-term. This means there is a market for the delivery of a different strategy for learning in the form of spaced learning, subtle influences outside the conscious awareness to learning, to facilitate engagement, motivation, and interaction between employees and ultimately long-term learning retention.

B. Learning Strategy, Memory Retention, and Online Behaviour Change

The strategy known as ‘spaced practice’ refers to the presentation of information in intervals. Björk and Allen [7] found spaced presentations, in comparison to massed presentations, led to a better final-test performance. Moreover, the retention of information was found to improve when learners had spaced distribution with one-minute intervals, compared to massed presentations. However, Cepeda et al. [8] argue the massed learning advantage perhaps only occurs when the retention intervals are extremely small (less than one minute). Additionally, Ebbinghaus [2] suggested, the long-term retention of learning can be enhanced by testing. These positive effects of spaced education have proved effective in a range of learning fields. Boespflug et al. [9] conducted an experiment using spaced education and online learning tools to reinforce long-term retention within medical education.

Participant performances increased when the spaced e-learning program was combined with the in-class training and regular testing. This shows that combining the spacing effect and the testing effect can increase performance and that there is a market for new learning tools combining testing with spaced learning, using new technology such as the internet, mobiles, desktops, and tablets [10].

Although there are a growing number of studies investigating spacing in educational environments, there is less research demonstrating convincing evidence that spacing is an effective learning approach when applied in non-educational contexts with employees and in online settings. One such study by, Pereira et al. [11] found that spacing in andragogy was an effective technique in improving retention and test performance in project management teams, within the industry. Kauffeld and Lehmann- Willenbrock [12] compared the effectiveness of spaced training and massed training in a sales department in behavior-orientated sales training to increase profit and gain more customers. The authors found that employees in the spaced learning condition reported higher sales than employees in the massed learning condition. Further research is needed on training to be applied to real work situations.

By increasing the long-term retention of learning through a spaced delivery mechanism, learners must change their behavior and use the information and knowledge they have retained. This section will include a discussion of online behavior change, persuasive design, and the element of choice in decision making, related to behavior change. Several behavior change theories were drawn upon in the design of the new tool (a separate paper provides further details). These included Ajzen’s [13] Theory of Planned Behaviour (TPB). Kahneman’s [14] dual systems of processing, and Protection Motivation Theory [15]. One of the most important was the theory of choice architectures (priming decision making) [16], providing correct cyber-security knowledge, in the form of ‘Nudges’ could influence decision making to counter the cognitive biases and increase privacy-sensitive behavior [17].

Research comparing spaced and massed learning continues to be conducted and shows significant effects across a wide variety of learning contexts; for example, Veremis et al. [18] showed that spaced repetition software aided retention in dental trainees, Lafleur studied spaced repetition in learning vocabulary [19], and Noor et al. [20] reviewed the use of spaced learning in foreign language teaching and learning finding that it enhanced memory retention. Recently, educators have begun to highlight the impacts of different learning strategies within corporate settings, e.g. see Hogle [21], however this is a review and real-world research is still needed.

III. METHODOLOGY

A. Rationale, Aims and Hypotheses

In summary, a cyber-security personal data nudge tool is proposed and this real-world study will test different presentations on the extent of memory retention and intended behavior change. A limitation identified in the literature review is that spaced learning is frequently researched in an educational

setting and e-learning is frequently designed as a massed learning strategy. Thus, this study aims to build upon the limited research on spaced learning in an organizational setting and to test different learning presentation methods of the tool to identify the most effective change in personal data security behavior. According to the best of our knowledge, no study thus far has examined a spaced learning tool and whether this influences long-term cyber-security knowledge retention and behavior change. The following hypotheses will be tested:

- H1: There will be significant differences on retention of information between the 3 presentation conditions.
- H2: There will be significant differences in behavior change intention between the 3 presentation conditions.

B. Research Design and Participant Recruitment

A quasi-experimental design was used to test the impact of the manipulated independent variable on the dependent variables. The independent variable ‘presentation style’ has three levels: spaced learning, massed learning, and mixed learning (spaced and massed learning together). The dependent variables are task performance (scores on immediate and delayed post-learning tests) and behavioral intention scores.

Employees within a company based in [anonymized place] were sampled using probability and stratified sampling, so the representative sample has similar characteristics to the population being studied. Ethical approval was granted for the study before participants were recruited. The sample was made up of 47 employees, i.e., 30 females, and 17 males. Participants were at least 25 years of age and under the age of 55 : 11 participants were aged between 25 – 34, 18 aged between 35–44, and 18 aged between 45–54. The participants were assigned to one of the three conditions and confounding variables were controlled for (e.g. department and baseline GDPR test) to ensure similar abilities across conditions.

