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Cognitive Psychological Expansions Of The Split-Attention Effect

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COGNITIVE PSYCHOLOGICAL EXPANSIONS OF THE SPLIT-ATTENTION EFFECT

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Abstract

The split-attention effect is in the area of multimedia learning an often examined and researched effect postulating higher learning success when corresponding sources are in spatial proximity. This article shows that it is possible by using new principles of grouping to have at least equal learning results with multimedia sources far away. To prove this it has been conducted an online survey and the data of almost 900 subjects have been analyzed regarding to their retention and transfer performance.

Keywords: *Multimedia Learning, Cognitive Load Theory, Split-Attention Effect, Cognitive Theory of Multimedia Learning*

1 INTRODUCTION

The area of multimedia learning is dominated by two psychological theories: the Cognitive Load Theory of Sweller, van Merriënboer and Paas (1998) and the Cognitive Theory of Multimedia Learning of Mayer (2005). Both theories have been evaluated quite often and lead to consistent findings. But both approaches have theoretical weaknesses if they try to handle effects which came into being directly from the theories. An example for this is the split-attention effect which arises if the learner has to divide his attention between different sources and at the same time has to combine the contents of these sources mentally. Sweller et al. (1998, p. 280) explain the creation of this effect in the following way: "Of considerable importance, the split-attention effect was obtained only when high element interactivity material was used, providing the first evidence of the importance of intrinsic, as well as extraneous, cognitive load." However no actual evidence is given but the derived conclusions are passed as results based on facts. Simple statements without any evidence can be found also in Mayer (2001, p. 81): "Students learn better when corresponding words and pictures are presented nearby rather than far from each other on the page or screen."

2 RELATED WORK

This chapter will give a brief outline of the related main theories, notably the Cognitive Load Theory of Sweller et al. (1998) and the Cognitive Theory of Multimedia Learning of Mayer (2005). The Cognitive Load Theory is very similar to the Cognitive Theory of Multimedia Learning and is mentioned at this point in order for completeness. Also the split-attention effect and the new principles of grouping of Palmer (1999) are introduced.

Different cognitive loads for the learning of multimedia contents are discussed within the literature. According to the Cognitive Load Theory of Sweller (2005) there are three different so called "loads": The intrinsic cognitive load, the extraneous cognitive load and the germane cognitive load. These three loads are added up to the cognitive load. However Mayer (2005) uses different names for this loads which are in correct order: representational holding, incidental processing and essential processing. The different naming is due to the fact, that the two theories were developed at almost the same time but by different researches and therefore received attention from different places within the scientific community.

Incidental processing is the load, which originates from an unadjusted design of the instructions. An easy to understand example would be e. g. additional multimedia elements like inappropriate sound effects, which divert the attention of the learner.

However essential processing is responsible for the construction and automation of schemata which Sweller (2005) regards to be the ideal solution for the learning with multimedia content. For the construction and automation of schemata it is important to observe the limited capacity of the working memory according to Baddeley (1997). If this limitation isn't observed and disregarded e.g. by too much learning material, then it impedes the effectiveness of the learning instruction and thereby the result of the learning itself is being left to chance.

Representational holding again arises from the natural complexity of the information which has to be learned. Therefore the element interactivity plays a very important role. On the one hand there are elements which can be learnt independently from others and therefore only cause a low cognitive load. Sweller (2003) calls this low-element interactivity material. The learning of vocabulary of a foreign language is an example for this due to the fact that the vocabulary can be learned singularly and independently without being confronted with problems.

On the other hand there are elements which correspond strongly to each other, called high-element interactivity material. Here a high cognitive load arises due to the fact that the information has to be learned simultaneously in order to achieve a high level of understanding by the learner. One example for this would be the syntax of a foreign language due to the fact that here everything has to be processed simultaneously in order to master the language adequately.

2.1 The split-attention effect

The split-attention effect is an effect which is often examined and which will now be dealt with more precisely. Ayres and Sweller (2005) define the split-attention as present, when the learner has to divide his attention between different sources and thereby simultaneously has to mentally combine the contents of these sources, like the simultaneous display of text and picture on a computer screen. These sources have to contain appropriate information which is necessary for the learner in order to understand the material which has to be learnt. For the now arisen split-attention effect the cognitive load is increased, especially the extraneous cognitive load, respectively the incidental processing. The solution of the problem according to Ayres (2005) is to present the contents which have to be learnt in an integrated format as shown in illustration 1.

