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Harmful Threshold of ICT Distraction on the Learning Process

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Abstract- Information and Communication Technology (ICT) are nowadays widely used during academic or occupational trainings from an official standpoint (integrated in pedagogical programs) as well as from an informal standpoint (non class-related use by students, trainers or learners). Regarding this latter point, the research question was to know how often students may authorized themselves to deal with non-class related secondary tasks during a lecture without reducing the learning process performance? Experiments were thus undertaken with *N*= 66 UK students (MSc.) listening to a 13 minutes video lecture in individual cublicles and then answering questionnaires for knowledge, fidelity and MSLQ (motivation) assessment. Whilst viewing the lecture, students were distracted by sms received on their personal mobile phone. These sms were with neutral emotional valence. The cohort was divided into 5 groups, each related to a distraction frequency *f*=0, 10, 15, 20, 30 occ/h. We identified a threshold f_{crit} between 10 and 15occ/h under which learning performance was not lowered compared to the control group and beyond which a significant decrease was observe (15%). These findings are discussed in the light of the Information Processing theory and on the basis of a modified cognitive model based on Mayer and Moreno's work. Concluding advices for learners and teachers are provided. Limits are discussed and further experiments are suggested.

Keywords- *computer-mediated communication, improving classroom teaching, media in education*

I. INTRODUCTION

In a recent paper [1], we discussed how Information and Communication Technologies (ICT) are increasing in importance every day, especially since the 90's (last decade of birth for the Millennials generation, born between 1979 and 1994; see [2]). A 2012 report from Educause Center for Applied Research [3] showed among *N*=10000 that North American students' wishes for teachers' technology usage had doubled from 2011 to 2012, with 85% estimating laptop was very/extremely important to academic success, objectivizing students' preference for face-to-face interaction immediately followed by email and text/instant messaging. Later, Fried [4] showed among more than one hundred North American students that 64.3% were using their laptops in at least one class period, multitasking (email: 81%, instant messaging: 68%, surfing the net: 43%, playing games: 25%, other: 35%). Our previous study [1] gave similar results with 63% students using ICT in UK during MSc. academic lectures in Social Psychology.

Despite problems induced by these behaviors and the resulting teachers' disapproval [5], few investigations are available regarding the use of the ICT by this generation as well as the impact on outcomes in education and professional training. Furthermore, until our work, all studies were indirect (results and conclusions based on self-perception of students through questionnaires) or when direct (observations of students' behavior), studies were carried out in laboratories and did not proceed to an accurate quantification of ICT uses. Our study was the first published presenting results of observations undertaken in naturalistic conditions with objective description and an accurate quantification of ICT uses by students [1, 5, 6].

Observing and interviewing students preparing a MSc at the London School of Economics and Political Science (LSE students) between from 2012 to 2014 [1, 5, 6], we found that students (*N*=596, 85% female) had an increasing tendency to use ICT during lectures over the period of observation towards a value oscillating around a mean value equal to 63%. In parallel, the involvement ratio of students in ICT use per gender (female/male) showed that female used more ICT than male at the beginning of the period of observation, but that it came to a stable value around one, illustrating now an equal use of ICT by female students and male students. During the observations, most of the students using ICT had their device on the table or on the knees or in hand during the whole hour. Some of them could use ICT during courses at a rate of 0.84 occurrence/minutes (about 50 occ/h) and they thought this involvement did not distract learning, even was helpful.

Students usually perceive that digital devices have positive impacts on their academic success [7] while some of them could spend 27% of their time for non class-related secondary tasks as showed by direct observations in classrooms [5]. Nonetheless, in 2013, researches undertaken with about *N*=300 students showed that multitasking led them think they are much better than they actually are [8], findings consistent with earlier studies [9]; it suggests students cannot multitask as effectively as they think they can. In parallel, several studies have shown the negative effect of ICT use during classroom on the global academic results (see for example [4, 10]), but conversely, recent longitudinal studies [3, 11] pointed out a positive effect of ICT on global academic assessment. However all these assessments were based on self-reporting of ICT use by the students, which are biased as said above.

The question of whether use of ICT contributes positively or negatively to the learning process in academic context relates to multitasking: the main task (attending the lesson to learn) is disturbed by a secondary or distracting task or distractor (using ICT). This notion of distraction is actual only when the use of ITC is effectively a secondary task, and not integrated in the learning process as it is the case with integrated environmental learning [13] or web-based blended courses [11].