C. Measures

1) *Test Performance Measures:* To test the retention of learning, three measures were collected: a pre-test before the learning tool has been taken, an immediate post-test after the learning tool had been taken and a delayed post-test. All three tests used the COMPANY’s massed learning GDPR test, which is embedded into the learning tool, validated by a pool of data protection business experts. The test is made up of 14 questions based on the content covered within the tool. This is termed the ‘testing effect’, which is the increase in long-term retention of information from being tested on the content previously [22]. Carpenter [23] supports this finding activation of elaborative information occurred during testing and that studying may be one mechanism that underlies the testing effect. This means that the baseline, immediate post, and delayed post-test should contribute to the long-term learning effect of the personal data tool. Moreover, the exploratory co-variable age was used to identify further insight of the study.

2) *Behavioural Change Intention Measure:* The tool used to measure data cyber-security behavioral change was the behavioral intention questionnaire for personal data security,

validated by Crossler [10]. The questionnaire is made up of 13 statements across the five categories: Perceived Security Vulnerabilities, Perceived Security Threats, Security Self-Efficacy, Response Efficacy, and Prevention Cost. These are based on the Protection Motivation Theory [15] in threat and coping appraisal of intention. The close-ended items offer a 5-point Likert scale of responses (from strongly agree to strongly disagree) [24]. These self-report survey measures are often used to research behavior change through a single post-intervention survey. However, Pickens [25] identifies the constraints of this method, whereby ‘social desirability bias’ can affect participants’ reported outcomes evaluations. Despite the social desirability bias, Chandon, et al. [26] propose the self-generated validity effect in their study of consumer purchase intentions. This predicts the measurement of intentions makes high intenders more likely to purchase and low intenders less likely to purchase but does not change the behavior of consumers with neutral intentions. This shows the commitment of an action can influence behavior.

IV. PROCEDURE

Testing took place over one month. Participants were provided with an information sheet detailing what the study would entail and written informed consent was obtained prior to the testing. The baseline, pre, and post-tests were distributed through Qualtrics personal link distribution software emailed by the COMPANY administrator. According to the participants’ score on the baseline test and business department, participants were randomly stratified into one of three conditions (spaced only, massed only, and the mixed learning condition). Participants used their computers at their workplace desk to carry out all tests, learning tools, and questionnaires with a choice of when they conducted the tasks. A week after the baseline tests, condition 1 (massed only learning) and condition 3 (mixed learning) took the COMPANY’s 45-minute GDPR massed learning tool and the immediate post-test through the Learning Management System (LMS). The three spaced learning tools were distributed weekly (one per week) to condition 2 (spaced only) and condition 3 (mixed), via a link to their email from the LMS. Each of the spaced learning tools videos was between 7–9 minutes long. An immediate post-test was distributed after the final spaced learning tool had been taken. To determine long-term retention of learning, a delayed post-test was distributed to all participants a week after the final learning tool. The delayed post-test was taken the week after learning as Wheeler and Roediger [27] found this time gap to be effective in long-term retention. A final behavioral intention questionnaire was administered to all participants. After all, tasks were completed, participants were debriefed about the study aims and hypotheses and encouraged to ask any questions.

V. RESULTS

Statistical analyses tested the impact of ‘presentation style’ on task performance and behavioural intention scores. All

analyses were performed as two-tailed and at a 0.05 significance level. Prior to testing, data were examined for normal distribution by means of descriptive statistics (i.e., skewness and kurtosis) and visually examining histogram plots. All variables were normally distributed. Univariate analyses revealed no significant effect of presentation style on immediate ($F(2, 44) = .896, p = .415$). or delayed ($F(2, 44) = .780, p = .465$) post-test scores, or gain scores ($F(2, 44) = .268, p = .766$). The confounding variable age univariate analysis revealed no significant effect on immediate ($F(2, 44) = 1.369, p = .265$) or *delayed* ($F(2, 44) = .929, p = .403$) post-test scores, or gain scores ($F(2, 44) = .641, p = .532$). There was no significant effect of presentation style on behavioural intention scores ($F(2,) = 144.307, p = .281$). A Pearson’s correlation test was conducted to assess the relationship between the baseline pre-score and behavioural intention score. There was no correlation between the two variables ($r = .287, n = 47, p = .051$).