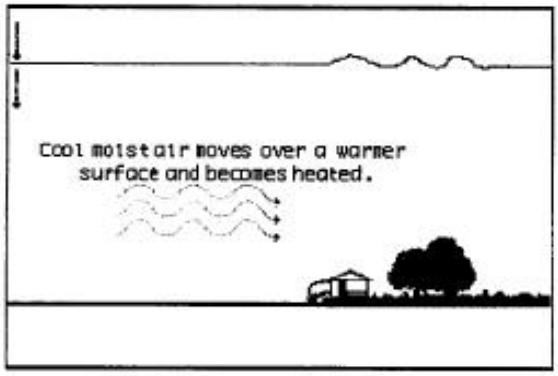

Illustration 1: Integrated version of the material in the experiment 1 of Moreno and Mayer (1999).

Illustration 1 clarifies the material of an often replicated experiment for the Cognitive Theory of Multimedia Learning of Moreno and Mayer (1999). The picture shows the integrated display format. The according text is placed in proximity to the corresponding graphic illustration, which should be useful for learning success.

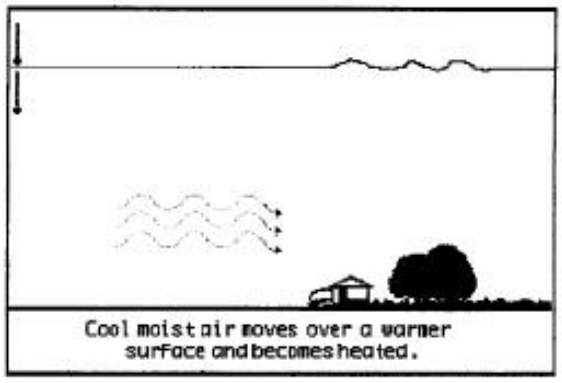

Illustration 2: Separated version of the material of the experiment 1 of Moreno und Mayer (1999).

In illustration 2 the separated version of the graphic illustration is presented, the descriptive text is in remote distance at the lower edge of the screen. The learning success is obstructed according to Moreno et al. (1999).

2.2 New Principles of Grouping

In order to find alternatives to the previous approach of spatial proximity of learning multimedia material, cognitive psychological expansions are considered. For this reason three additional Gestalt principles of Palmer are taken into account: common region, element connectedness and synchrony. The main attention of this study is directed towards the first two factors, which have been confirmed by Beck and Palmer (2002) empirically.

The grouping factor common region implies according to Palmer (1992) that – all else being equal - elements are perceived as a group if they are integrated within a connected, similarly coloured or uniformly structured area with the same included contour and color. By “all else being equal” Palmer (1992) means that all other features are held constant or being eliminated, the so called "ceteris-paribus-rule". However if this is not the case, an estimation of the result can no longer be made due to the fact that interactions are neither measureable nor controllable.

Illustration 3: Example of Palmer (1992) for the factor of the common region.

An example for the grouping factor common region is shown in illustration 3. It's clarified that the proximity of the points is no longer important for the perceived grouping, although the points within an ellipse are more distant than the two bordering points in two bordering ellipses. Nevertheless these points are not evaluated as connected following the proximity principle by Wertheimer (1923), but only the points within the ellipses.

Illustration 4: Example of Palmer et al. (1994) for the factor of the element connectedness.

Illustration 4 shows an example for the grouping factor element connectedness of Palmer and Rock (1994). All else being equal, elements tend to be grouped together when they are connected by other elements. As well the proximity principle of Wertheimer (1923) isn´t working, the connected points are perceived as being grouped, not the closer points between.

2.3 Research question and hypotheses

Derived from the work of Mayer (2001), as well as of Moreno et al. (1999) the following result is presented: Text and a graphic illustration should be grouped as near as possible on the computer screen, due to the fact that otherwise it would result in significant losses of learning performance.

In this article it is argued against it, that not only the proximity between the elements “text" and "picture" is important, but also that an artificially created relationship between these elements leads to at least equal learning success for the subjects. The following hypotheses are therefore examined:

H1. The linked display format (artificially created relationship) with the new principles of grouping according to Palmer (1999) does not lead to less retention- and transfer performance than the integrated display format.

H2. The animation without a descriptive text performs as a control condition significantly worse than all other test conditions, the animation is therefore not self-descriptive and needs for understanding the descriptive text.

3 THE ONLINE FIELD STUDY

In this part the conducted field study will be introduced, an online-survey which was realized on the Internet, in which the subjects had to solve retention and transfer tasks regarding the meteorological phenomenon "The creation of lightning". The study has been divided into three subsequent phases. In phase 1 the subjects first had to judge about their own meteorological knowledge. This action is analogous to the proceeding of the Moreno et al. (1999) experiment.