Based on a review of studies involving students in a long term task and distracted meanwhile [1], we analyzed the question in a fully controlled context implying controlling the content of tasks, their duration and their frequency. Applying such controlled conditions were a first: the studies selected for the review [14-20] i) suffered of a lack of accuracy regarding duration and frequency characterizations and ii) did not consider the emotional characteristics of the distractor which have a significant impact on the distraction valence (negative, positive, neutral) [21-24] and subsequently an effect on performance. The review undertaken in the previous study [1] suggested the hypothesis that non-class related secondary tasks (such as instant texting, web browsing) at a frequency f equals to 30occ/h was disturbing the learning process during an academic lecture and could significantly lower the performance: this was verified experimentally [1].

Yet a question rose: is there any threshold around which the effect of non-class related secondary tasks on the learning process switches from negative to neutral? In other words, how often students may authorized themselves to deal with non-class related secondary tasks during a lecture without reducing the learning process performance?

The present study aimed at producing a quantified assessment of this threshold, suggesting a theoretical depiction of the findings and providing concluding advices for learners and teachers. Investigations are based on our previous study [1] which led to the hypothesis that this threshold might be between f=6.6 and 30occ/h.

II. METHOD

This study came in complement of the previous one [1] and therefore respected the same design.

A. *Design of the experiment*

The design of the experiment was motivated by the desire to compare learning performance obtained after different distraction conditions in class. Subjects were involved in a main task (attending a lecture to learn) and periodically distracted by a secondary task. Controlled parameters were: the nature and duration of the main task, type, nature and frequency of the distractor (secondary task), profile of students attending the lecture.

Main task. Students were attending a 13 minute video-recorded lecture (lecturer presenting PowerPoint slides) at the Behavioral Research Laboratory (BRL) of the LSE. Student had to come with their own ICT (a mobile phone, a smartphone, a netbook, a laptop or tablet with Wi-Fi), pen and notebook, as if they were going to a daily course. The lecture was about an unknown simplified topic (related to Physics Science) for the students (Human Science).

Type and nature of distractors. The distractors was based on the use of mobile phone to exchange messages (sms); these distractors were non class-related. Relying on other researches showing that the valence of the emotional content (negative, positive, neutral) of a cognitive secondary tasks affected differentially the performance of a main task [201-24], the distractors were made as neutral as possible from the emotional standpoint. This choice was done in order to produce a distraction as similar as possible from one subject to another. This choice had another consequence: reducing the impact of the distraction by avoiding the emotional contribution, we could postulate that our experimental condition would give the lowest effect possible regarding the distraction. In other words, we could consider that any other naturalistic situation of learning distracted by message exchanging would give poorer performance. Therefore these were basic sms such as: Where are you? How is the weather? These sms were prepared before the experiment. Full list is given in appendix.

We verified that the overall potential time spent regarding the secondary tasks was in agreement with previous results obtained by Kraushaar and Novak [25] and applied by Sana et al. [12] suggesting that this would not exceed 40% of class-time.

Frequency of distractors. The frequency of the distractors was set up from the results of the very few studies available in the literature and review in a previous work [1] and from the results obtained during this work. As we proved that a distraction frequency f equals to 30occ/h had a negative effect on the learning process, subjects were divided in four groups each one related to a controlled value of f (occ/h): 30; 20; 15; 10 and an additional control group with f=0.

B. *Subjects*

The selection of the subjects was processed by the administrator of the BRL via an internet portal according to the criteria given by the researcher online. Participants were expected to be in first or second year MSc at the LSE (Human Science program), between 20 and 35 yo. in order to represent to generation of students said Millenial generation according to Myers & Sadaghiani [2]. Students engaged in Economics or Statistics courses were refused because they could have been given information related to the taught topic in a far past. Students had to be English native language or to have a TOEFL score greater than 107/120 in order to avoid a bias due to comprehension (all foreign students of the LSE are required a 107 score at least). Students were granted of £10 for retribution of their participation. Each student agreed and signed the conditions of the consent form regarding the experiment, the ethics application of which was approved by the Ethics Committee of the Dept. of Social Psychology of the

LSE and by the BRL. The total of students expected was *N*=66 and total of students participating was *N*=63 as three of them did not come.