Qualitative data were also collected through follow-up interviews. We asked the interviewees for their behavioral intentions of maintaining correct personal data behaviors inside the workplace and the concept diagram can be seen in Figure 1.

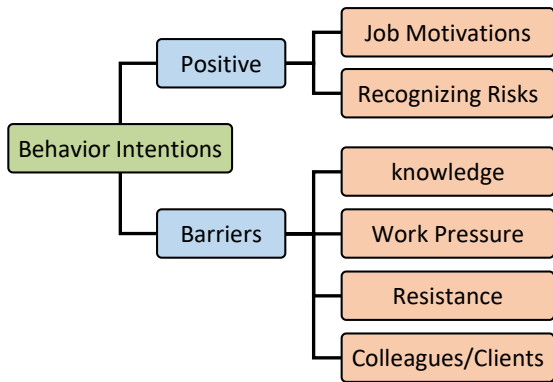


Fig. 1. Concept Map of Behavioral Intentions.

The factors that emerged were the intentions to adhere to personal data regulations, was job motivations, and recognizing the risks of personal data security. It is suggested that being in a job that holds responsibility for the data protection in the company is a drive to keep personal data compliance. However, this is an external motivation and is only seen to hold true in work scenarios, whereas personal data protection also applies to personal life. Therefore, recognizing the risks when dealing with other peoples’ personal data, it is essential to maintain good practice.

The barriers to personal data compliance were identified as a lack of knowledge, resistance, work pressures, colleagues, and clients. The employees had taken GDPR training prior to taking the study, however, perhaps threat awareness was used for the intention for the change of behavior, which has been found to have no means of sufficient change in behavior. Moreover, barriers to change were cited as work pressures, colleagues, and clients. This explains the importance

of desirable behaviors between the group environment at the workplace setting and warrants a sense of ownership of the object under attack.

VI. DISCUSSION

A. Immediate Post Test scores

There were no significant differences between presentation styles on immediate post-test scores. However, observing the means, massed learning has a higher immediate post-test score than spaced and massed learning conditions. This supports Cepeda et al. [8] who argue the massed learning advantage perhaps only occurs only when the retention intervals are extremely small. The immediate post-test for the massed learning condition was embedded at the end of the 45-minute learning tool. This may hold an explanation for the extremely short time that the participants had to retain the information. In comparison, the spaced learning conditions had to click on a link after their final spaced learning episode to administer their immediate post-test, where the retention interval would have been longer.

B. Delayed post-test scores and gain scores

The results indicated no significant differences between presentation styles on delayed post-test scores. Observing the gain scores between the immediate post-test and the delayed post-test showed there to be no significant differences. The finding opposes Kerfoot et al. [28] who found when information is repeated over spaced intervals, it is retained more effectively than if it was only learned once in a massed format. However, the study by Kerfoot et al. was a randomized controlled trial and conducted over an 18-week program with six spaced learning modules, repeated in three cycles, which is noticeably longer than the current study. This study was conducted in an areal-world business environment and thus contributes to key findings of a body of research that is predominately conducted in a controlled environment. The findings oppose Pereira et al. [11] who found that spacing was an effective technique in improving retention and test performance for adults working in project management teams within the industry. However, this study administered 12 modules, manipulating the number of days interval between each module delivery. In comparison to the present study, there are a considerably higher number of modules that employees took, and Pereira et al. did not consider a massed learning technique comparison. The current study has a delayed post-test one week after their learning and perhaps this length of time was too short to see a significant effect for the spaced learning to increase knowledge retention.

C. Behavioural Intentions

The results indicated no significant differences between presentation styles on behavioral intentions to act on the personal data regulations, however observing the means, spaced learning has a higher behavioral intention score than the massed and mixed learning conditions. This supports Kauffeld and Lehmann-Willenbrock [12], who found the effectiveness of higher reported sales using spaced learning than massed

TABLE I
IMMEDIATE AND DELAYED POST-TEST SCORES, GAIN SCORES, AND BEHAVIOURAL INTENTION FOR EACH PRESENTATION FORMAT.

Presentation Style (N)	Immediate Mean (SD)	Delayed Mean (SD)	Gain Score Mean (SD)	Behavioural Intention Mean (SD)
Massed (n=16)	12.06 (1.43)	11.68 (1.53)	-.37 (1.31)	39.44 (4.67)
Spaced (n=15)	11.20 (1.47)	11.13 (1.59)	-.07 (1.33)	41.13 (5.18)
Mixed (n=16)	11.87 (2.50)	11.87 (1.96)	.00 (1.89)	38.44 (4.16)
Total (n=47)	11.72 (1.87)	11.57 (1.70)	-.15 (1.51)	39.64 (4.71)

learning condition. This explains the massed learning technique has elicited a behavioral change. The nudge technique for learning could explain this where the GDPR law was not enforced upon them, but 'nudged' employees, motivating employees to consciously consider the options. **Heuristics [14]** [14] may be able to explain the behavior where it is suggested the incorporation of nudges exploit human bias to make more intelligent choices and to prevent risky behaviors [16].