The subjects had to answer the following yes-no questions about meteorology: 1.) I regularly read the weather maps in the newspaper. 2.) I know what a cold front is. 3.) I can distinguish between cumulous and nimbus clouds. 4.) I know what a low pressure system is. 5.) I can explain what makes the wind blow. 6.) I know what this symbol means: [symbol for cold front]. 7.) I know what this symbol means: [symbol for warm front].

Subsequently the subjects have been assigned by random to one of six conditions for the experiment in which a three minute-long animation about the creation of lightning has been displayed. The conditions of the experiment provided a connection between the split-attention effect and the new principles of grouping, respectively surveyed the split-attention effect itself. The conditions of the experiments were different in respect to 2 characteristic features: On the one hand the spatial proximity of text to the corresponding animation and on the other hand the used principle of grouping. By the combination of these factors the following six conditions were created:

- The integrated text condition with the text placed in spatial proximity (IT)

- The integrated text condition with common region (ITCR)
- The control condition without a descriptive text (CG)
- The separated text condition with text placed in spatial distance (ST)
- The separated text condition with common region (STCR)
- The separated text condition with element connectedness (STEC)

Due to the restrictions of the length of this article only one illustration is shown. Illustration 6 shows the separated text condition with common region (STCR).

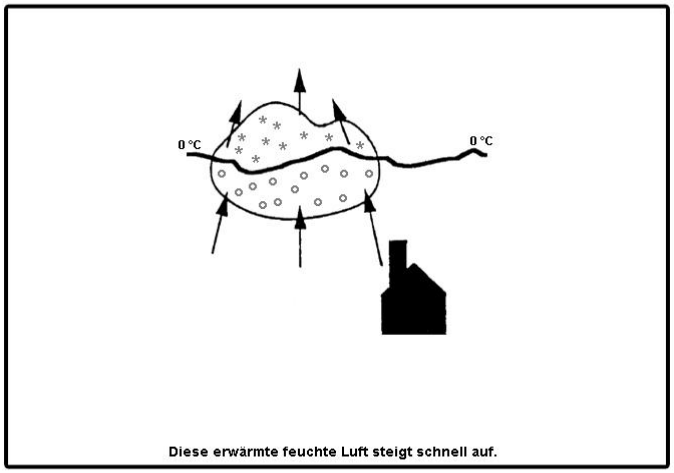

Illustration 6: Picture of the animation in the experiment about the creation of lightning. Hereby it is shown the separated condition with common region in German language. (STCR). English translation: Warmed moist air rises rapidly.

In phase three the subjects answered five open questions with time constraint connected to the seen animation. The questions in full detail were:

Question 1: Please explain how lightning works.

Question 2: What could you do to decrease the intensity of lightning?

Question 3: Suppose you see clouds on the sky, but no lightning. Why not?

Question 4: What does air temperature have to do with lightning?

Question 5: What causes lightning?

Therefore the first question was the retention question, questions 2 to 5 the transfer questions. For every correct answer a point was awarded, false answers were not counted.

4 RESULTS

The sample included 869 subjects, 452 were male gender and 417 female. The subjects were on average 25 years of age, with a standard deviation of seven years; 63 % were students. The results of the analysis of variance are presented in the following section. These are divided between the performance of retention and transfer.

4.1 Results for retention performance

	IT	ITCR	CG	ST	STCR	STEC
IT	----	.52	**99.92*** **	.01	*.24*	*.25*

ITCR	----	----	**95.43*** **	*.66*	1.91	*1.52*
CG	----	----	----	**131.20*** **	**130.61*** **	**116.46*** **
ST	----	----	----	----	.21	.25
STCR	----	----	----	----	----	.02
STEC	----	----	----	----	----	----

*** $p < 0.001$

Table 1: F-values for the comparison of the test conditions for the retention performance. Italic printed values cannot be interpreted in an unequivocal way due to the "ceteris-paribus-rule".

Table 1 supports the first hypothesis, that the integrated text condition (IT) is not significantly superior to the three linked text conditions (ITCR, STCR and STEC).

4.2 Results for transfer performance

	IT	ITCR	CG	ST	STCR	STEC
IT	----	.01	**9.43** **	.74	*.32*	*.24*
ITCR	----	----	**10.80*** **	*.91*	.42	*.33*
CG	----	----	----	**5.17***	**9.82** **	**6.80** **
ST	----	----	----	----	.26	.13
STCR	----	----	----	----	----	.01
STEC	----	----	----	----	----	----

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 2: F-values for the comparison of the test conditions for transfer performance. Italic printed values cannot be interpreted in an unequivocal way due to the „ceteris-paribus-rule“.