C. Apparatus

Students were welcomed in a room of the BRL where each one sat in individual cubicle at a desk with PC screen, keyboard and mouse during 1h. This configuration reduced any influence of the group on individual, reduced the number of external stimuli that could distract the subject and therefore allowed researchers to control distracting stimuli, and likely reinforce the subjects' implication as isolated in a cubible and watching the video alone. Students used their own mobile phone.

The sms were sent altogether at the same time to all mobile phones.

This was performed from the researcher's computer through the online service of the French operator Orange in a first stage. Due to changing rules without prior announcement from Orange operator, we had to use another online portal than Orange and chose smsenvoi.com for its easy use, its reliability regarding sms sending-receiving delay and its efficient and very quick hotline. The distortion of frequency (difference between the sending frequency and the receiving frequency) due to the online application was 1.67% for an expected frequency equals to 1 sms/minute with smsenvoi.com. It was .83% for an expected frequency equals to 1 sms/2 minutes (it was 6.6% with Orange). Despite a better performance of smsenvoi.com compared to Orange, in both cases the value of distortion was low enough to consider the frequency accuracy satisfactory.

Just before undertaking the experiment, the reliability of mobile phone network in the BRL was verified, and computer in each cubicle was tested to be sure of the audio-video quality.

D. Procedure

Students were received in the BRL (expected *N*=66), were assigned randomly to a condition and then were placed in a cubicle. They were presented the aim of the experiment, had to read and sign (if agreement) the informed consent. Students were updated that performance assessment would be taken at the end of the lecture and that the answers for would be available online after the experiment.

The random assignment divided the students in five groups.

Group 1 (group control, *N*=12) had to listen to the lecture, taking notes on paper, laptop or tablet as they wanted, not allowed to use mobile phone (switched off) and not allowed to use websites.

Group 3 (*N*=14) had to listen to the lecture, taking notes on paper, laptop or tablet as they wanted, had to keep the mobile phone switched on, and not allowed to use websites. They had (mandatory) to answer 6 sms (neutral from cognitive and emotional standpoints) sent to them regularly (*f*= 30occ/h). These students had to communicate before the experiment their mobile phone number in order to receive sms. They had to reply to each sms sent by the researcher, sending back an answer.

Groups 11, 12 and 13 (resp. *N*= 12; 14; 14) were participating in the same conditions of group 3. Only the sms frequency changed. They respectively received 4 and 3 and 2 sms corresponding to *f*= 20 and 15 and 10 occ/h.

The distribution of the subjects per groups gave rise to preliminary statistical calculations in order to verify that a t-test of Student regarding the comparison of the mean performance per group could be relevant. Combined to a pilot study, we found that the statistical power would be greater than 0.8.

Immediately after watching the lecture, subjects were given the assessment form made up of two parts: a knowledge assessment and a fidelity assessment. Thirty of them received an additional motivation assessment form.

The performance or knowledge assessment was based on the revised Bloom's taxonomy [26, 27] using adapted level of assessment of the taxonomy according to the context. This was complemented by an Ontology-based assessment technique (list of words or expressions, related to a same main topic, to be organized according to a hierarchically structured set of terms for describing a domain; see [28, 29]). Both recalling and encoding were concerned. The performance score was calculated as a success rate to the 15 criteria assessed by 19 points. The use of written notes or any ICT during the assessment was forbidden. A pre-test assessment of knowledge was not necessary as the students did not know the topic before.

The fidelity assessment was elaborated in the line of Wood et al. [15] to characterize the subjects' compliance to instructions (what profile they had, whether or not they knew about the taught topic before the lecture, whether or not they adhered to instructions), the amount of secondary tasks and their nature (if students had used devices, how many times, due to which reason), the technology use (whether or not students had used the required devices).

The motivation assessment was made up of three scales of the Motivated Strategies for Learning Questionnaire (MSLQ) of Pintrich et al. [30]: the Extrinsic Goal Orientation scale (4 items to evaluate the degree to which participants perceived themselves to be participating in a task for reasons such as grades, rewards, performance, evaluation by others, and competition), Task Value scale (6 items referring to the participants' evaluation of the how interesting, how important, and how useful the talk was), the Self-Efficacy for Learning and Performance scale (8 items assessing expectancy for success (performance expectations thus referring to task performance) and self-efficacy as a self-appraisal of one's ability to master a task). These scales were chosen among the six motivation scales because of their relevance regarding the experiments; the remaining scales dealing with long term academic courses (student's general goals or orientation to the course as a whole; contingency of academic outcomes on one's own effort) or anxiety were not selected. Two recent in-depth analyses showed the reliability of the MSLQ [31; 32].