The employees had participated in GDPR previous in-house training from the COMPANY. This may be the reason for the high behavioral intention scores. This finding is in accordance with Huang and Chuang [29] who suggested behavior of information security use, is positively associated with the attitude, normative beliefs, and habits on intention to conform. The attitude of the employee may have been positive with the GDPR data protection as they have received GDPR training. This would have been instilled previously by positive normative beliefs across companies from top management, supervisors and colleagues can ensure the information security policy compliance, producing security response efficacy and self-efficacy have that of a positive influence of backing up data [10].

The factors that emerged from the participants' verbalized intentions to adhere to personal data regulations, were job motivations and recognizing the risks of personal data security. It is suggested that being in a job that holds responsibility for the data protection in the company is a drive to keep personal data compliant. However, this is an external motivation and is only seen to hold true in work scenarios, whereas personal data protection also applies to personal life. Therefore, recognizing the risks when dealing with other peoples' personal data, it is essential to maintain good practice. When job responsibilities are combined with recognizing person data risks, it provides strong behavioral change intention. The barriers to personal data compliance were identified as a lack of knowledge, resistance, work pressures, colleagues, and clients. The employees had taken GDPR training prior to taking the study, however, perhaps threat awareness was used for the intention for the change of behavior, which has been found to have no means of sufficient change in behavior. This shows the importance of keeping the employees up to date with cyber-security knowledge throughout the year, meaning a spaced learning episode once a month could provide the knowledge employees need to maintain personal data protection behaviors.

D. Strengths and Implications

This study contributes to the emerging literature on the effects of spaced and massed online learning approaches, applied in non-educational contexts. Although there is no control over extraneous variables that might bias the findings, this naturalistic study holds high ecological validity, resulting in real-world applications to the COMPANY business. This is a key strength and the difference in findings compared to laboratory studies shows the importance of future research to test laboratory results in the field. The behaviors in this study reflect the participant's working day, and conducting their learning was a decision to schedule amongst their working tasks. This implication is imperative to future research in naturalistic business environments, to identify how spaced online learning tools are going to be used.

This study is the first to research the robustness of the spaced learning tool. This provides a platform for the tool to be further developed through the research of behavioral intention and delayed post-tests. Although the results from this study suggest that spacing of the tool may not lead to differences in the gain scores of an immediate test and post-test effect, the research suggests the tool has the potential to be an effective learning tool within businesses to ensure the maintenance of learning and a reminder of cyber-security and personal data behavioral change.

E. Limitations and Future Research

Although the findings offer valuable insight into the relationships between presentation style, test scores, and behavioral intention, they must be interpreted in the context of several limitations. First, the behavioral intention was accessed using a self-report questionnaire therefore the participants could have been subject to social desirability bias. The COMPANY has invested in being GDPR compliant to avoid sanctions and therefore the company enforces a policy of GDPR and personal data protection, which may have subsequently affected 'participants' responses. The retention of learning was only measured a week after the participants took their final learning tool. For further research, GDPR tests and behavioral intention questionnaires could be followed up throughout the year, to enhance investigations into the long-term retention of learning and behavioral intention. This would be a longitudinal study to address the long-term retention of spaced learning. The current spaced learning program was three episodes long, spaced 1 week apart. For future research, the spaced learning program could be developed further with more episodes with varied spacing time between the episodes to be investigated.

VII. CONCLUSION

This research compares the intention to comply with GDPR immediate post-test, delayed post-test, and behavioral intention scores using spaced and massed presentation styles. No significant differences between spaced and massed presentation styles were found. Further research into expanding the number of spaced learning tools and long-term retention over a year is needed. Moreover, the proposed COMPANY spaced learning tool was trialed in a real-world business environment, obtaining important feedback on the tool's content, timing, and structure. The aim was to elicit engagement and, ultimately, positive behavioral change in the workplace, related to GDPR. This study highlights the lack of significant differences between presentation methods, therefore each method can be used without unduly affecting learning. The research provides a foundation for further research on cyber-security e-learning tools in the workplace, extending on the limited research that has been done so far.

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