It is apparent from table 2 that transfer performance in the linked text conditions (ITCR, STCR and STEC) is not significantly worse than in the integrated text condition (IT), the first hypothesis is accepted. Also the control group (CG) without descriptive text performed significantly worse both in learning performance as well as in transfer performance. Therefore the second hypothesis is accepted, the animation is not self-descriptive.

Finally a positive trend towards the new principles of grouping was shown due to the fact, that the results in the linked text conditions were partly better than in the separated text conditions. Exemplarily table 3 shows this for the retention performance. Due to a technical error in quota allocation, the test condition STCR has almost 3 times more subjects than any other test condition.

Test condition	N	M	SD
IT	115	5.06	4.12
ITCR	114	4.69	3.79
CG	116	1.00	1.46
ST	113	5.08	3.54
STCR	303	5.27	3.92
STEC	108	5.33	4.05
Total	869	4.58	3.92

Table 3: Mean and standard deviation of the test conditions for retention performance (question 1).

5 CONCLUSION AND FUTURE WORK

The aim of this article was to test additional possible solutions for the split-attention effect in an empirical way. The until now used way of spatial proximity for knowledge acquisition and knowledge transfer of multimedia contents was extended by the new principles of grouping of Palmer (1999) in cognitive psychology, detailed by common region and element connectedness. As long as information systems are artificial socio-technical systems, an at least equal focus should be given to non-functional aspects like user interface design and therefore take into account spatial grouping for a better processing of important information.

The first hypothesis regarding the equal value of the linked text conditions and the integrated text condition was supported. An artificial connection of the distant elements text and picture didn't lead to significantly worse results than a display of these elements in spatial proximity, the subjects had not learnt significantly less than in the integrated test condition.

For retention and transfer of knowledge the animation without a descriptive text was not sufficient. The second hypothesis was confirmed, the animation was not self-descriptive.

This study is measured by the size of the sample, which is probably the largest in the context of research done on the split-attention effect. The number of subjects of the 37 studies in the meta-analysis of Ginns (2006) in respect to this effect were mostly in the range of two number digits, sometimes even in the very low three digits number of subjects.

Both the practitioner when designing multimedia learning programs as well as the theorist can profit from the available results by an additional angle of perspective when examining the Cognitive Load Theory and its effects. The utility for multimedia learning programs in the future is that one doesn't need to place corresponding text and picture as closely together as possible at any cost, but e.g. is able to save time and money by the creation of a more simple to handle common region instead. Science on the other hand has the opportunity to deal in a more extensive way with the results of cognitive psychology in order to develop further alternative possibilities for explaining the effects of the Cognitive Load Theory.

The results of the present study as well as the results of related studies of Michas and Berry (2000), as well as of Bodemer et al. (2004) generally lead to doubts about the often commonly cited universal validity of the split-attention effect. But it has to be additionally stated that the two mentioned studies didn't have the aim of questioning the effect, but can only be interpreted in that direction by the non discovery of this effect.

Another very promising field of research would be to show the existence of any cultural differences in multimedia learning, especially for the Mediterranean region. Because the Mediterranean Sea has a coastline with three different continents, Europe, Africa and Asia, it would be a great opportunity to see if they are fundamental learning differences. This possible future work is inspired by the findings of Pfeil, Zaphiris and Ang (2006). Pfeil et al. (2006) used Hofstedes cultural dimensions (power distance, collectivism vs. individualism, femininity vs. masculinity and uncertain avoidance) to show different types of contribution to Wikipedia, subject to regional provenance. For the Mediterranean region it would be a challenge to take large efforts to achieve the same categorization like Pfeil et al. (2006) achieved.

In addition to the research for showing different cultural styles of contribution, it could be helpful to use a psychologically well-founded personality questionnaire like the NEO-FFI. The NEO-FFI measures the following personality dimensions: neuroticism, extraversion, openness to experience, agreeableness and conscientiousness. The author argues that different cultures would benefit in different ways from different display formats. Without knowing the basic differences and without elaborating these differences in an empiric and scientific way, future e-learning programs could just fail in the Mediterranean region because of the nonobservance of these possible cognitive and perceptive psychological differences in the area of information

systems. Using a categorization method like the cultural dimensions of Hofstede or the personality dimensions of a personality questionnaire could shed light on previous failed e-learning efforts in the Mediterranean region.

In conclusion it can be recorded that the split-attention effect cannot be replicated as universally valid and the new principles of grouping have successfully passed their debut in research about the Cognitive Load Theory due to the acceptance of the first hypothesis and should be investigated and used more extensively in this context. Especially the introduced concepts and theories are not yet widely known in the information systems research community, but could in principle give rise to important and relevant research in the future.

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