III. Results

A. Motivation

Some of the students thought that the right answers to the assessment questionnaire would be given in place after the test and when leaving the lab, they asked confirmation about this to be online soon. Other students left the place thanking the researcher for the interesting lecture. These behaviors illustrated their commitment to answer correctly the questionnaire.

The motivation scales being assessed on a seven point Likert scale from 1 to 7, we found that most of the subjects presented a score for each selected motivation scale higher than the average 3.5 ($p<.001$), and that the mean score of all subjects for each scale was higher than this average value. Data are presented in Table 1. The Cronbach alpha was .88 for the total sample of subjects.

TABLE I. Results of motivation self-assessment using MSLQ (N=30).

Motivation scale	Extrinsic Goal Orientation	Task value	Self-Efficacy for Learning and Performance
Proportion of subject over the average value 3.5 of the MSLQ	60,00%	73,33%	73,33%
Mean score of all subjects on MSLQ	3,87	4,03	3,99

For each motivation scale, we compared the mean score calculated for each group with the mean score calculated for all subjects given in Table 1. We then applied a t-test of Student and did not find significant difference.

The modal analysis undertaken in order to view the distribution of the individual score for the three selected motivation scales is presented on Figure 1. Each distribution spreads over a Gaussian type curve which extremum is higher than the average Likert scale value. For the scales “Task value” and “Self-Efficacy”, the data distribution positions subjects’ motivation clearly in upper part of the scale. This is less clear for the “Extrinsic goal orientation” scale.

No significant correlation was identified between performance and motivation scales. No significant influence on motivation was identified neither from gender, age, nor academic background.

The same analyses were undertaken for restricted samples (subjects with best performance and subjects with worse performance) and no specific characteristics could be highlighted.

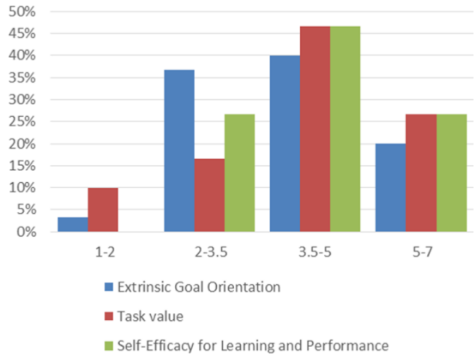


Figure 1. Proportion of subjects per mode according to the modal analysis of MSLQ scores. E.g.: for the “Task value” scale, 10% of subjects had a score between 1 and 2.

B. Performance

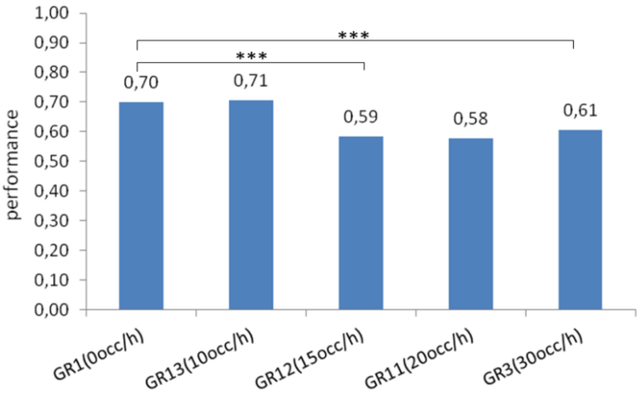
The number of participants was lowered compared to the 66 expected; 28 were not considered:

- 3 subject did not come,
- 10 did not comply strictly with instructions (e.g. replied to extra sms (higher frequency and no control on the emotional content) or connected on line while forbidden or looked at written notes during assessment),
- 5 did not matched the required academic training,
- 1 did not filled the sociodemographic data,
- 4 were eliminated because out of the age range considered,
- 4 was eliminated because knew partly the subject before taking the test
- 1 was eliminated after statistical Q test.

This means that about 42% of the cases could not be used. This rather high level of rejected subjects is assumed to be partly due to the way participants registered online at the BRL and how information was available: participants read one box and not the additional information. It means that the research team must write all requirements in one box. These difficulties were combined with the fact that no control was possible before the day of the experiment, according to what explained the BRL administrator, due to anonymity concerns. Thus, it was just when participants were fulfilling the sociodemographic questionnaire that selection could be done, but this was however too late to summon other participants. We must also notice that among these 42%, about a third related to subjects not complying with instructions most of the time because they were more often connected than required.

The remaining subjects included 30% male students and the average age was 21 years old for the whole sample.

The results obtained are summarized in Figure 2. Significance of the differentiation of the mean values was assessed through a t-test of Student.



(***p<.001)

Figure 2. Subjects' performance according to the distraction frequency: significant difference is calculated by t-test of Student between high and low values (p<.001)

No significant influence on performance was identified neither from gender, age, nor academic background. The only influence was due to distraction frequency.

The right answers for the assessment questionnaire where not given in place but put online a few hours later. Subjects were updated about this detail at the beginning of the experiment.

Statistical power calculations showed afterwards that when mean values have significant difference applying t-test of Student, the test power was greater than 0.8 which confirms the consistency of the data. This confirmed the a priori calculation.

IV. DISCUSSION

A. Motivation

Motivation assessment was carried out because some researchers, during private exchanges, asked us to prove that motivation was not a factor significantly influencing the performance. This pertained to two hypotheses. Hypothesis 1 was that subjects would perhaps not be motivated to listen to the lecture disconnected from their academic program and then to answer correctly the assessment questionnaire. Hypothesis 2 was that when distracted by a lot of sms, subjects would not be motivated to answer as correctly as possible the assessment questionnaire conversely to these not so much distracted, therefore creating a bias.

Results led to reject both hypotheses. Hypothesis 1 was rejected as we demonstrated that the level of motivation on the MSLQ was high for most of the subjects in terms of mean score (see Table 1) and distribution (see Table 1 and Figure 1). Hypothesis 2 was rejected as no significant difference was found for each motivation scale when comparing the mean score calculated for each group with the mean score calculated for all subjects given in Table 1.

The conclusion was that motivation did not created any bias to the experiment.

B. Experiment

The distraction by sms (non-class-related distraction), induced a significant step of learning performance (p<.001) at a frequency f_{crit} between 10 and 15 occ/h (see Figure 2): when $f \leq$10occ/h, the learning performance was this of the control group with subjects not disturbed by any use of ICT; when $f \geq$15occ/h the learning performance decreased about 15%. This value of threshold is completely coherent with results obtained elsewhere and reviewed in the previous study [1].

Nevertheless, while we thought that learning performance would decrease with distraction frequency increasing, results showed that it was not the case: the decrease of performance remained at a same level for all frequencies higher than 15occ/h.

This led to the conclusion #1 that, for texting-based secondary task, higher distractor frequency than 10occ/h produces a negative effect on the learning process. On the contrary, when decreasing the frequency, this negative effect may disappear as proved our results and also by Bowman et al.'s experiments [14].

Furthermore, as usually instant texting like sms sent or received by students have a higher emotional valence than these used in the present study, the conclusion #2 is that the threshold f=10occ/h identified here is a minimum. When dealing with sms charged with emotional content (likely the case of naturalistic contexts), this threshold must be higher.

The step of learning performance at a given threshold separating two distinct levels of performance identified through our experiments may be explained in the light of functional neuroimaging. It is showing that increasing cognitive load by dealing with a secondary task during learning modulates the degree to which subjects use declarative memory (mainly involved in this kind of learning process), not reducing accuracy but reducing the amount of declarative learning about the task [33]. Mayer and Moreno [34] suggested an interesting theoretical approach to explain the associated overloaded information process in the case of multimedia use as it is the case for the present study. Information process starts with sensory functions before being accessed by the cognitive channel to be processed by basic cognitive functions such as attention, memory (working memory, WM, and long term memory, LTM) and reasoning, while complex cognitive processes are the combination of these basic cognitive functions.

The interaction between WM and LTM during multimedia use is interestingly described by Mayer and Moreno's model [34] integrating earlier work [35] suggesting that subjects use separate memory channels for oral and visual information leading to a dual processing conception of learning.

However, in their model, Mayer and Moreno neglected an important sensory aspect regarding touch: indeed, when people are using multimedia such as mobile phones, smartphones or computers, they have to manage input information for the devices, pressing keys, feeling the haptic feedback of keystrokes in their fingers.

Mayer and Moreno's model divides WM into a visual channel and an auditory channel, independent of one another to some extent and both limited in capacity. We must here complete the model with the tactile and kinesthetic aspects of the sensory system which are yet concerned by interactions with ICT. Hence, whereas Mayer and Moreno [34] showed that in the case of multimedia learning, a dual processing could significantly overload the cognitive process of information, we claim that this overload also involves a haptic component. Figure 3 presents a modified chart of the model.

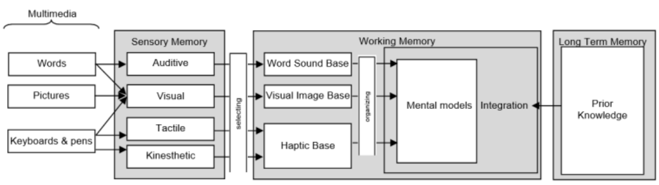


Figure 3. Mayer and Moreno's [34] modified model for cognitive process of multimedia use.

In the present experiment, subjects were submitted to a periodic overload in the frame of a multi-cognitive process of information, processing speech, pictures, reading words and keyboard interactions. When subjects only watched the lecture (group 1), auditive and visual channels were solicited and there was likely no overload. When subjects dealt with sms in parallel, four channels, auditive, visual, tactile and kinesthetic were solicited. The visual channel was overloaded compared with the non-distracted group 1: the visual channel overload was due to information provided by the lecture (not watched but heard simultaneously), by the mobile phone (reading sms) and phone keyboard management. The load of the multi-cognitive process of information increased with f . At the same time, referring to Information Processing theory and more specifically to Wickens and Hollands' model [36], attention distraction increased with f and subjects' attention was directed to another purpose than this of the lecture. This explains the decrease of performance with f increasing compared with the control group 1 in which subjects were not disturbed.

We also can see on Figure 1 that f_{crit} separates the learning performance in two plateaus differing of 15% in terms of level of performance. Whereas we expected performance to decrease with f increasing, the deteriorated performance remained constant on the range of f investigated. We may here suggest two hypotheses happening beyond f_{crit}. Hypothesis A is that the cognitive channels reached an overloaded state remaining the same whatever the value of f over the investigated range, resulting thus in a constant performance level. Hypothesis B is that the overload of the cognitive channels increased with the value of f, and subjects could compensate the distraction over the investigated range of f for the best at the level of performance measured, doing their best in all cases but up to the level resulting in a plateau of performance. This may explain why the threshold f_{crit} separated two distinct levels of performance identified through our experiments. Yet we may assume that, with very high value of f , the performance would fall down to a value tending to zero. This means that this performance plateau would not be observed for higher values of f ; the interesting question is to know whether this decrease would occur through different plateaus of decreasing values or through a linear decreasing curve. To conclude about this point, further experiments are needed.

V. CONCLUSION

From a practical standpoint, the findings of the present study are of great interest both for academic teaching and professional training.

For academic teaching, it must be known that non-class related distractors (in their basic form, i.e. with neutral emotional valence) are related to a frequency threshold separating neutral and negative effect at a distraction frequency equals to 10occ/h; any use of ICT with a frequency higher than this threshold during the lectures reduces students' capacity for learning. Furthermore in practice, this threshold is higher as most of the time students are concerned by emotional non-class related distractors.

For professional training, as it involves for a great part newcomers of the companies in teaching classrooms, concerns are the same. As mentioned in [5, 6], observations in companies show that newcomers keep the same habits of ICT use when living the universities or schools and entering the world of work. Therefore the same warning applies.

From a theoretical standpoint, the findings of the present study are of great interest regarding the cognitive load. It identifies a minimum value for the critical threshold regarding distraction frequency of subjects involved in the learning process of an academic lecture, it suggest that there may be a plateau of cognitive load in multitasking that further experiments would advantageously help to describe for a better understanding and it presents a modified model for cognitive process of multimedia use based on the Mayer and Moreno's model [34].

In terms of limits, as the present study relates to a particular taught topic (a simplified Physics Science lecture) for a particular sample of students (Human Sciences MSc.), it would be interesting to vary the context under similar controlled conditions and compare the results with these of the present paper. It would also be interesting to study the effect of the relationship students-taught topic on the resulting performance in distracted conditions, i.e. for a sample of students of a given discipline, studying the performance and the motivation in similar distraction conditions in several experiments, each one related to a lecture linked to different disciplines.

In terms of perspective, reproducing these experiments for higher values of the distraction frequency would be interesting. It would give relevant information regarding the variation of cognitive load for this particular multitasking context.

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Appendix

List of neutral sms used during experiment with group 3:

- Hi, where are you?
- Are you free now?
- How is the weather?
- Don't you feel it is cold?
- And now, where are you?
- At what time are you free?

References

[1] Ph. Fauquet-Alekhine, "Assessment of ICT Contribution to the Learning Process". International Journal of Science and Engineering Investigations, vol.4(40), 2015, pp.1-10.

[2] K. K., Myers, and K. Sadaghiani, "Millennials in the workplace: A communication perspective on millennials' organizational relationships and performance". Journal of Business and Psychology, vol.25(2), 2010, pp.225-238.

[3] E. Dahlstrom, J. D. Walker, and C. Dziuban, ECAR study of undergraduate students and information technology, 2012. Boulder, CO: Educause Center for Applied Research. 2012.

[4] C. B. Fried, "In-class laptop use and its effects on student learning". Computers and Education, vol.50(3), 2008, pp.906-914.

[5] Ph. Fauquet-Alekhine, "Informationand Communication Technologies vs Education and Training: Contribution to understand the Millennials' generational effect", Proc. of the International Conference on Electrical, Computer, Electronics and Communication Engineering, Venezia, IT, vol.80, 2013, August, pp.358-363

[6] Ph. Fauquet-Alekhine, "Learners' behavior in teaching context: characterizing the use of Information and Communication Technologies", Proceedings of the 1st International Science and Applied Research Conference Social Psychology in Education Space, Moscow, Russia, 2013, October, pp.262-264 .

[7] A. Demb, D. Erickson, and S. Hawkins-Wilding, "The laptop alternative: Student reactions and strategic implications". Computers and Education, vol.43(4), 2004, pp.383-401.

[8] D. M. Sanbonmatsu, D. L. Strayer, N. Medeiros-Ward, and J. M. Watson, "Who multi-tasks and why? Multi-tasking ability, perceived multi-tasking ability, impulsivity, and sensation seeking". PloS one, vol.8(1), 2013, pp.e54402.

[9] E. Ophir, C. Nass, and A. D. Wagner, "Cognitive control in media multitaskers". Proceedings of the National Academy of Sciences, vol.106(37), 2009, pp.15583-15587.

[10] D. K. Duncan, A. R. Hoekstra, and B. R. Wilcox, "Digital devices, distraction, and student performance: Does In-Class cell phone use reduce learning?". Astronomy education review, vol.11(1), 2012, pp.010108.

[11] P. Moskal, C. Dziuban, and J. Hartman, "Blended learning: A dangerous idea?". The Internet and Higher Education, vol.18, 2013, pp.15-23.

[12] F. Sana, T. Weston, and N. J. Cepeda, "Laptop multitasking hinders classroom learning for both users and nearby peers". Computers and Education, vol.62, 2013, pp.24-31.

[13] K. D. Su, "An Intensive ICT-Integrated environmental learning strategy for enhancing student performance". International Journal of Environmental and Science Education, vol.6(1), 2011, pp.39-58.

[14] L. L. Bowman, L. E. Levine, B. M. Waite, and M. Gendron, "Can students really multitask? An experimental study of instant messaging while reading". Computers and Education, vol.54(4), 2010, pp.927-931.

[15] E. Wood, L. Zivcakova, P. Gentile, K. Archer, D. De Pasquale, and A. Nosko, "Examining the impact of off-task multi-tasking with technology on real-time classroom learning". Computers and Education, vol.58(1), 2012, pp.365-374.

[16] A. D. Froese, C. N. Carpenter, D. A. Inman, J. R. Schooley, R. B. Barnes, P. W. Brecht, and J. D. Chacon, "Effects of classroom cell phone use on expected and ectual learning". College Student Journal, vol.46(2), 2012, pp.323-332.

[17] J. H. Kuznekoff, and S. Titsworth, "The impact of mobile phone usage on student learning", Communication Education, vol.62(3), 2013, pp.233-252.

[18] H. Pashler, S. H. Kang, and R. Y. Ip, (2013). "Does multitasking impair studying? Depends on Timing". Applied Cognitive Psychology, vol.27(5), pp.593-599.

[19] L. D. Rosen, A. F. Lim, L. M. Carrier, and N. A. Cheever, "An empirical examination of the educational impact of text message-induced task switching in the classroom: Educational implications and strategies to enhance learning". Psicología Educativa, vol.17(2), 2011, pp.63-177.

[20] R. L. Bannerman, E. V.Temminck, , and A. Sahraie, "Emotional stimuli capture spatial attention but do not modulate spatial memory". Vision research, vol.65, 2012, pp.12-20.

[21] M. Chan, and A. Singhal, "The emotional side of cognitive distraction: implications for road safety". Accident Analysis and Prevention, vol.50, 2013, pp.147-154.

[22] E.A. Kensinger, and S. Corkin, "Memory enhancement for emotional words: are emotional words more vividly remembered than neutral words?", Memory and Cognition vol.31, 2003, pp.1169-1180.

[23] T. Sharot, E.A. Phelps, "How arousal modulates memory: disentangling the effects of attention and retention". Cognitive, Affective, and Behavioral Neuroscience, vol.4, 2004, pp.294-306.

[24] D. Talmi, A.K. Anderson, L. Riggs, J.B. Caplan, and M. Moscovitch, "Immediate memory consequences of the effect of emotion on attention to pictures". Learning and Memory, vol.15, 2008, pp.172-182.

[25] J. M. Kraushaar, and D. C. Novak, "Examining the effects of student multitasking with laptops during the lecture". Journal of Information Systems Education, vol.21, 2010, pp.241-251.

[26] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill, and D. R. Krathwohl, Taxonomy of educational objectives: the classification of educational goals; Handbook I: Cognitive Domain. New York, Longmans, Green. 1956.

[27] D. R. Krathwohl, "A revision of bloom's taxonomy: An overview", Theory into Practice, vol.41(4), 2002, pp.212-218.

[28] T. Gavrilova, E. Strakhovitch, and I. Leshcheva, "Ontologies for project management teaching". Joint Proceedings of the Work-in-Progress Poster and Invited Young Researcher Symposium at the 18th International Conference on Computers in Education. Putrajaya, Malaysia, 2010, pp.7-9.

[29] I. Leshcheva, D. Gorovaya, and D. Leshchev, "Ontology-based Assessment Technique", Proceedings of the 2nd International Workshop on Semantic Web Applications in Higher Education (SemHE'10), Southampton, UK. 2010, November-December. Retrieved from http://eprints.soton.ac.uk/271753/1/semhe10-leshcheva-et-al.pdf

[30] P. R. Pintrich, D. A. F. Smith, T. Garcia, and W. J. McKeachie (1991). A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ). Report n° NCRIPTAL-91-B-004. Ann Arbor: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.

[31] R. T. Taylor, Review of the motivated strategies for learning questionnaire (MSLQ) using reliability generalization techniques to assess scale reliability (Doctoral dissertation, Auburn University), 2012.

[32] Kivinen, K., Assessing motivation and the use of learning strategies by secondary students in three international schools. Tampere University Press, 2003.

[33] K. Foerde, B. J. Knowlton, and R. A. Poldrack, "Modulation of competing memory systems by distraction". Proceedings of the National Academy of Sciences, vol.103(31), 2006, pp.11778-11783.

[34] R. E. Mayer, and R. Moreno, "Nine ways to reduce cognitive load in multimedia learning". Educational psychologist, vol.38(1), 2003, pp.43-52.

[35] S. Y. Mousavi, R. Low, and J. Sweller, "Reducing cognitive load by mixing auditory and visual presentation modes". Journal of educational psychology, vol.87(2), 1995, pp.319-334.

[36] C.D. Wickens, and J.G. Hollands, Engineering psychology and Human Performance (third ed.). Upper Saddle River, NJ: Prentice-Hall. 2000.

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